

Abstract

The new subfamily Redmondininae is characterized by coarsely perforated and strikingly thick chamber walls, a reduced umbilical filling but with a canal system that tends to extend onto the dorsal side of the shell. This group encompasses four genera (*Redmondina*, *Slovenites* n. gen., *Rotaliconus*, *Pachyrotalia* n. gen.). Seven species (*R. henningtoni*, *R. garganica* n. sp., *S. praecursorius* n. sp., *S. pembaphis* n. sp., *S. decastroi* n. sp., *R. arachosiae* n. sp., *P. massa* n. sp.), are described and illustrated.

This is a group of rotaliids with coarsely perforated and strikingly thick chamber walls, a reduced umbilical filling but with a canal system that tends to extend onto the dorsal side of the shell. Few and coarse funnels may appear in the umbilical filling. *Redmondina* Hasson, 1985, represents a branch of small-sized shells with a relatively simple morphology, *Slovenites* n. gen. a parallel group with a more complex architecture and a peculiar dorsal ornamentation by perforate pustules. In Pakistan's SBZ 4 (Upper Paleocene), they are associated to *Pachyrotalia massa* with an enveloping canal system invading the dorsal side.

All rotaliines and redmondinines remain limited in size during all the Paleogene; there are never extreme morphological variants like multiple spirals (*Dictyoconoides*, *Dictyokathina*) with their corresponding, extreme dimorphism.

4.1 Redmondina Hasson, 1985

Type species: *Redmondina henningtoni* Hasson, 1985

Remarks: The trochospiral shells with very coarse pores are comparatively small. The dorsal ornamentation is scarce and often obscured by the large pores. The periphery of the shell is rounded, without any differentiation of the perforation. The septa are radial, curved and inclined backwards on the dorsal side of the shell. They house a simple canal system with orifices near the junction of the spiral suture with chamber sutures. There seems to be a single radial canal in the septum below the septal suture (Plate 4.3, Fig. 2). The ventral side of the shell is characterized by radial, deeply sunk septa admitting a large, radial interocular space. The

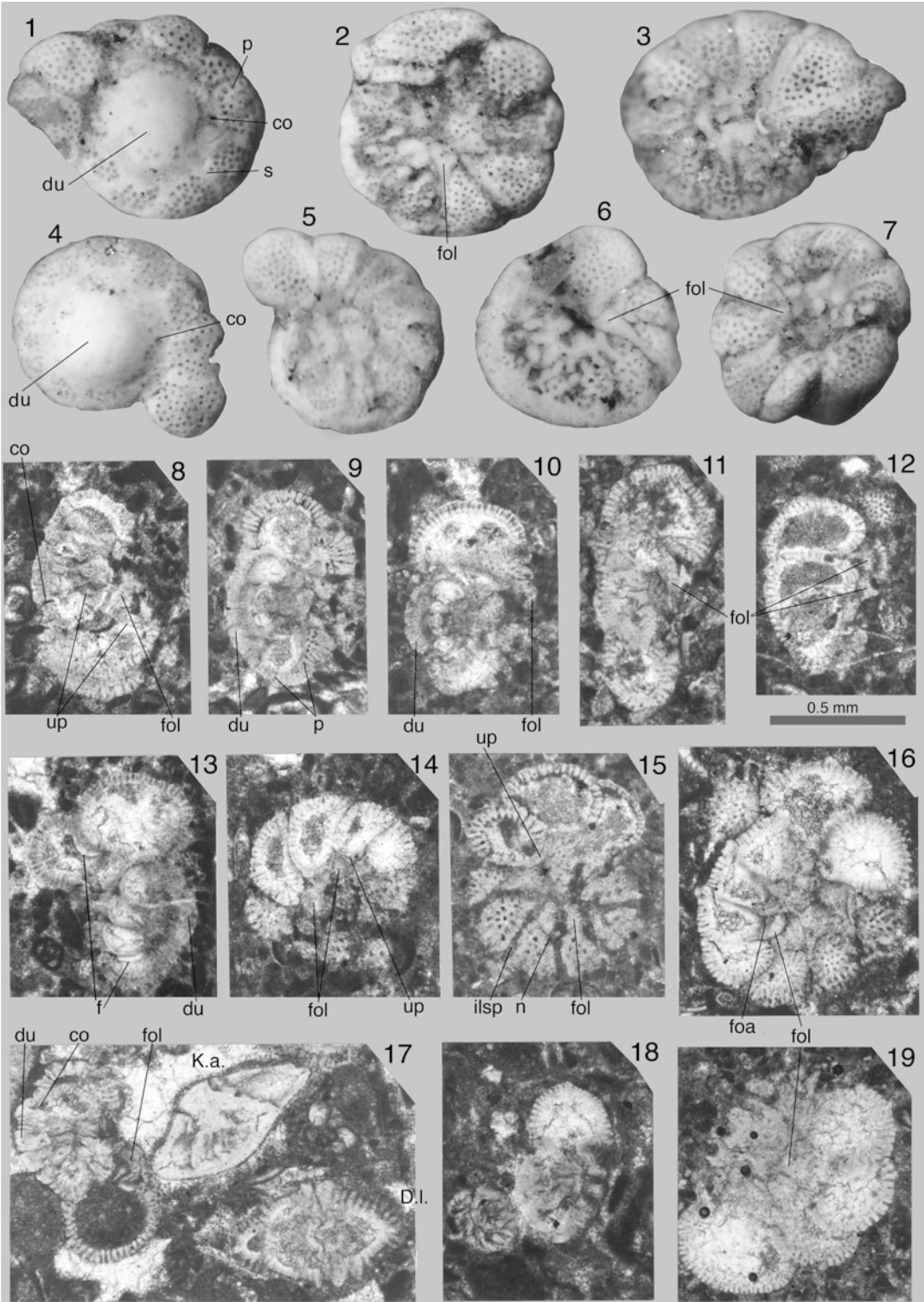


Plate 4.1 *Redmondina henningtoni* Hasson, 1985. (1–7) Western Aquitaine, Southern France, collected by Y. Tambareau; Paleocene (SBZ 3). (8–10) Axial sections.

foramina form very low and narrow arches in interiomarginal position (Plate 4.1, Fig. 13). The folia are long and narrow, only a little bit inclined in respect to the axis of the ventral part of the chambers. The narrow umbilicus is empty or filled with a few piles that do not fuse. The piles arise from the imperforate narrow folia along their radial axis (Plate 4.3, Fig. 2) but do not fuse to a solid umbilical filling. In early species, the umbilical plate is small and difficult to see in random sections of the shell. In later species, the umbilical plates are much larger. The spiral interloocular space is obscured by the heavy ornaments produced by the umbilical piles. We have not observed any dimorphic features.

Redmondina henningtoni Hasson, 1985; Plate 4.1, Figs 1–19; Plate 4.2, Figs. 1–13. 1985 *Redmondina henningtoni*—Hasson, p. 352, pl. 3, figs. 4–9.

? 1973 *Epistomaria separans* Le Calvez—Ferrer et al., p. 43, pl. 1, figs. 9–11.

2000 *Redmondina henningtoni* (Hasson)—Peybernès et al., p. 46, pl. 6/7–8.

Remarks: A species with the characteristics of the genus *Redmondina* characterized by a smooth dorsal umbo covering the early whorls of the shell. The umbo has few or no pores forming a kind of white cap that strikes the eye when picking free specimens from washed residues. The adult whorls of the shell have 8–10 chambers. The size of the proloculus is about 0.04 mm. Compare the short, radial folia that do not touch each other with their adaxial tips in Hasson (1985, pl. 3, fig. 4) and in the present paper (Plate 4.1, Fig. 15).

Hasson's (1985) holotype of *R. henningtoni* has a rounded periphery whereas her specimen illustrated pl. 3, fig. 4 shows a strong keel.

I consider the latter as an artefact due to the glue used to prepare the specimen for SEM analysis.

Redmondina garganica n. sp.; Fig. 4.1A–J; Plate 4.3, Figs. 1–12.

Syntypes: Specimens figured in Plate 4.3, Fig. 3 (section perpendicular to coiling axis) and Fig. 9 (axial section).

Type locality and type level: Monte Gargano, Italy; Early Eocene, middle Cuisian (SBZ 11).

Derivation of name: Monte Gargano represents the highest point on the Peninsula Garganica, the spur of the Italian boot.

Diagnosis: Shells with the generic characteristics of *Redmondina*, somewhat larger than the type species. 12–14 inflated chambers are counted in the last adult whorl. The septal sutures are sunk without revealing the enlarged intraseptal interloocular space below that reaches from the ventral to the dorsal cameral suture with single orifices on both sides. The equatorial to axial diameter ratio for adult shells varies from 1.5 to 1.7.

Extending over the shell apex, the dorsal umbo is scarcely perforated but distinctly inflated. It may be composed of a certain number of dorsal piles grouped closely around the shell apex. Umbilical filling reduced to few, free umbilical piles standing on the foliar walls that fuse around the shell axis with one another without showing on the shell face any central plug. Proloculus diameter is about 0.04 mm.

Remarks: *Redmondina garganica* n. sp. is distinguished from *R. henningtoni* by the higher number of chambers in the last whorl, by a reduced size of the dorsal umbo and by a widening of the intraseptal interloocular space over the whole septum from ventral to dorsal.

Plate 4.1 (Continued) (11–13) Sections parallel to coiling axis. (14–16) Sections perpendicular to coiling axis; note imperforate foliar walls and the absence of axial umbilical piles or plugs. (17) Oblique section inclined for more than 45° in respect to the coiling axis, associated with *Kathina aquitanica* n. sp. (K. a.) and *Miscellanea juliettae* Leppig, 1988 (M. j.). (18–19)

Oblique sections with a respective inclination for more or for less than 45°. 8–19 sections in cemented rock from Tena section sample Stop 2 in Robador et al. (1991). Abbreviations: *f* foramen, *up* umbilical plate, *p* pores, *foa* foliar aperture, *fol* folia, *s* septum, *co* canal orifice, *du* dorsal umbo, *ilsp* intraseptal interloocular space, *n* notch

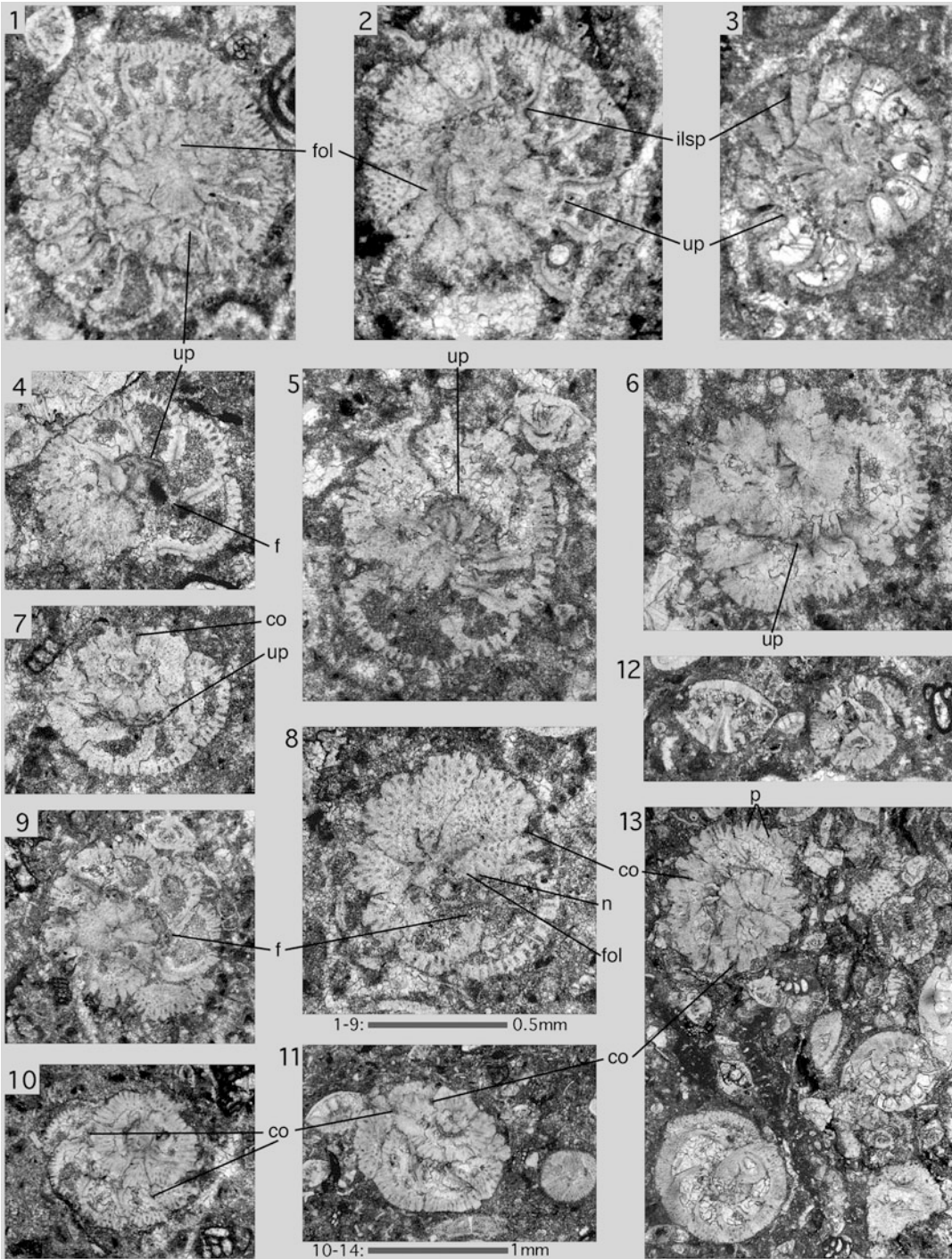


Plate 4.2 *Redmondina henningtoni* Hasson, 1985; sample All77232 collected by F. Allemann, Zhob valley, Baluchistan, western Pakistan; Paleocene (SBZ 4). (1–3) Sections perpendicular to the shell’s coiling axis. (4–5, 7–8) Oblique sections. (6) Oblique section showing the

umbilical plate at the base of a chamber in the last whorl. (9) Section perpendicular to coiling axis. (10–11) Oblique sections respectively inclined for about 60° and 40° against the coiling axis; note the comparatively large canal orifices at the intersection of the spiral whorl sutures

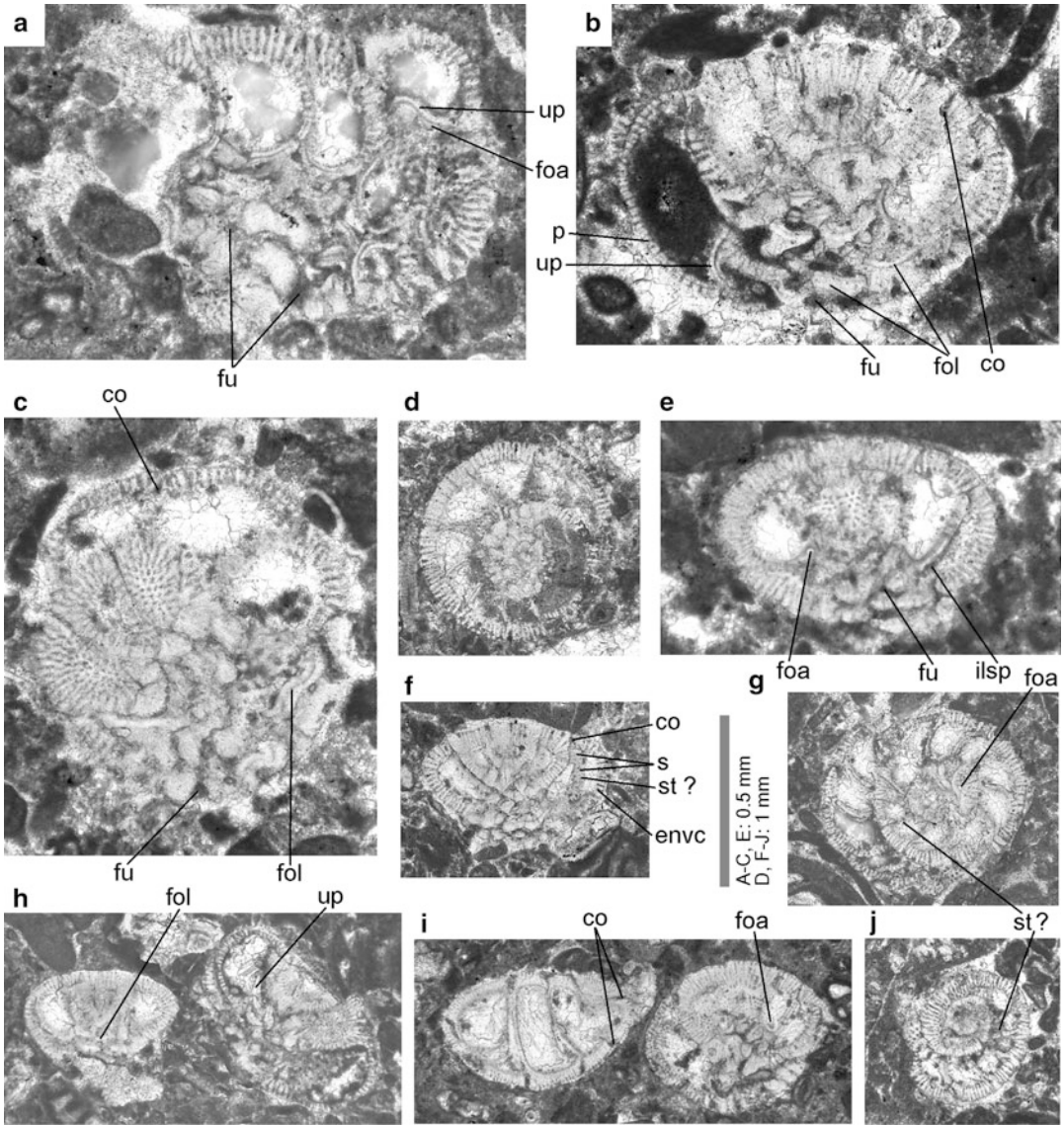


Fig. 4.1 *Redmondina garganica* n. sp.; sample Kar 13, collected by J. Braud, Kuh-e-Kargan, Kermanshah, Zagros, Iran. (A, C, E, H, I) Oblique sections with different inclination in respect to the shell's coiling axis. (B, F) Subaxial sections; note the poor development of the

apical umbo. (D, G, J) Sections perpendicular to the coiling axis. Abbreviations: *up* umbilical plate, *foa* foliar aperture, *p* pores, *fol* folia, *fu* funnel, *co* canal orifice, *ilsp* intraseptal interloccular space, *s* septum, *st?* suture?, *envc* enveloping canals

Plate 4.2 (Continued) with the more or less radial chamber sutures. (12) Oblique section (*left*) associated with a *Kathina delseota* Smout, 1954 (K. s.). (13) Oblique section inclined for about 30° in respect of the coiling axis

(*top*) and section perpendicular to the coiling axis (*bottom*). Abbreviations: *f* foramen, *up* umbilical plate, *p* pores, *fol* folia, *co* canal orifice, *ilsp* intraseptal interloccular space, *n* notch

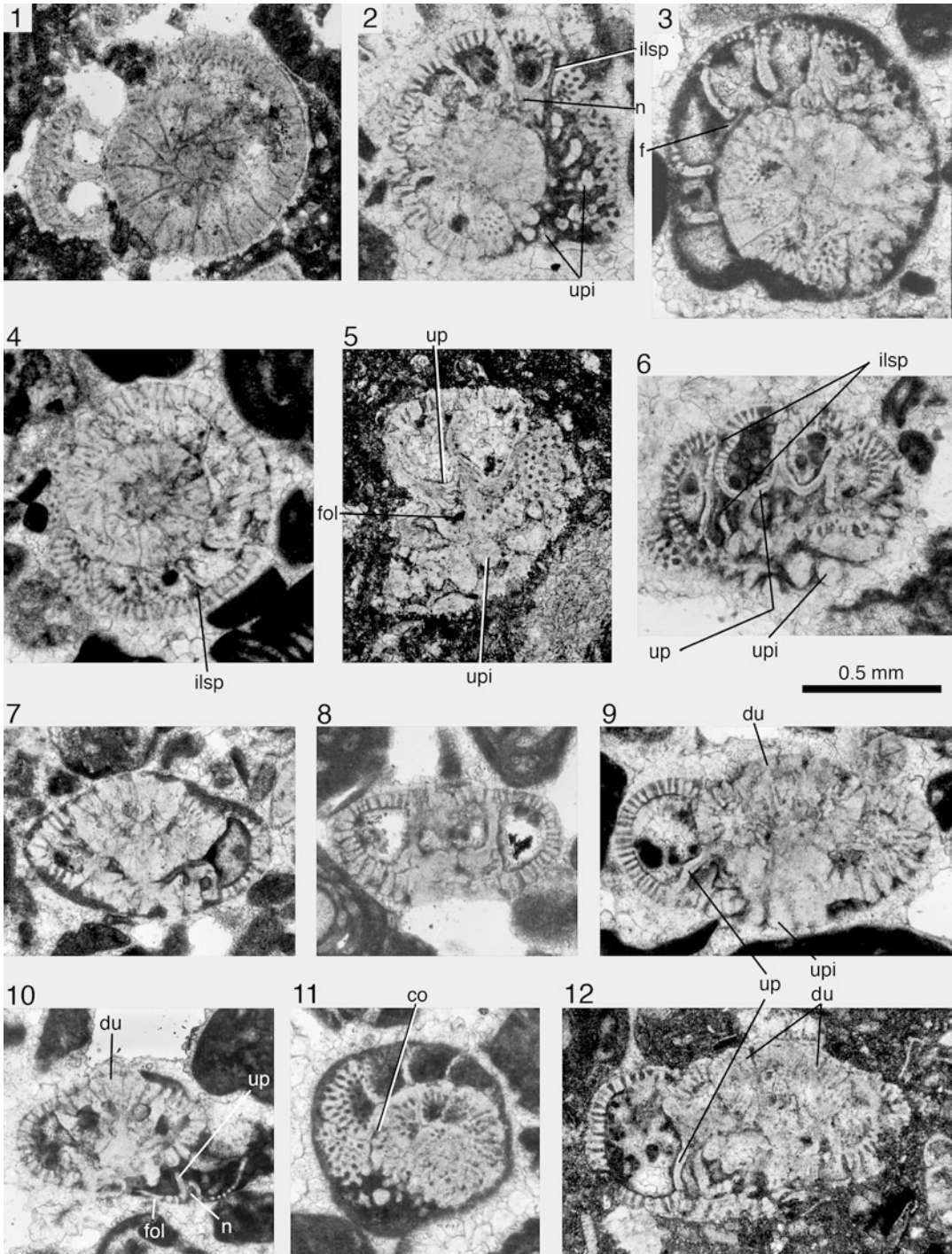


Plate 4.3 *Redmondina garganica* n. sp.; all from *Alveolina* limestone of Monte Gargano (south-eastern Italy), Early Eocene, Middle Cuisian (SBZ 11), collected by Piero De Castro and deposited in the collections of the Dipartimento di Scienze della Terra, University of Naples “Federico II”, Italy. (1–4) Sections perpendicular to coiling axis. (5–6) Oblique sections illustrating the

comparatively simple umbilical architecture. (7, 9–10, 12) Axial sections. (8, 11) Transversal sections parallel and perpendicular to the shell axis. Abbreviations: *f* foramen, *up* umbilical plate, *upi* umbilical piles, *du* dorsal umbo, *fol* folia, *co* canal orifice, *ilsp* intraseptal interlocular space, *n* notch

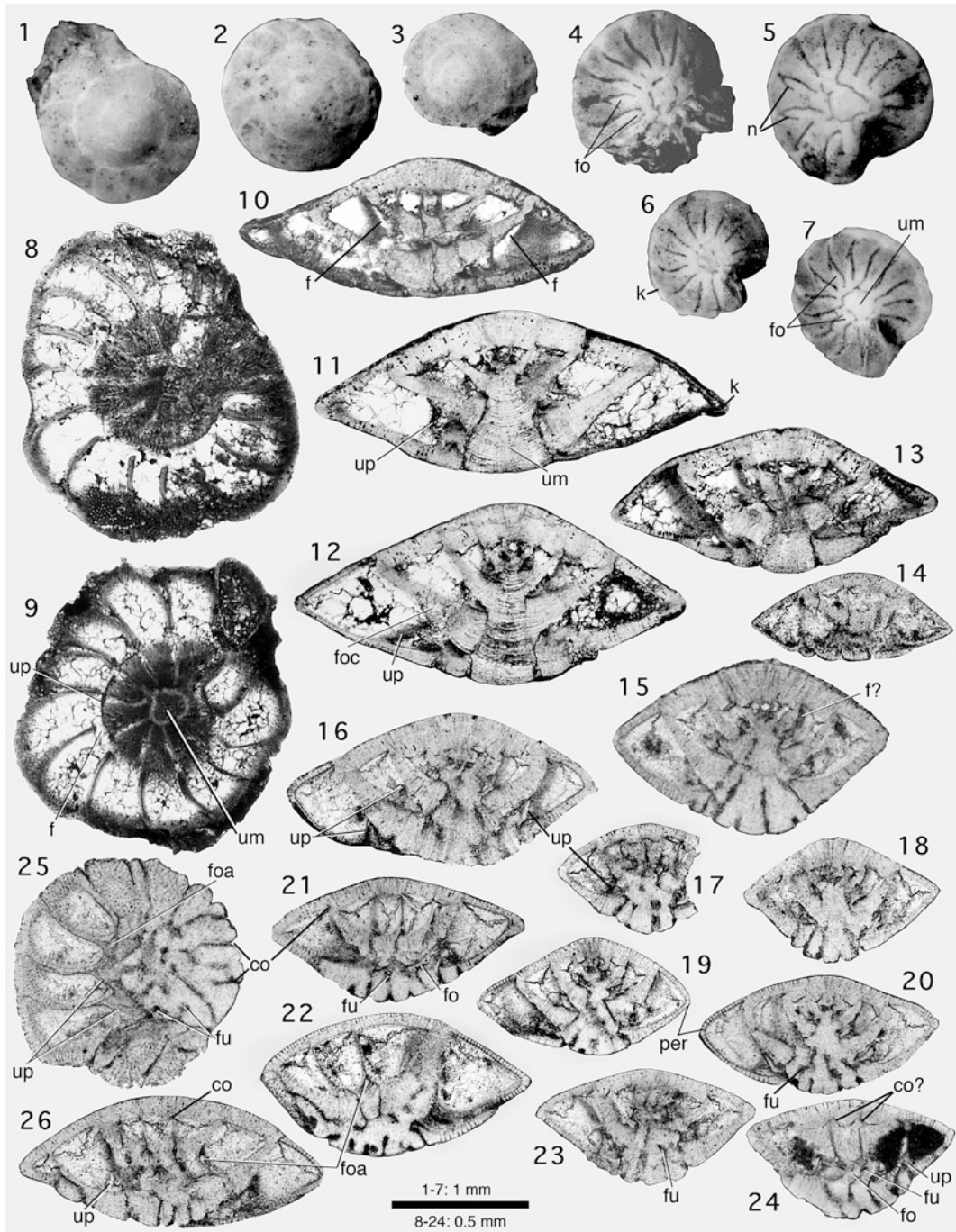


Plate 4.4 (1–14) *Kathina aquitana* n. sp.; isolated specimens from sample 6, Lafarge Quarry, Western Aquitaine, Southern France; Paleocene (SBZ 3). (1–3) Dorsal view. (4–7) Ventral views; note the simple, slit like openings of the intraseptal interloccular space and the few funnels encircling the undivided, massive umbo. (8–9) Sections perpendicular to the coiling axis. (11–14) Axial and adaxial sections. (15–26) *Slovenites praecursorius* n. sp.; specimens from Cuccuru 'e Flores Conglomerate, Orosei, Sardinia, collected by I. Dieni (see

Dieni et al. 1985), associated with *Orduella sphaerica* Sirel, 1998, *Miscellanites globularis* (Rahaghi, 1983) and *Cincoriola* cf. *ovoidea* (Haque, 1958); Paleocene (SBZ 2). (15) Centered axial section, syntype. Abbreviations: *f* foramen, *up* umbilical plate, *fu* funnel, *foa* foliar aperture, *fo* folium, *per* periphery, *co* canal orifice, *n* notch, *um* umbo, *k* keel, *foc* foliar chamber

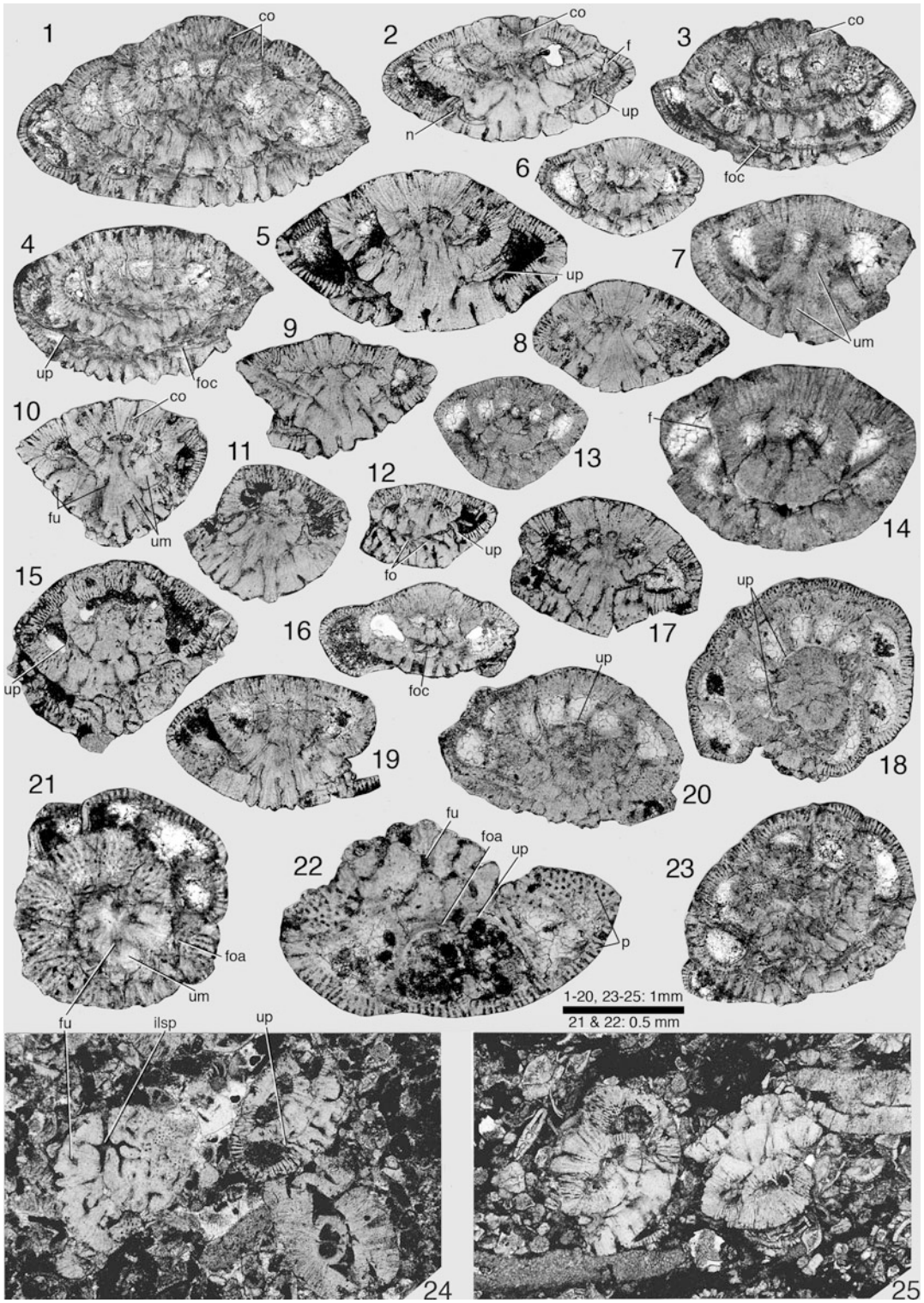


Plate 4.5 (1–25) *Slovenites pembaphis* n. sp.; from Sopada, Slovenia, Adriatic platforms, Paleocene (SBZ 3–SBZ 5). (1–5) Oblique sections. (6–10, 12–13, 16–17, 19, 24–25) Axial and adaxial sections. (11, 20, 21, 23)

4.2 *Slovenites* n. gen.

Type species: *Slovenites pembaphis* n. sp.

Diagnosis: The lenticular shells have a spiral chamber arrangement that is evolute on the dorsal side and involute on the ventral side. The lamellar chamber wall is particularly thick and perforated by very coarse pores. The folia are thick and perforate. They are inclined backwards and fused with their tips to the umbilical filling produced by previous whorls. This umbonal mass is composed of few, thick units separated by furrows in random directions (ilc in Fig. 1.2C). The foliar lumina are separated from the main chamber lumen by an umbilical plate similar to all Rotaliidae. Comparatively few funnels connect the interocular space from the junction of the intraseptal with the spiral canals to orifices in the umbilical furrows or at the umbilical surface of the shell. The intraseptal space is reduced to a canal running closely above the rim of the foramen for the entire extension of the interiomargin of the septal face. It opens in an orifice positioned at the proximal junction of whorl and chamber sutures on the dorsal side of the test. The position of this orifice is illustrated in Fig. 1.2C (dsc: dorsal sutural canal orifice).

Remarks: *Slovenites* n. gen. is closest to *Medocia* Parvati, 1971 by its similar, coarse funnels. It differs from *Medocia* by its much coarser perforation, its ornamented dorsal side of the shell with sutural canal orifices, and by its fissures in the umbilical mass where part of the funnels open onto the substrate of the shell. *Rotalia sensu stricto* has no funnels in its umbilical filling, nor has it dorsal sutural orifices of the canal system. However, the foliar

characteristics including the foliar apertures in *Slovenites* and *Rotalia* are so similar that we consider this new genus as a member of the Rotaliinae.

Slovenites is a conservative genus with a long range from Middle Paleocene (SBZ 2) to Lutetian (SBZ 13 at least). The earliest species, *S. praecursorius*, from SBZ 2 has been found in Sardinia. *Slovenites pembaphis* is widespread on the Adriatic platform in SBZ 4 and 5. *Slovenites decastroi* is present at several levels of the Monte Gargano Peninsula and of the Adriatic platform with alveolinids from SBZ 11–13.

Slovenites praecursorius n. sp.; Plate 4.4, Figs. 15–26.

Syntypes: Axial section figured in Plate 4.4, Fig. 15 and section almost perpendicular to the coiling axis figured in Plate 4.4, Fig. 25.

Type locality and type level: From sample F 4a, Sardinia, see Dieni et al. (1985); Paleocene (SBZ 2).

Derivation of name: precursor species of a genus discovered first in Slovenia.

Diagnosis: The shells are lenticular, equally convex on both sides, composed of three to four whorls of low-trochospiral chambers. The ratio equatorial to axial diameter oscillates between 1.3 and 2.0. The periphery is angular, lacking any keel and marked by a looser disposition of the pores. The cameral septa are curved backwards on their dorsal side, radial on their ventral side. They are flush on the dorsal side of the shell but marked by a deep interocular fissure on the ventral side. An adult whorl has about 12 chambers. The folia have thick, perforate walls and fuse their proximal tips with the umbilical mass produced by previous whorls. At the

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Plate 4.5 (Continued) Oblique sections inclined for more than 45° in respect to the coiling axis. (14–15) Oblique sections inclined for less than 45° in respect to the coiling axis. (18, 21) Section perpendicular to the coiling axis. (22, 24) (left) Tangential sections to the

ventral surface of the cone exhibiting the intraseptal interocular space. Abbreviations: *f* foramen, *up* umbilical plate, *um* umbo, *fo* foliar chamber, *foa* foliar aperture, *fu* funnel, *co* canal orifice, *n* notch, *fo* folium, *p* pores, *ilsp* intraseptal interocular space

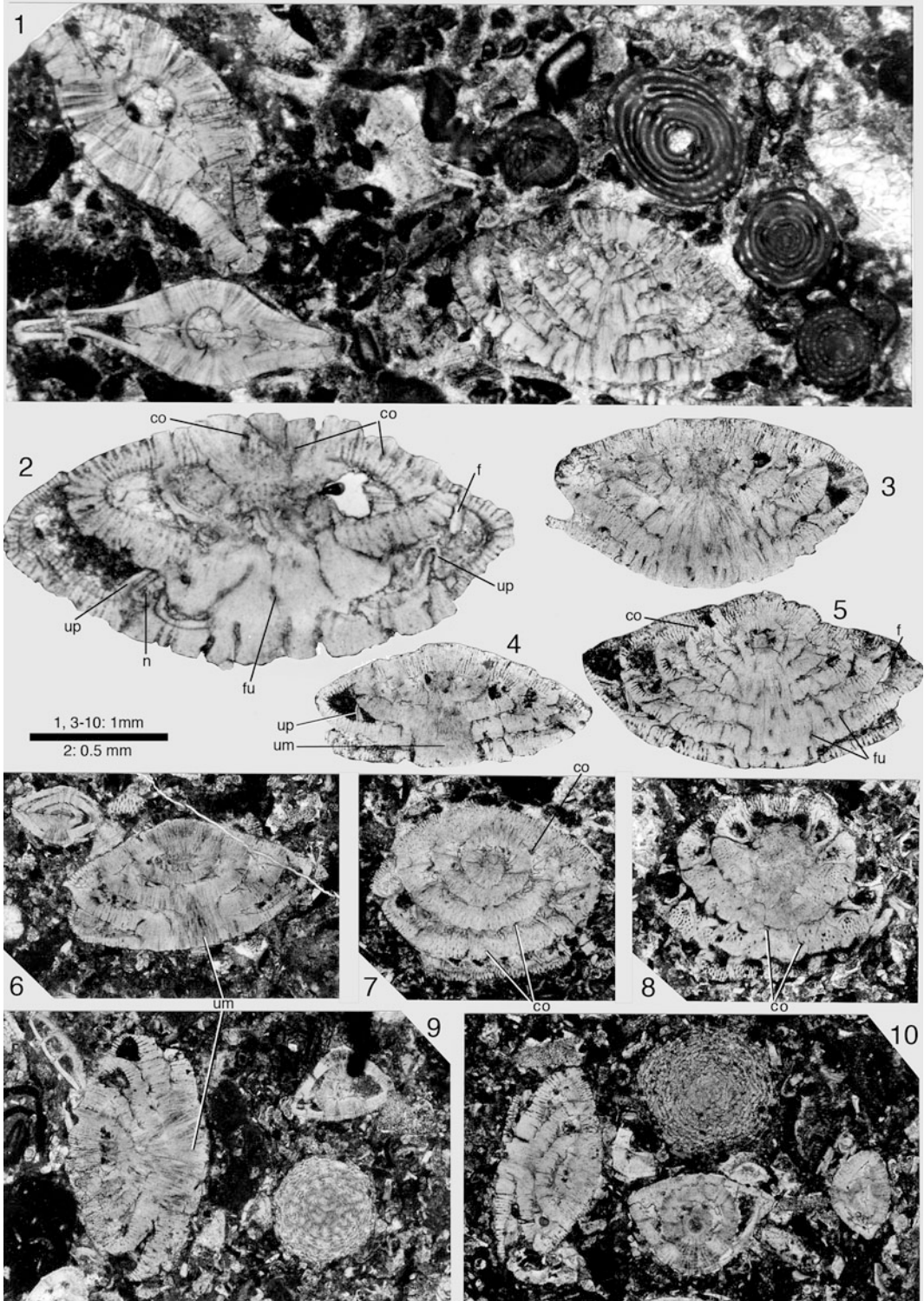


Plate 4.6 (1–2) *Slovenites pembaphis* n. sp.; from Sopada, Slovenia, Adriatic platforms, Paleocene (SBZ 3–5). (1) Holotype, megalospheric specimen axial section. (2) Axial uncentered section associated

junction of the intraseptal space with the umbilical interocular space and in some places in the sutures of neighboring folia, wide open funnels are generated that seem to distribute their orifices at random over the ventral surface of the umbilical fill. The foramen is a very low, slit-like arch in interiomarginal position followed in ventral direction by a small, low umbilical plate.

Remarks: All known specimens of his taxon are from cemented carbonate rock. Their morphology can be defined only in thin sections. The minimum number of sections that permit to support a morphological definition of the taxon is two. These sections must be perpendicular to each other, one of them centered. Therefore, two syntypes are selected from the restricted material at our disposal.

Slovenites pembaphis n. sp.; Plate 4.5, Figs. 1–25; Plate 4.6, Figs. 1–2.

1969 *Lockhartia tipperi* (Davies, 1926)—

Butterlin and Monod, p. 586, pl. 1, fig. 7.

1998 ?*Kathina* sp.—Accordi et al., p. 202, pl. 17, fig. 5.

Holotype: Megalospheric specimen figured in Plate 4.6, Fig. 1.

Type locality and type level: Sopada, Slovenia, Adriatic platforms, Paleocene (SBZ 3–SBZ 5).

Derivation of name: *Slovenites*, first discovery in Slovenia; *pembaphis*, Greek allusion to swelling walls and coarse pores like the state of a corpse floating for some time in the water.

Diagnosis: Lenticular shells composed of about four whorls of spiral chambers with thick, coarsely perforate walls. The lens is equally convex on both sides, reaching an equatorial

diameter of 2.5 mm. The ratio of equatorial to axial diameter of the lens varies from 1.65 to 1.85. There are 10–12 slightly inflated chambers in an adult whorl. The umbilical architecture is described in the definition of the genus *Slovenites* above. The proloculus is small, reaching 0.08 mm in diameter. No dimorphism has been observed so far.

Slovenites decastroii n. sp.; Plate 4.6, Figs. 3–10; Plate 4.7, Figs. 1–12.

Holotype: Megalospheric specimen figured in Plate 4.6, Fig. 5.

Type locality and type level: Monte Gargano, Italy, samples A 4340, A 4344, collected by P. De Castro; Cuisian (SBZ 11–12) by association with alveolinids.

Derivation of name: in honour of Piero De Castro (Naples) and his work on the Monte Gargano.

Diagnosis: The lenticular shells are composed of five to six whorls of low-trochospiral chambers that are dorsally evolute and ventrally involute, with a wide umbilicus filled by thick foliar walls that are fused to a solid mass. The lens is almost equally convex (index 1.9–2.2); the ventral side however may be flattened in the center of the umbilicus. The lenticular shells reach an equatorial diameter of about 1.8 mm, with 20 dorsally isometric chambers in the adult last whorl. The megalosphere reaches a diameter of 0.12 mm at most. No dimorphism has been observed so far.

Remarks: *Slovenites decastroii* is distinguished from *S. pembaphis* by its larger number of spiral chambers that are arranged in a spiral with more whorls. The differences in the umbilical architecture all are due to the higher

← **Plate 4.6** (Continued) with *Ranikothalia* sp., *Lacazinella* sp. and alveolinids. (3–10) *Slovenites decastroii* n. sp.; Specimens from Bencovac, Croatia, associated with nummulitids and alveolinids, Cuisian (SBZ 11–12). (3, 5) Axial uncentered sections. (4, 6) Axial sections showing axial umbilical plug with few or

without funnels. (7–8) Oblique sections inclined for more than 45° in respect to the coiling axis. (9) Axial slightly off center. (10) Oblique section inclined for about 45° in respect to the coiling axis. Abbreviations: *f* foramen, *up* umbilical plate, *fu* funnel, *co* canal orifice, *n* notch

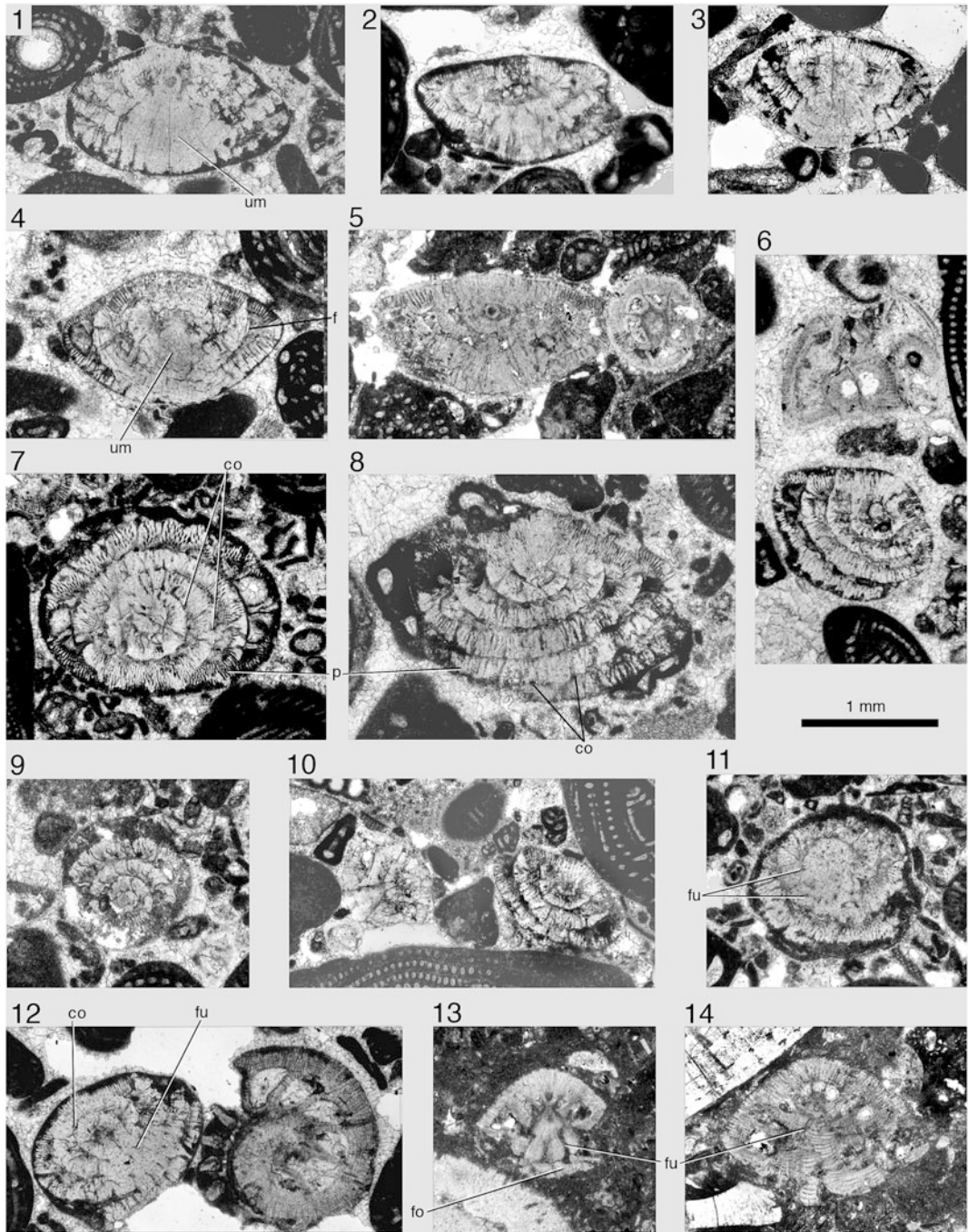


Plate 4.7 (1–12) *Slovenites decastroi* n. sp.; all specimens from Monte Gargano (Italy), samples A 4340-A 4344, collected by Piero De Castro; Cuisian (SBZ 11–11) by association with alveolinids. (1) Axial section. (2–5) Oblique sections with inclinations by far less than 45° in respect to the coiling axis. (6–8) Oblique sections inclined for much more than 45° , associated in 6 (top) to (G. m.) *Gyroidinella magna* Le Calvez, 1949. (9) Centered section perpendicular to the coiling axis.

(10–12) Oblique sections with various inclinations associated in 10 with Cuisian alveolinids and in 12 with *Gyroidinella* sp. (13–14) *Medocia* sp. (13) Oblique section inclined at the same angle as the cone mantel defining the umbilical fill with fused foliar tips (compare with Hottinger 2007, pl. 12, fig. 4 and pl. 13, fig. 4). (14) Axial section. Abbreviations: *f* foramen, *um* umbo, *fu* funnel, *co* canal orifice, *p* pores, *fo* folium

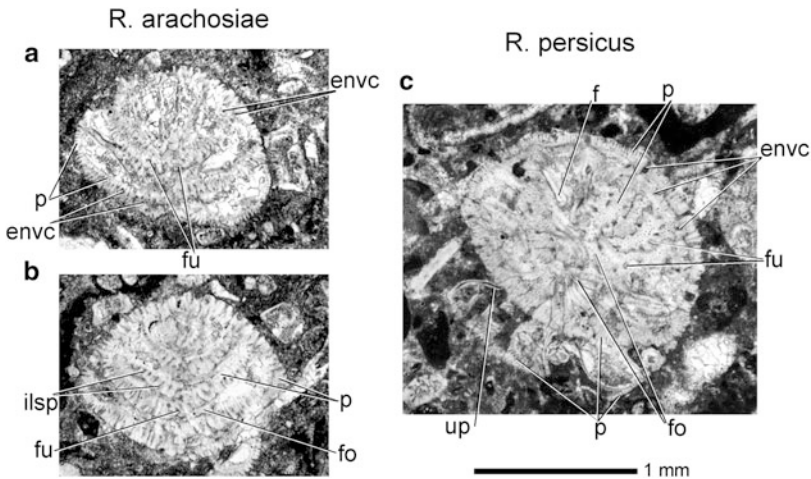


Fig. 4.2 *Rotaliconus arachosiae* n. sp. (A) and (B) compared to *R. persicus* Hottinger, 2007 (C) in oblique sections with similar inclination in respect to the shell's coiling axis. Note the much denser primary subdivision of the intraseptal interloccular space (envc) in *R. arachosiae* that gives access to a ventral enveloping canal system whereas in *R. persicus* the much coarser primary

subdivision of the intraseptal interloccular space produces only a corresponding row of funnels. (A) and (B) from Zhob valley, Baluchistan, Pakistan, Paleocene (SBZ 4); (C) from Shiraz, Iran, SBZ 17 or 18, late Bartonian (Hottinger 2007). Abbreviations: *f* foramen, *p* pores, *fu* funnels, *fo* folium, *up* umbilical plate, *ilsp* intraseptal interloccular space, *envc* enveloping canals

number of whorls and spiral chambers: the number of funnels increases with the number of septa in the adult whorls while the very first, small sized nepionic whorls do not develop any funnels and keep therefore the center of the umbilicus free of these structural elements.

Pakistan; Late Paleocene (SBZ 4), dated by association with “*Orbitolina*” *daviesi* Hofker jun., 1966.

4.3 *Rotaliconus* Hottinger, 2007

Type species: *Rotaliconus persicus* Hottinger, 2007

Rotaliconus arachosiae n. sp.; Fig. 4.2A–B; Plate 4.8, Figs. 1–11, 14–15.

Syntypes: Specimen figured in Plate 4.8, Figs. 1, 4. *Rotaliconus arachosiae* is known only from cemented rock of SBZ 4 (Late Paleocene) in Pakistan. Since there are only thin-sections available, syntypes have to be designated to fix the main diagnostic morphological elements.

Type locality and type level: All77232 and 77233, Zhob valley, Baluchistan, western

Derivation of name: Arachosia, classical name of the country West of the Indus in times of Persian dominance (500 a. s.), corresponding today to the western Pakistani border provinces.

Diagnosis: High-conical shells with a subspherical outline produced by a rounded apex and a round periphery. The cone base is slightly flattened. The chamber walls are thick and coarsely perforate. In sections perpendicular to the wall surface, they seem to be ornate by numerous pustules, each carrying many pores. The “pustules” are intersections of the perforate shell between the enveloping canals covering the free chamber walls. The foramen corresponds to a very narrow slit (Plate 4.8, Fig. 1) in interiomarginal position placed on the dorsal angle of the septal face. The intraseptal interloccular space is widely open and undivided. The enveloping canals appear only below the surface

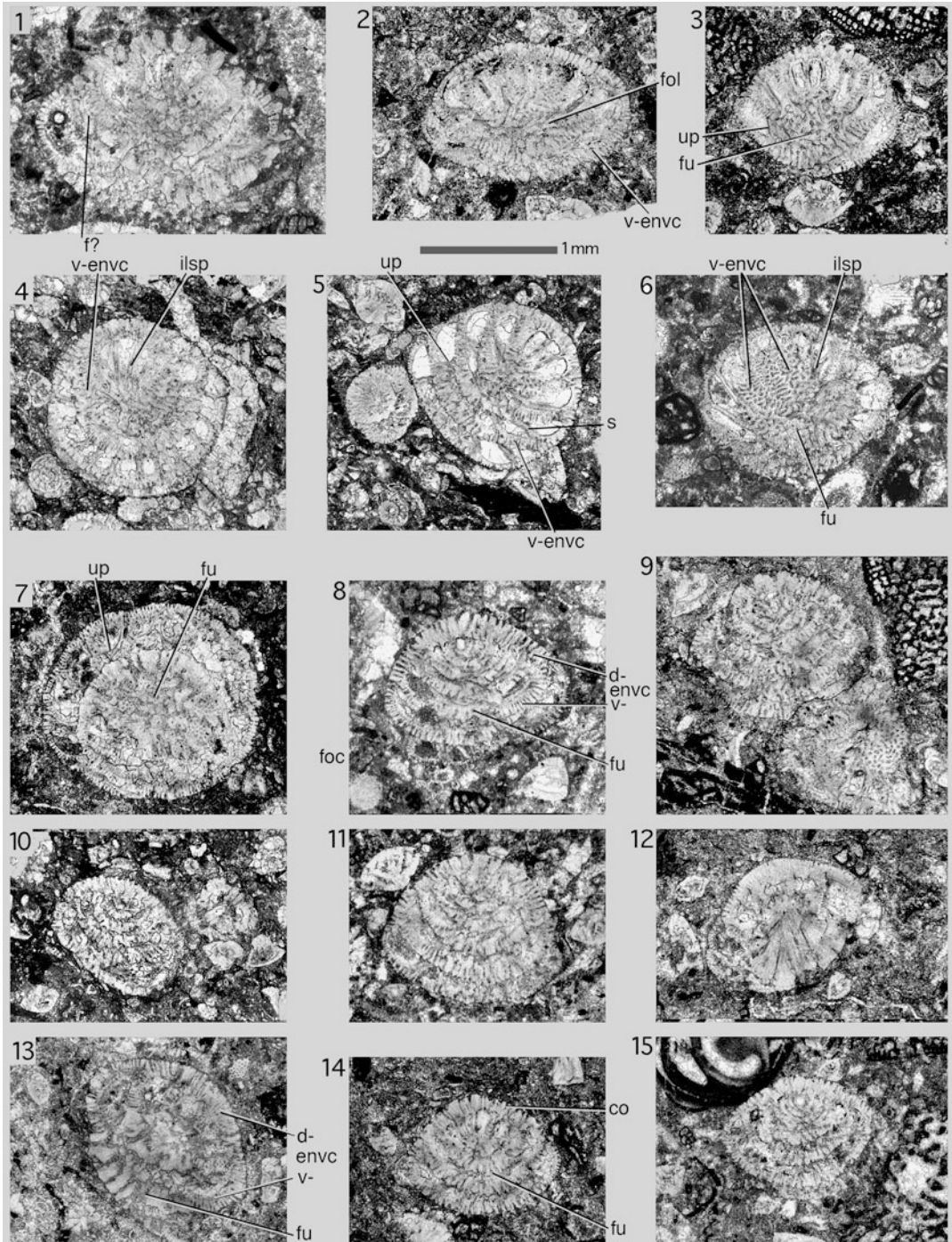


Plate 4.8 (1–11, 14–15) *Rotaliconus arachosiae* n. sp. (1) Oblique section inclined for about 20° in respect to the shell's coiling axis, syntype; note the ornamental dorsal pustules with their regular, dense perforation. (2) Oblique section inclined for about 35°. Note in the ventral part of the section the minute imperforate folia. (3) Oblique

section inclined for about 35°; note the umbilical plate and the funnels communicating with each other by a network of fissures. (4) Syntype, section perpendicular to the coiling axis showing the ventral intraseptal interlocomental space subdivided in a row of canals that give rise to an enveloping canal system invading all the

of the chambers, whereas the interocular space is bridged by numerous ponticuli. The folia are radial, short and loosely fuse at their tips to an umbilical mass that admits some funnels placed over the sutures of neighboring folia. Over the septal sutures of the main chambers the interocular space is subdivided and transformed into a ventral enveloping canal system that is denser than on the dorsal side (Plate 4.8, Fig. 6).

The equatorial to axial diameter ratio is 1.0–1.5. There are 16–18 spiral chambers in the last whorl. The nepiont exhibits 9–10 chambers per whorl following a proloculus of 0.08 mm in diameter. No dimorphism of generations has been observed.

Remarks: *Rotaliconus persicus* Hottinger, 2007 from the late Lutetian-Bartonian of Iran has an outline of the shell and a habit of the umbilical architecture that is similar to the ones observed in *Rotaliconus arachosiae* from the Late Paleocene. *R. persicus* (Fig. 4.2C) is distinguished from *R. arachosiae* by the absence of a ventral canal system that envelops the main spiral chamber walls. There is only a single row of orifices for communication of the interocular space in the septa with the ambient environment in front of the shell's face.

4.4 *Pachyrotalia* n. gen.

Type species: *Pachyrotalia massa* n. sp.

Remarks: The test is coarsely perforated and has very thick walls. The trochospiral

arrangement of the chambers throughout does not impede the subglobular shape of the shell.

***Pachyrotalia massa* n. sp.;** Plate 4.8, Figs. 12–13; Plate 4.9, Figs. 1–15.

1998 unidentified rotaliid—Accordi et al., p. 182, pl. 7, fig. c.

Syntypes: Specimens illustrated in Plate 4.9, Figs. 1–2 (top left), 4.

Type locality and type level: Sample All77232 collected by F. Allemann; Zhob valley, Baluchistan, western Pakistan; Paleocene (SBZ 4).

Derivation of name: *Pachyrotalia* for thick (walled) *Rotalia*, *massa* for heavy, massive umbilical plugs.

Diagnosis: Trochospiral shells with a subglobular outline (equatorial to axial diameter ratio is 1.1–1.3). The walls are very thick and perforate. The outer shell surface exposed to the ambient environment exhibits a loose meshwork of enveloping canals. Their radial parts interrupt the much finer, regular perforation of the walls. The periphery is rounded or slightly angular, always without any keeled marks. The narrow umbilicus is filled with a very massive, composed umbilical plug composed of several piles. Their separate origin is marked by funnels or fissures. The umbilical architecture is limited to a narrow space around the axial umbilical plug showing minute and thin folia covering a foliar chamberlet by small umbilical plates. The intraseptal interocular space is comparatively wide and undivided, giving rise to the enveloping canal system on the abaxial, ventral as well as on the

Plate 4.8 (Continued) free surfaces of the shell and in particular also the base of the cone, the shell's face. (5) Oblique section inclined for about 45°, associated with *Kathina selveri* Smout, 1954 (left). (6) Syntype, section tangential to the ventral surface of the shell cone exhibiting the intraseptal interocular space transformed into a ventral enveloping network of canals. (7) Section perpendicular to the coiling axis; note the oblique pathway of the umbilical plate and the network of communications between neighboring funnels. (8) Nearly axial, centered section showing the dense enveloping canal system on both sides of the shell; note the size of the proloculus. (9) Oblique section with an inclination of

about 35°, associated with "*Orbitolina*" *douvillei* J. Hofker jun., 1966. (10) Oblique section inclined for about 60°. (11) Oblique section inclined for about 30°. (14–15) Centered oblique sections inclined for about 45°. (12–13) *Medocia* n. sp. (12–13) adaxial and oblique sections. All specimens on this plate from the samples All77232 and All77233, Zhob Valley, Baluchistan, western Pakistan, collected by F. Allemann; Paleocene (SBZ 4). Abbreviations: *f* foramen, *v-envc* ventral enveloping canals, *d-envc* dorsal enveloping canals, *up* umbilical plate, *ilsp* intraseptal interocular space, *fu*, funnel, *s* septum, *co* canal orifice, *fol* folia, *fo*c foliar chamber

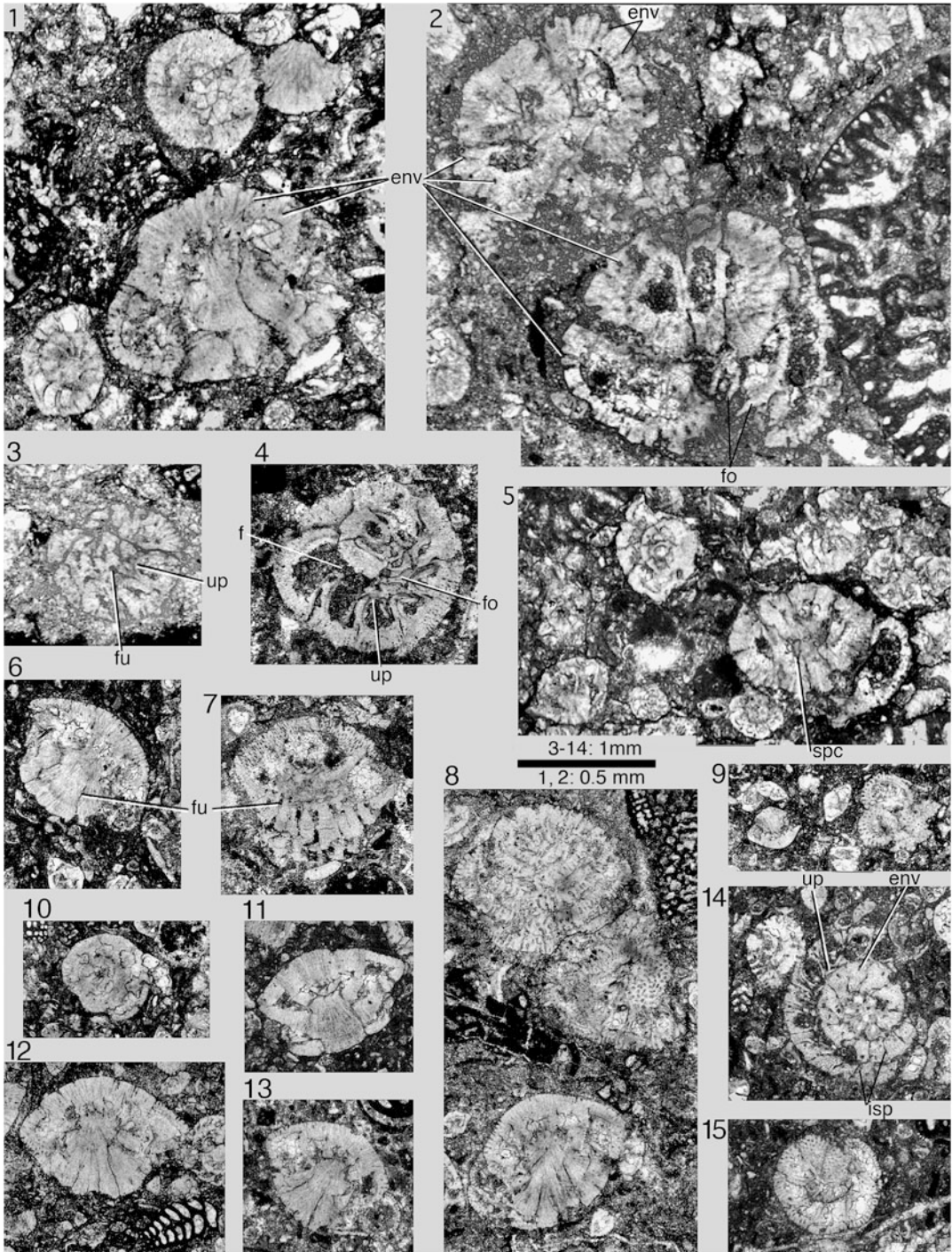


Plate 4.9 *Pachyrotalia massa* n. sp.; sample All77232, collected by F. Allemann; western Pakistan, Paleocene (SBZ 4). (1) Syntype, axial section slightly off center showing the massive umbilical plug. (2) Section parallel to the shell's coiling axis (*upper left*, syntype) and oblique section (*bottom center*); both sections are out of reach from the adaxial umbilical plug; note the enveloping

canal system and the tiny foliar walls; associated with "*Orbitolina*" *daviesi* J. Hofker jun., 1966 (*right*). (3, 5, 9–10) Oblique sections. (4, 14–15) Sections perpendicular to coiling axis. (6–8, 11–13) Axial sections. Abbreviations: *f* foramen, *env* enveloping canals, *up* umbilical plate, *fu* funnel, *spc* spiral canal, *fo* folium, *isp* intra-septal space

dorsal side of the shell. A single centered section (Plate 4.9, Fig. 4) reveals a megalosphere of 0.08 mm. At an early equatorial diameter of about 0.8 mm, the shell has 8 chambers per whorl.

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