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Structural Analysis and Taxonomic Revision of Miscellanea, Paleocene, Larger Foraminifera

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ABSTRACT

Miscellanea, a perforated planispiral involute larger foraminiferal genus of Middle to Upper Paleocene age is characterized by a single intercameral foramen and a canal system. Intraseptal canals generate sutural canals tending to envelop the lateral chamber walls (compare "enveloping canal system" in *Calcarina* and *Pellatispira*). The sutural canals have an almost radial direction in the equatorial region of the shell caused by the strong backward bent of the septum. A symmetric pair of spiral canals and vertical umbilical canals are present. *Miscellanea* lacks a "marginal cord", common for all nummulitids. Therefore, *Miscellanea* is excluded from the family Nummulitidae and is regrouped together with *Cuvillierina*, *Fissoelphidium*, *Laffitteina* and *Thalmannita* in the revalidated family Miscellaneidae SIGAL. Three new species of Lower Middle Paleocene age are present in the Pyrenean Basin and in northwestern Yugoslavia. Two species of possibly Middle Paleocene age were found in southern Yugoslavia. The generotype *M. miscella* of Upper Paleocene age which does not occur in Europe, is described from Iran and from Pakistan.

ZUSAMMENFASSUNG

Miscellanea, Grossforaminiferenform aus dem Mittel- bis Oberpaleozän, besitzt eine perforierte Schale mit planspiral involuter Kammeranordnung, deren einzelne Kammern durch ein basal gelegenes Foramen untereinander in Verbindung stehen. Das Kanalsystem setzt sich zusammen aus Intraseptalkanälen, von denen Suturalkanäle zur Schalenoberfläche abzweigen mit der Tendenz, die laterale Kammerwand zu umwachsen (vgl. «enveloping canal system» bei *Calcarina* und *Pellatispira*). Durch die extreme Konvexität der Septen verlaufen die Suturalkanäle im Äquatorbereich der Schale in radialer Richtung. Weitere Elemente des Kanalsystems sind zwei symmetrische Spiralkanäle und vertikale Umbilikalkanäle. Da *Miscellanea* keinen Dorsalstrang («marginal cord») besitzt, wie er für alle Nummulitiden charakteristisch ist, wird diese Gattung aus der Familie Nummulitidae ausgeschlossen. Sie wird zusammen mit *Cuvillierina*, *Fissoelphidium*, *Laffitteina* und *Thalmannita* in die 1952 von SIGAL aufgestellte, von LOEBLICH & TAPPAN 1964 wieder verworfene Familie Miscellaneidae eingeordnet. Das zur Verfügung stehende Material lieferte drei neue Arten aus den Unteren Mittelpaleozän des Pyrenäen-Beckens und Nordwestjugoslawiens. Zwei Arten aus dem Mittelpaleozän(?) wurden in Südjugoslawien gefunden. Aus dem Oberpaleozän des Iran und Pakistans wird der Generotyp *M. miscella* beschrieben, der aus Europa bisher nicht bekannt ist.

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1. Introduction

The perforate Rotaliacean *Miscellanea* is a widespread genus occurring all over the Tethyan area from Spain to the Far East in deposits of Middle to Upper Paleocene age. The few species belonging to this genus were incompletely described and their range in the framework of biostratigraphic zonation is not clear. Often, the description of the lithology and its succession in the type locality of the species is inadequate. The following species names are in use today: *M. miscella, M. stampi* (DAVIES 1927; SMOUT 1954), *M. meandrina* (SIREL 1975), *M. globularis* (RAHAGHI 1978), *M. primitiva, M. minuta, M. iranica* (RAHAGHI 1983). All miscellaneas so far known from Europe, have been mentioned in the literature as *Miscellanea* sp. In order to use the *Miscellanea* species as a biostratigraphic tool during Middle and Upper Paleocene, a taxonomic revision of this genus, based on zonal correlation of the species' type locality, has become necessary. A complete structural analysis of the miscellaneid shell is a prerequisite for the revision of the genus.

What are the patterns in the architecture of the shell; which structural elements are delimiting the spaces forming the canal system and how is the miscellaneid pattern of canals to be distinguished from the nummulitid pattern of a "marginal cord" and a siderolitid or calcarinid pattern with "enveloping canal systems"? The inadequacy of the structural analyses carried out up today is responsible for the changing conception of higher taxonomic units in the canaliferous larger foraminifera.

SIGAL (1952 in PIVETEAU) established the family Miscellaneidae and the subfamily Miscellaneinae including the genera *Miscellanea, Sulcoperculina* and *Laffitteina*. Because of the absence of a marginal cord he separated this group from the Nummulitidae.

REISS (1958) united *Miscellanea* with *Sulcoperculina, Daviesina, Pellatispira, Storrsella, Arnaudiella, Biplanispira* and *Pseudosiderolites* within the subfamily Miscellaneinae. His classification is based on chamber arrangement, on apertural character and on presence or absence of lateral chamberlets and alar prolongations.

In the "Treatise on Invertebrate Paleontology" (LOEBLICH & TAPPAN 1964) the family Miscellaneidae was suppressed. Most of the planispiral genera with a single intercameral foramen including *Miscellanea* were regrouped in the Nummulitidae despite of the absence of a marginal cord. Thus, in this classification, chamber arrangement and foraminal character have higher ranks than canal system patterns. Within the Nummulitidae, presence or absence of a subdivision of the main chambers are the distinctive features of the two subfamilies Nummulitinae and Cycloclypeinae (COLE in LOEBLICH & TAPPAN 1964). This does not seem practicable as the subfamily limit would divide even particular species of different ages such as *Planoperculina complanata* or *Operculina gomezi* (see HOTTINGER 1977) belonging to different phyletic lineages. The generic diagnoses are too generalized to distinguish the genera commonly in use. In their preliminary note (1984) for a new classification of foraminiferal genera, still in preparation, they reestablish the subfamily Miscellaneinae SIGAL within the family Rotaliidae. *Cuvillierina* is accommodated in an own subfamily.

Since most of these classifications were proposed, the anatomical knowledge has improved. In rotaliid foraminifera, HANSEN & REISS (1971) and MÜLLER-MERZ (1980) recognized the primary or secondary closing of a chamber against the umbilicus as well as the elements themselves in the umbilicus as important characteristics of high rank.

Structural analysis of operculinid foraminifera (HOTTINGER 1977), of Calcarinidae (HOTTINGER & LEUTENEGGER 1980), of Siderolitinae (WANNIER 1980) and of *Daviesina* (CAUS, HOTTINGER & TAMBAREAU 1980) point out the differences in the particular geometry of the canal system in the different groups of canaliferous foraminifera with planispiral chamber arrangement. The patterns recognized differ in most cases from one traditional genus to the other. Therefore, they are used for emended generic diagnoses. The revision of *Miscellanea*, of its species and at generic level, is a prerequisite to use this genus as type for a revised family *Miscellaneidae* in modern systematics of canaliferous larger foraminifera.

2. Origin of the studied material

The studied material has yielded three new species of Lower Middle Paleocene age known so far from the Pyrenean Basin and from northwestern Yugoslavia. Samples from southern Yugoslavia contain two *Miscellanea* species described by RAHAGHI (1983) from different places in Iran. They probably are of Middle Paleocene age. The generotype *M. miscella* is present in samples from Iran and from Pakistan (Fig. 1). All figured specimens are deposited in the "Naturhistorisches Museum" Basel, Switzerland.

Miscellanea juliettae pfenderae n. ssp.
— Sierra de Cantabria, Montes Obarenes, northwestern Spain, 12 sections (Fig. 2, 3)

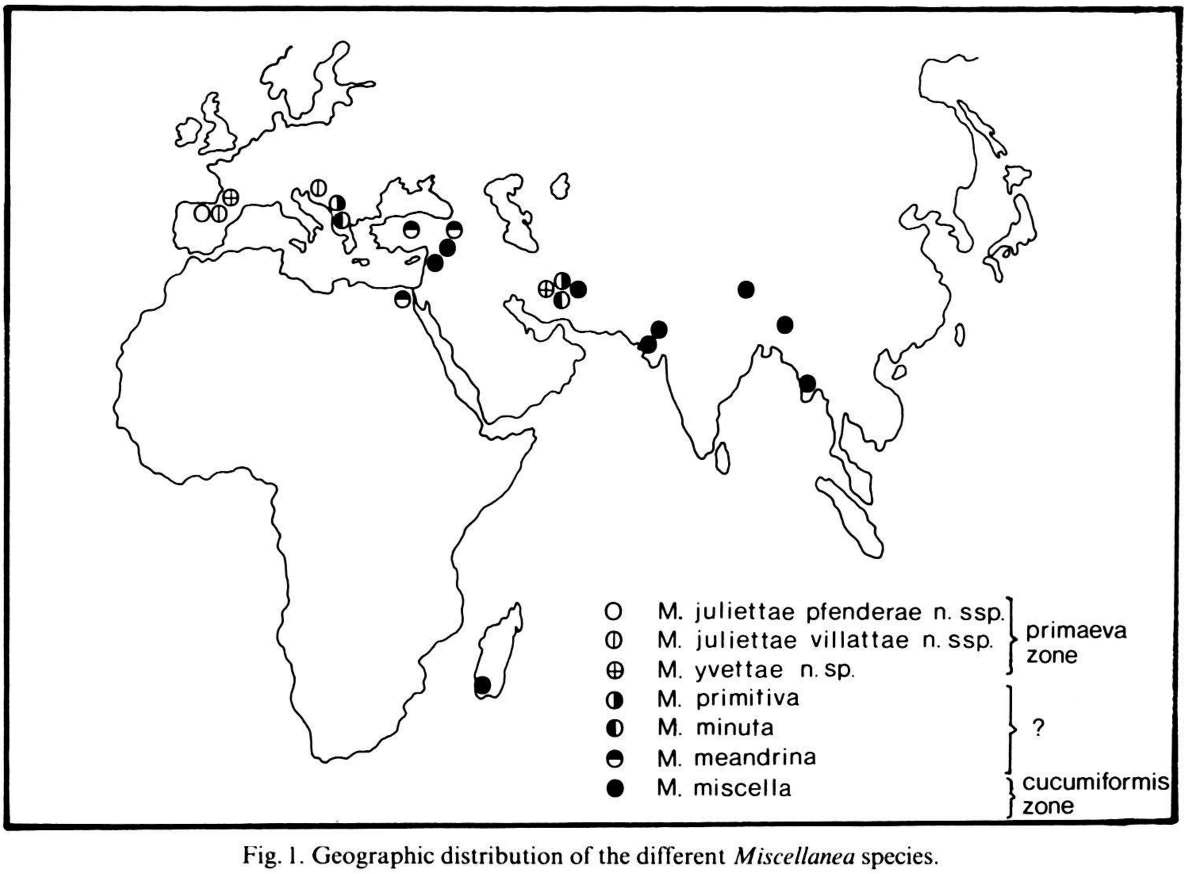


Fig. 1. Geographic distribution of the different *Miscellanea* species.

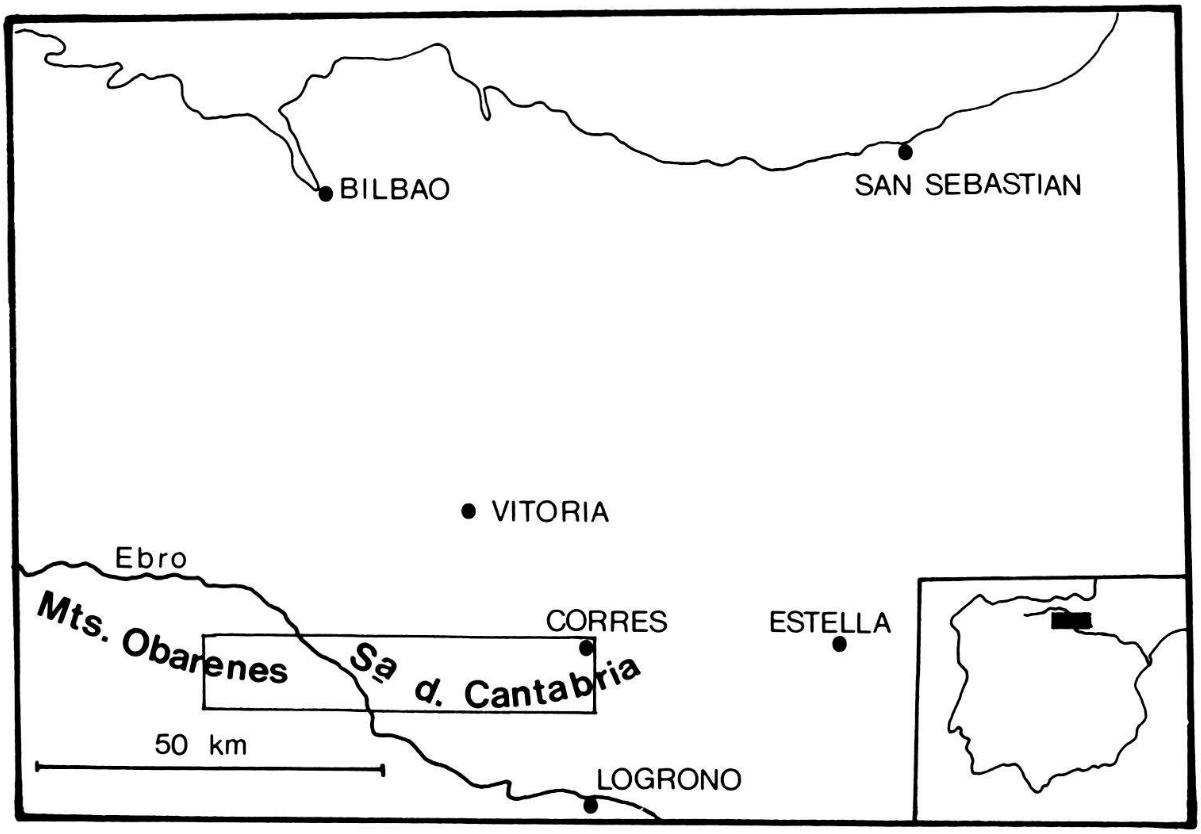


Fig. 2. General location map of the Sierra de Cantabria and the Montes Obarenes in northwestern Spain.

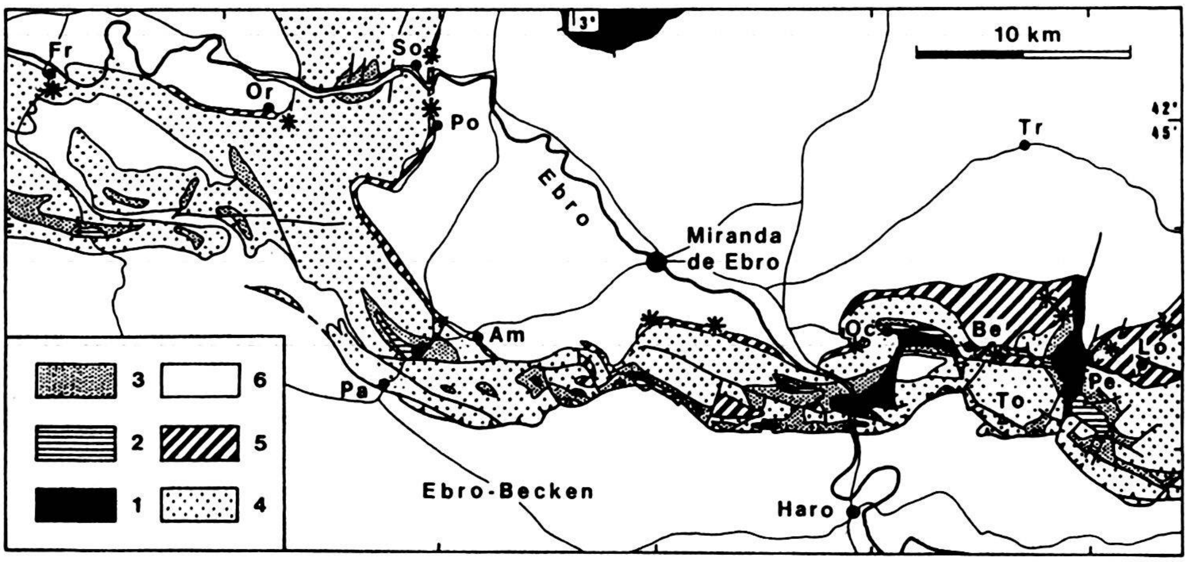


Fig. 3. Geological map of the studied area based on "Mapas Geologicos de España", IGME 1:50,000 and on several MSc students mapping of the Geological Institute, Freiburg i. Br. (drafting E. Funk).
Am = Ameyugo, Be = Berganzo, Fr = Frias, Lo = Loza, Oc = Ocio, Or = Orbañanos, Pa = Pancorba, Pe = Peñacerrada, Po = Portilla, So = Sobron, To = Toloño, Tr = Treviño. – 1: Keuper, 2: Jurassic, 3: Lower Cretaceous, 4: Upper Cretaceous, 5: marine Lower Tertiary, 6: non-marine Tertiary. – *Location of studied sections.

Miscellanea juliettae villattae n. ssp.
— Northwest of the Sierra de Cantabria, near Corres, 1 section (Fig. 2)
— Dolenja vas, near Senožeče, Slovenia, northwestern Yugoslavia, samples 86004, 86006 (collection Drobne/Hottinger)

Miscellanea yvettae n. sp.
— Petites Pyrénées, East of Saint-Michel, southern France, sample 73933 (collection Hottinger)

Miscellanea miscella
— Kuh-E-Kargan, Kermanshah, Iran, samples Kar 3, (collection Braud)
— Ranikot Limestone, Dak Pass, Salt Range, Pakistan, long. 71°49′, lat. 32°40′
— Ranikot Limestone, Khairabad, Salt Range, Pakistan, long. 71°37′, lat. 32°53′
— Ranikot Limestone, Kala Chitta, Pakistan, long. 72°20′, lat. 33°40′
— Ranikot Shale, Fatehjang, Kala Chitta, Pakistan (collection Gill), long. 72°31′, lat. 33°37′
— Base Ranikot Limestone, Hyderabad, Pakistan, sample Pr 3315 (collection Marks)

Miscellanea primitiva

Miscellanea minuta
— Stanisiči near Budva, southern Yugoslavia, samples LH 356B, LH 358B (collection Hottinger)

3. Methods

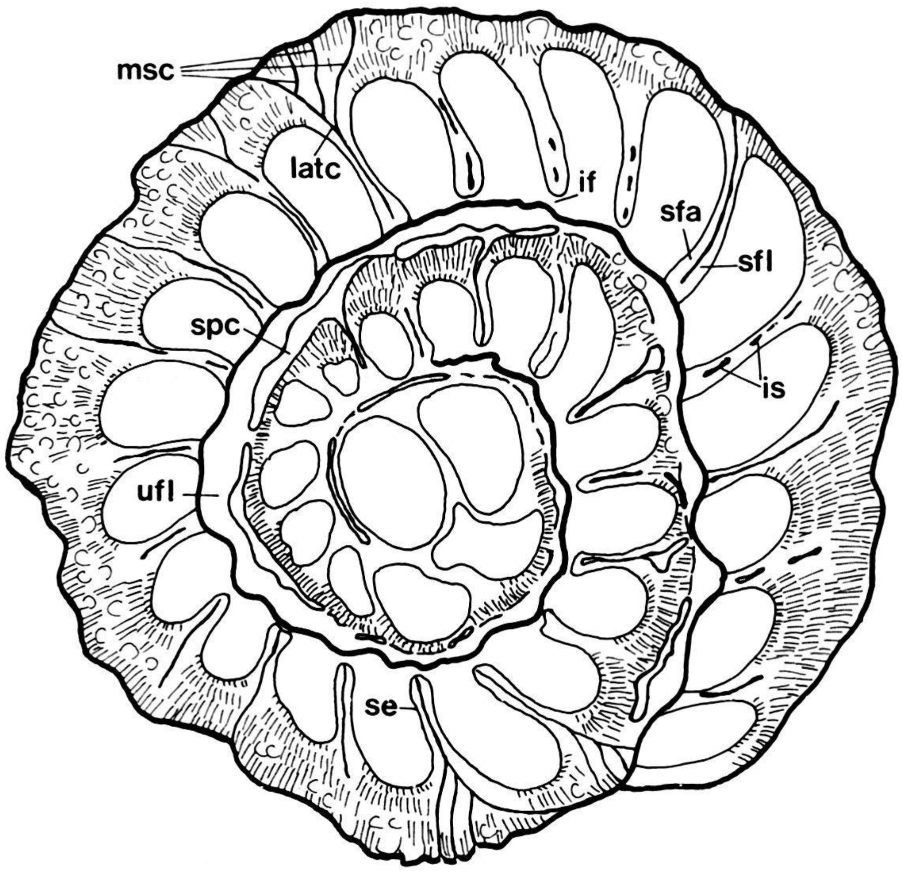
The present study is based on the examination of random thin sections (Spain, Yugoslavia, Iran) and of orientated thin sections of isolated specimens (France, Pakistan). For structural analysis and for taxonomic revision the sections were drawn with the aid of a Leitz transparency projector with attached micro device and projector prism. From these drawings, a three dimensional model is derived. The different species were defined on the basis of pictures of orientated sections drawn at uniform enlargement. Enlarged pictures can be inspected and compared simultaneously in great numbers, while in the light microscope only a single object can be observed at the same time. The attempt to carry out a lamellar analysis (Hansen & Reiss 1971; Hottinger & Leutenegger 1980) with isolated specimens failed because heavy diagenesis obscures the lamellar planes in the ultrastructural fabric of the wall.

4. Structural analysis of the shell

4.1 Shell architecture

Miscellanea produces a perforated shell with a planispiral involute chamber arrangement. The double septa comprise an intraseptal space which is subdivided in order to generate a canal system tending to envelop the lateral chamber wall.

a) External shape of test. – Well documented *Miscellanea* species show a distinct dimorphism. Macrospheric specimens always are lenticular, microspheric specimens



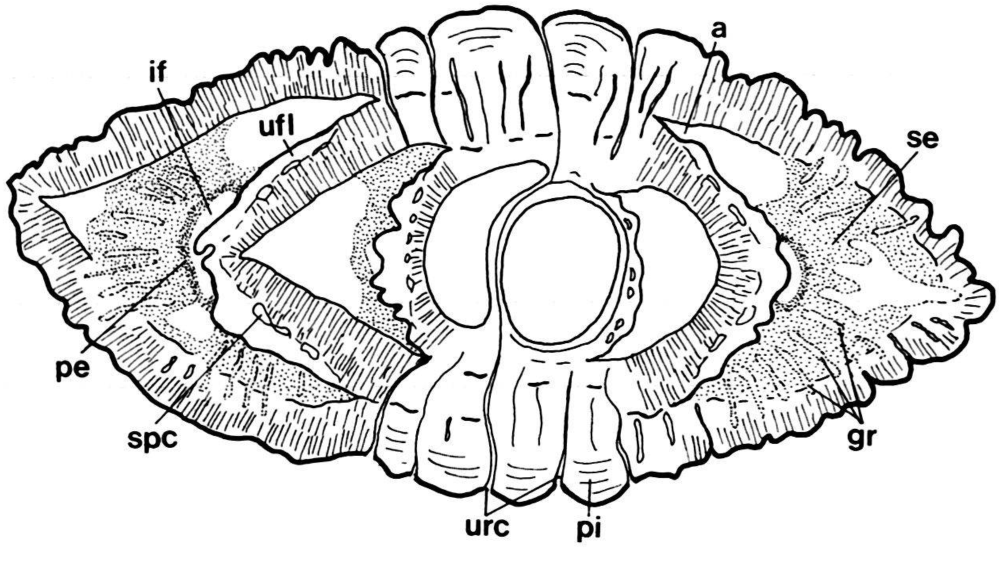


Fig. 4. Explanation of the different structural elements in *Miscellanea*. a: equatorial section, b: axial section. *a* = alar prolongation of chamber, *gr* = grooves, *if* = intercameral foramen, *is* = intraseptal space, *latc* = lateral canal, *msc* = marginal sutural canals, *pi* = pillar, *se* = septum, *sfa* = septal face, *sfl* = septal flap, *spc* = spiral canal, *ufl* = umbilical flap, *urc* = umbilical radial canal.

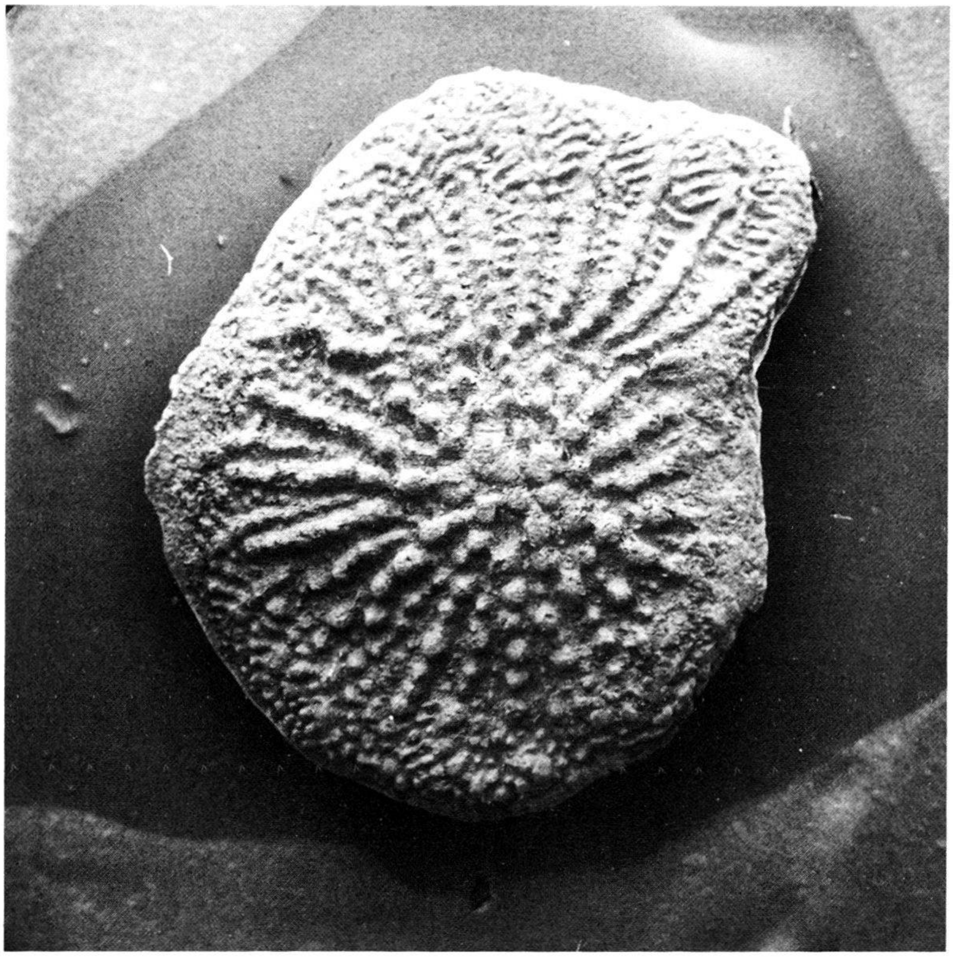


Fig. 5. *Miscellanea miscella*, Ranikot Limestone, Kala Chitta, Pakistan, macrospheric, note ornamental pillars and rafter-shaped pattern of ridges and depressions. – × 25.

larger than about 2,0 mm in diameter may invaginate the periphery of the shell in the last whorl (Pl. 4, Fig. 7), in the largest species *M. miscella* in several whorls (Pl. 8, Fig. 1).

From Middle to Upper Paleocene shell size increased distinctly, in macrospheric specimens the ratio equatorial/axial diameter decreases resulting in a decrease of biconvexity of the shell in general.

b) Ornamentation. – Ornamental pillars are restricted to the umbilical area in early species and scatter over the lateral shell surface in the latest species *M. miscella*. Around pillars open gutters communicate with radial umbilical canals. A rafter shaped pattern of depressions and ridges covers the lateral chamber walls rectangular to the septal sutures (Fig. 5).

c) Septum and plates. – Each septum is composed of a proximal septal face and a distal septal flap including an intraseptal space (Pl. 4, Fig. 4). The septal flap continues as an imperforate plate (umbilical flap, MÜLLER-MERZ 1980) covering the chamber floor as in *Cuvillierina* and leaving a narrow channel uncovered in the median plane (Pl. 4, Fig. 7). The rim of the umbilical plate in the median plane does not run parallel to the equator of the shell but forms arches in polar direction from one septum to the next. In nearly equatorial sections this rim of the umbilical plate is seen as undulated surface of the whorl

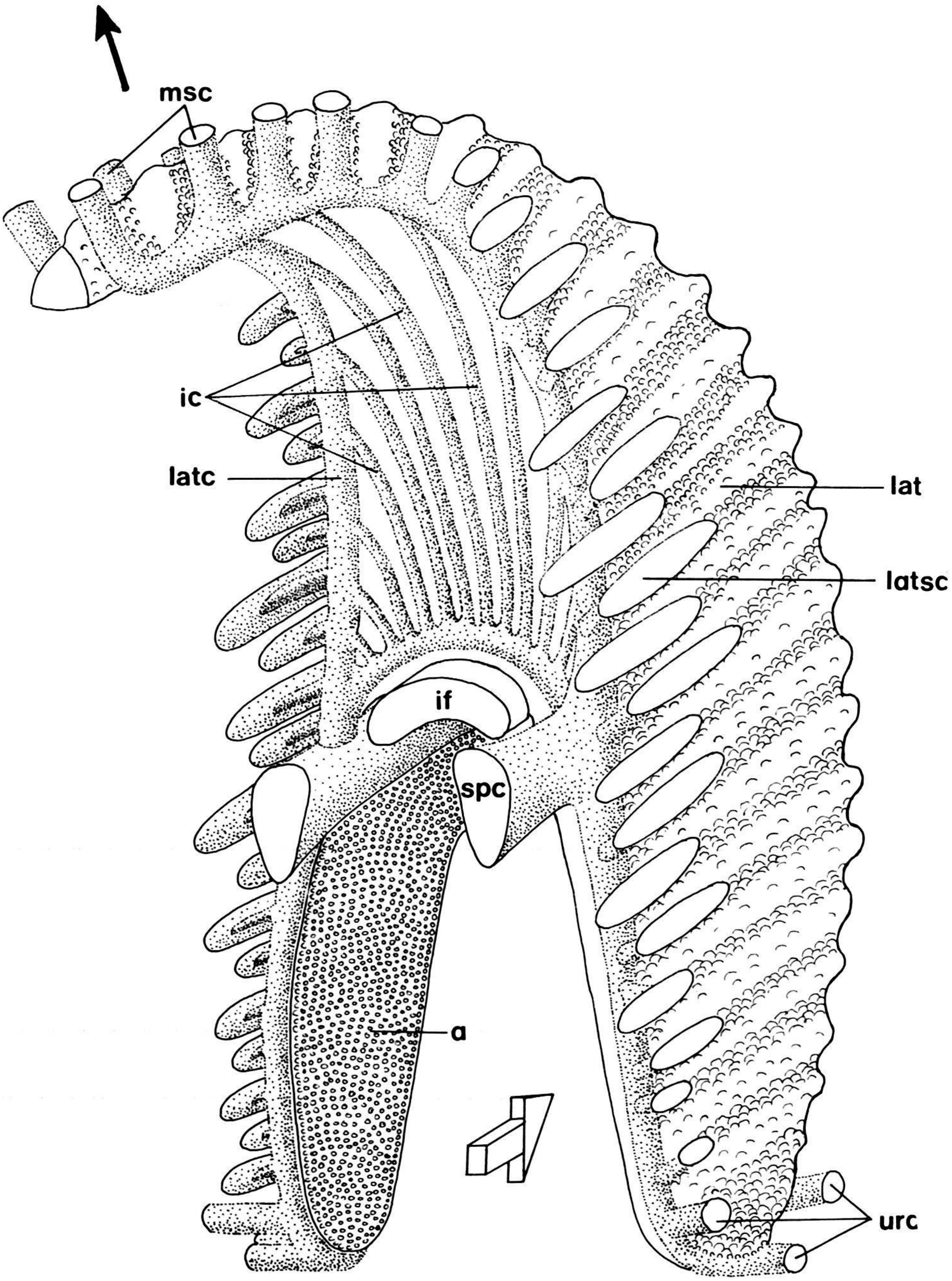


Fig. 6. Structural model of *Miscellanea* showing the geometry of the canal system. *a* = alar prolongation of chamber, *ic* = intraseptal canals, *if* = intercameral foramen, *lat* = lateral chamber wall, *latc* = lateral canal, *latsc* = lateral sutural canal, *msc* = marginal sutural canal, *spc* = spiral canal, *urc* = umbilical radial canal; *black arrow:* direction of protoplasma flow, *white arrow:* growth direction.

(Pl. 6, Fig. 2). The plate is attached to the previous whorl but leaves open two symmetric cavities (spiral canals, Pl. 4, Fig. 6; Pl. 6, Fig. 7) which extend along the chamber on both sides of the shell's equator in the direction of growth. As this plate is present in the last chamber as well, it is a primarily formed structural element of the shell produced simultaneously with a new chamber. Thus, it is not homologous with a secondarily formed cover plate. Septal faces and apertural face are furrowed by fan-shaped grooves (Pl. 4, Fig. 7; Pl. 6, Fig. 5) as in *Cuvillierina* (MÜLLER-MERZ 1980). The septal flap is attached to the apertural face on the ridges between the grooves. The peripheral septum is bent backward for at least 40° in respect to the radius of the shell at the base of the chamber.

4.2 Cavities

a) Chambers. – Planispirally arranged chambers are delimited from each other by a distal septal face and a proximal septal flap. They communicate by a single intercameral foramen. The alar prolongations of the chamber nearly reach the pole of the shell, defined by the coiling axis, (Pl. 4, Fig. 2, 7) and turn meandrine in the subspherical species *M. meandrina*.

As mentioned above, microspheric specimens invaginate the periphery of their shell in the last whorl. It is obvious in axial sections that the chamber lumen changes distinctly in the course of the growth. This change has been measured as surface of the cut chamber in axial sections. The surface measurement from one whorl to the next shows an increase whereas the radii in the equatorial plane decrease. In the specimen from Plate 6, Figure 8 the measured surface in the axial section is doubled from one whorl to the next, in the last whorl, however, it is trebled. The radii in the same specimen are equal in the first two whorls, increase in the third whorl for ¼ and decrease in the last whorl for one half.

The invagination of the last whorl could be explained as a counteraction to the larger growth step in order to guarantee a quick radial communication in the equatorial plane despite of the enlarged chamber lumen.

b) Foramina, openings

- A foramen could never be observed in the last septum of isolated specimens.
- A single intercameral foramen produces a broad but low symmetric arch over the periphery of the previous whorl at the base of the septal face carrying a peristome (Pl. 6, Fig. 5; Pl. 7, Fig. 3).
- It is most probable that there are temporary openings at the base of the apertural face situated between the points of contact of the ridges with the previous whorl and which is transformed into an intercameral foramen with the addition of a new chamber by resorption (compare apertural features in operculinids).

c) Nepionts. – In axial section, the macrospheric nepiont seems to be composed of a subspherical protoconch and a reniform deuteroconch (Pl. 6, Fig. 5). In equatorial section, the nepiont looks like an isolepidine embryo, the deuteroconch remaining always smaller than the protoconch (Pl. 6, Fig. 2). The microspheric proloculus consists of a tiny proloculus rarely to be seen in sections (Pl. 6, Fig. 9). With increasing proloculus size in the macrospheric generation from Middle to Upper Paleocene, dimorphism gets more dictinct. The microspheric/macrospheric specimen ratio in washed samples amounts to about 1:20.

d) Canal system (Fig. 6). – The planispiral chamber arrangement in *Miscellanea* corresponds to the symmetric disposition of all canal system elements. The plate covering the chamber floor admits a pair of spiral canals (Pl. 4, Fig. 6). The intraseptal space is transformed in a fan of canal cavities (Pl. 4, Fig. 7; Pl. 6, Fig. 5) with clearly differentiated lateral canals running below the septal suture. Lateral canals and an arched canal (Pl. 6, Fig. 5) over the intercameral foramen communicate with the spiral canals. In contrast to the sutural canals in the Calcarinidae where they lie under a "flying cover" formed by the outer lamella, they end open in the depressions between ridges and tend to envelop the lateral chamber wall (Pl. 4, Fig. 10).

The backward bent of the septum produces an almost radial direction of the sutural canals in the equatorial region of the shell (Pl. 4, Fig. 9; Pl. 7, Fig. 5).

In the Siderolitinae equatorial canals are present too, but they are arranged in a different way. The radial septa are connected in the equatorial plane by marginal canals producing numerous short canals in radial direction (WANNIER 1980). Umbilical radial canals (Pl. 4, Fig. 5; Pl. 6, Fig. 6) originate from the polar ends of the lateral canal and represent in fact ordinary sutural canals in polar position.

Conclusions as to the function of the canal system. – The geometry of the canal systems reflects specific functions. The backward bent of the septum producing sutural canals in almost radial direction shortens communication in equatorial direction between the early inner whorls and the ambient environment. In addition, the invagination of the periphery of the shell of microspheric specimens shortens distances between the pennultimate whorl and the periphery of the shell in the equatorial plane. The tendency to develop large numbers of radial connections hints to high water energy in the *Miscellanea* environment in analogy with extant calcarinids. Radial connections in the median plane of the shell are known in particular in *Pseudosiderolites* and *Siderolites* (WANNIER 1980) while similar invaginations of the periphery are known in *Daviesina langhami* (SMOUT 1954). This pattern meets the basic requirement of canal systems in general, namely 'backdoor' communications for the extrusion of pseudopodial protoplasm during the retraction of the shell plasm in a spiral shell (HOTTINGER 1977; REISS & HOTTINGER 1984).

4.3 Taxonomic consequences

Despite of the absence of a "marginal cord" *Miscellanea* was placed by LOEBLICH & TAPPAN (1964) in the Nummulitidae. In their new classification (preliminary note 1984) they establish the subfamilies Cuvillierininae and Miscellaneinae within the Rotaliidae. It is not obvious, however, why *Cuvillierina* and *Miscellanea* should be placed in the Rotaliidae because both do not have an asymmetric, dorsally closed canal system. Transferring *Miscellanea* from the Nummulitidae to a particular taxon of family rank together with *Cuvillierina, Fissoelphidium, Laffitteina* and *Thalmannita,* we are obliged, by priority, to revalidate SIGALS's family Miscellaneidae (1952). Their features are planispiral involute *(Miscellanea, Fissoelphidium, Thalmannita)* to internally slightly asymmetrical shells *(Cuvillierina, Laffitteina)*, single, basally arched intercameral foramina correspondingly symmetric to slightly asymmetric in position. In all genera sutural canals are common.

Table 1: *List of the characteristics in Miscellanea and related groups of perforated larger foraminifera.*

	Rotaliidae	*Calcarinidae*		*Nummulitidae*	*Miscellaneidae*	*Elphidiidae*
	Rotaliinae	*Calcarininae*	*Siderolitinae*			*Elphidiinae*
Arrangement of chambers	trochospiral	trochospiral	planispiral	planispiral	planispiral to internally slightly asymmetric	planispiral
General arrangement of canal system	asymmetric	asymmetric	symmetric	symmetric	symmetric	symmetric
Canal system	umbilically open, dorsally closed	umbilically and dorsally open	umbilically and dorsally open	umbilically and dorsally open	umbilically and dorsally open	umbilically and dorsally open
Elements of canal system: spiral canal	+	+	+	+	+	+
Sutural canals	−	+	+	+	+	+
Marginal canals	−	+	+	+	−	−
Canals in equatorial direction	−	+	+	−	+−	−
Primary cover (umbilical flap) or secondary cover (cover plate)	umbilical flap cover plate	umbilical flap	umbilical flap	umbilical flap	umbilical flap	umbilical flap
Special characters		enveloping canal system, spines	enveloping canal system, spines	marginal cord	fan-shaped intraseptal canals, sutural canals tending to envelop lateral chamber wall	retral processes

Their stratigraphic extension is limited to Maestrichtian *(Fissoelphidium)*, Paleocene *(Miscellanea, Laffitteina, Thalmannita)* and Lower Eocene *(Cuvillierina)*.

It will have to be clarified in how far the *Faujasininae* (placed within the *Elphidiidae* by LOEBLICH & TAPPAN 1964) differ from the *Miscellaneidae*. Both the *Miscellanea*- and the *Faujasina*-group do not possess retral processes common for the *Elphidiinae* and both have distinct sutural canals.

The genera, remaining in LOEBLICH & TAPPAN's subfamily *Cuvillierininae*, are assigned here to higher taxa as follows: *Daviesina* has an asymmetric canal system which is dorsally closed and should be placed therefore within the *Rotaliidae*. *Pokornyella* probably is a siderolitid. WANNIER (1980) regrouped *Pseudosiderolites* within the *Calcarinidae* in an own subfamily *Siderolitinae*. *Storrsella*, closely related to *Pararotalia*, belongs to the *Rotaliinae*. *Crespinella, Penoperculinoides* and *Pseudowoodella* are insufficiently described so far and have to stay at the moment as genera incertae sedis. Consequently the subfamily *Cuvillerininae* becomes superfluous and should not be used any more.

5. Taxonomic revision

Family *Miscellaneidae* SIGAL 1952

Emended diagnosis. – Test involute planispiral to internally slightly asymmetrical. Single intercameral foramen in basal symmetrical to asymmetrical position. Presence of umbilical flap. Canal system with intraseptal and sutural canals. Paired spiral canal, vertical umbilical canals between coarsely spaced pillars. Rafter shaped pattern of ridges and depressions rectangular to the septal sutures on the lateral chamber walls. No "marginal cord", spines, retral processes, lateral chamberlets or clearly defined "enveloping canal system".

Remarks. – The different *Miscellanea* species are separated from each other by their proportions. The differentiated diagnoses are given in Table 2.

Miscellanea juliettae pfenderae n. ssp.

Pl. 1, Fig. 4; Pl. 2, Fig. 4; Pl. 3, Fig. 4/1, 4/2; Pl. 4.

Holotype. – Sample CT3(85)11 (Pl. 1, Fig. 4; Pl. 4, Fig. 1), NMB[2]) Nr. C 36625.

Type locality. – Sierra de Cantabria, Montes Oberenes (northwestern Spain).

Derivatio nominis. – In honour to Juliette Pfender who described *"Nummulites" miscella* as mixture of *Nummulites, Siderolites* and *Rotalia*.

Stratigraphic distribution. – Middle Paleocene, *primaeva zone*.

Geographic distribution. – Known from type locality only.

Diagnosis. – Macrospheric specimens lenticular and strongly biconvex. Microspheric specimens occasionally invaginate parts or the whole periphery of their shell in the last whorl. Ornamental pillars restricted to the umbilical area. Diameter of the megalosphere 0,12–0,25 mm. 16 chambers in the last whorl and an equatorial diameter of the shell of 1,2 mm. Microspheric specimens with 21 chambers in the last whorl and an equatorial diameter of the shell of 2,0 mm (Table 2).

[2]) Naturhistorisches Museum, Basel.

Table 2: *Measurement of parameters in the different Miscellanea species.*

		Diameter equat. (mm)			Diameter axial (mm)			Ratio diam. eq./diam.			Diameter ax. Proloculus (mm)			Number chamb. Past whorl			Numb. chamb. last but one			Number of whorls
		min.	max.	av.	min.	max.	av.	min.	max.	av.	min.	max.	av.	min.	max.	av.	min.	max.	av.	
M. juliettae	macro	0.7	1.8	1.2	0.4	0.9	0,6	1.5	2.2	1.84	0.12	0.25	0.16	10	20	16	10	16	13	2–2.5
pfenderae	micro	1.6	3.0	2.0	0.8	1.4	1.0	1.7	2.2	2.0		–		19	22	21	13	17	14	4–5
n. ssp.																				
M. juliettae	macro	0.9	1.9	1.3	0.5	1.0	0.7	1.5	2.1	1.85	0.12	0.23	0,173	14	20	17	10	13	12	2–2.5
villattae	micro	1.5	2.7	2.1	0.9	1.3	1.1	1.6	2.3	2.0		–		21	27	23	17	20	18	4–5
n. ssp.																				
M. yvettae	macro	1.3	2.1	1.7	0.8	1.1	0.9	1.8	2.2	2.0	0.15	0.27	0.21	18	25	20	12	18	14	2.5–3
n. sp.	micro	1.9	3.2	2.8	1.0	1.6	1.3	1.7	2.1	2.0		0.02		23	26	25	22	25	23	6
M. miscella	macro	1.5	3.4	2.8	0.9	1.4	1.0	1.4	2.9	2.4	0.20	0.40	0.27	22	31	26	12	22	16	2.5–3
(D'ARCH. &																				
HAIME)	micro	3.0	10.1	5.0	1.1	1.4	1.2	3.0	4.0	3.6		0.02		26	40	31	20	32	25	6–7
M. primitiva	macro	0.9	1.1	1.0	0.5	0.6	0.6	1.7	2.3	2.0		0.1		13	15	14		10		2.5
RAHAGHI	micro		–			–			–			–			–			–		
M. minuta	macro	0.9	1.1	1.0	0.6	0.7	0.7		2.1			0.1		13	15	14		10		2.5
RAHAGHI	micro		–			–			–			–			–			–		

Generally there is a marked abundance of *M. juliettae pfenderae* n. ssp. while other larger foraminifera are absent. Immediately above the horizons with *M. juliettae pfenderae* n. ssp. we find layers with *Alveolina (G.) primaeva* and *Fallotella (F.) alavensis*.

Miscellanea juliettae villattea n. ssp.

Pl. 1, Fig. 3; Pl. 2, Fig. 3; Pl. 3, Fig. 3; Pl. 5)

Holotype. Sample T/XV Basis (8) (Pl. 1, Fig. 3; Pl. 2, Fig. 3; Pl. 3, Fig. 3; Pl. 5), NMB Nr. 36626.

Type locality. – North of the Sierra de Cantabria, near Corres (northwestern Spain).

Derivatio nominis. – In honour to Juliette Villatte who mentioned *Miscellanea* from the Petites Pyénées for the first time.

Stratigraphic distribution. – Middle Paleocene, *primaeva* zone.

Geographic distribution. – Northwestern Spain, northwestern Yugoslavia.

Diagnosis. – Macrospheric specimens lenticular and strongly biconvex. The majority of the microspheric specimens invaginates the periphery of their shell in the last whorl. Ornamental pillars restricted to the umbilical area. Diameter of the megalosphere 0,12–0,23 mm. 17 chambers in the last whorl and an equatorial diameter of the shell of 1,3 mm. Microspheric specimens with 23 chamber in the last whorl and an equatorial diameter of the shell of 2,1 mm (Table 2).

M. juliettae villattae n. ssp. occurs in Spain together with *Discocyclina seunesi* and *Operculina* sp., immediately below the layers with *Alveolina (G.) primaeva* and *Fallotella (F.) alavensis*.

Miscellanea yvettae n. sp.

Pl. 1, Fig. 2; Pl. 2, Fig. 2; Pl. 3, Fig. 2; Pl. 6

1962 *Miscellanea* sp., VILLATTE, p. 63, p. 80, Pl. XXII, Fig. 1, 2.
1971 *Miscellanea* sp. HOTTINGER, p. 147.

Holotype. – Sample 73933/61 (Pl. 1, Fig. 2; Pl. 6, Fig. 1), NMB Nr. 36627.

Type locality. – Petites Pyrénées (southern France) eastern of Saint-Michel.

Derivatio nominis. – In honour to Yvette Tambareau who studied in detail the sedimentary sequence with their fossil content from Lower to Upper Thanetian in the Petites Pyrénées.

Stratigraphic distribution. – Middle Paleocene, *primaeva* zone.

Geographic distribution. – Southern France.

Diagnosis. – Macrospheric specimens lenticular and biconvex. All macrospheric specimens invaginate the periphery of their shell in the last whorl. Ornamental pillars restricted to the umbilical area. Diameter of megalosphere 0,15–0,27 mm. 20 chambers in the last whorl and an equatorial diameter of the shell of 1,7 mm. Microspheric specimens with 26 chambers in the last whorl and an equatorial diameter of the shell of 2,8 mm (Table 2).

M. yvettae n. sp. occurs in the Petites Pyrénées together with *Discocyclina seunesi*, immediately below *Alveolina (G.) primaeva* and *Fallotella* (F.) *alavensis*.

Miscellanea miscella (D'ARCHIAC & HAIME) 1853

Pl. 1, Fig. 1; Pl. 2, Fig. 1; Pl. 3, Fig. 1; Pl. 7–8

1853 *Nummulites miscella* D'ARCHIAC & HAIME, p. 345, Pl. 35, Fig. 4a–c.
1916 *Siderolites miscella* (D'ARCHIAC & HAIME), DOUVILLE, p. 38, Pl. 15.
1926 *Siderolites miscella* (D'ARCHIAC & HAIME), NUTTALL, p. 116, Text-Fig. 3.
1927 *Siderolites miscella* (D'ARCHIAC & HAIME), DAVIES, p. 227, Pl. 20.
1934 *Miscellanea miscella* (D'ARCHIAC & HAIME), PFENDER, p. 231, Pl. 11, Fig. 6, 7, Pl. 13, Fig. 2–4.
1937 *Miscellanea miscella* (D'ARCHIAC & HAIME), DAVIES L. M. & PINFOLD, E. S., p. 43, Pl. 4, Fig. 1–3, 7–8.
1937 *Miscellanea stampi* (DAVIES), ibidem, p. 42, Pl. 4, Fig. 4, 6, 9–10, 17–18.
1951 *Miscellanea miscella* (D'ARCHIAC & HAIME), NAGAPPA, p. 43.
1959 *Miscellanea miscella* (D'ARCHIAC & HAIME), NAGAPPA, Text-Fig. 8, 11, Pl. 3, Fig. 3; Pl. 4, Fig. 1.
1971 *Miscellanea miscella* (D'ARCHIAC & HAIME), HOTTINGER, p. 147, 148.
1971 *Miscellanea miscella* (D'ARCHIAC & HAIME), HOTTINGER & DROBNE, p. 228.

Stratigraphic distribution. – Upper Paleocene, *cucumiformis* zone.

Geographic distribution. – Turkey, Syria, Madagascar, Iran, Pakistan, India, Tibet, Burma.

Diagnosis. – Macrospheric specimens lenticular, biconvex. Microspheric specimens irregularly invaginate the periphery of their shell in the outer whorls (Pl. 8, Fig. 6). Ornamental pillars not only concentrated to the umbilicus but scattered over the lateral shell surface. Diameter of the megalosphere 0,20–0,40 mm. 26 chambers in the last whorl and an equatorial diameter of the shell of 2,8 mm. Microspheric specimens with 31 chambers in the last whorl and an equatorial diameter of the shell of 5,0 mm (Table 2). Spiral very irregular in the equatorial plane (Plate 8).

All isolated specimens, handed over to me as *Miscellanea stampi* together with *M. miscella* proved to be microspheric specimens. Obviously "*M. stampi*" is the microspheric generation of *M. miscella*, which is all the more supported by the smaller *Miscellanea* species where all specimens, larger than about 2,0 mm in diameter, invaginate their periphery in the last whorl.

In the samples from Kuh-E-Kargan, *M. miscella* is associated with *Alveolina (G.) lepidula*, *Ranikothalia nuttalli*, *Operculina ornata* and *Discocyclina* sp.

Middle-Eastern "Minimiscellaneas"

Miscellanea primitiva RAHAGHI 1983

Pl. 1, Fig. 5; Pl. 2, Fig. 5

1983 *Miscellanea primitiva* RAHAGHI, p. 61, Pl. 42, Fig. 8–16.

Stratigraphic distribution. – Middle Paleocene?

Geographic distribution. – Southern Yugoslavia, Iran.

Remarks. – In the descriptions of RAHAGHI no data about the associated larger foraminifera are available. No difference is made between macro- and microspheric specimens of *M. primitiva* although both are figured. After RAHAGHI, *M. primitiva* and *M. minuta* both occur in Iran in the Upper Paleocene. There is, however, no indication about the correspondence with alveolinic and nummulitic biozones. It is not probable that the small Miscellaneas are of the same age as the large *M. miscella* which is dated by associated larger foraminifera (HOTTINGER 1971) and which belongs to the cucumiformis biozone (Upper Paleocene).

Macrospheric specimens lenticular and strongly biconvex. Ornamental pillars restricted to the umbilical area. Diameter of megalosphere 0,10 mm. 14 chambers in the last whorl and an equatorial diameter of 1,1 mm. Microspheric specimens could not be observed (Table 2). *M. primitiva* occurs in southern Yugoslavia below the horizons with *Cuvillierina*.

Miscellanea minuta Rahaghi 1983

Pl. 2, Fig. 6

1983 *Miscellanea minuta* Rahaghi, p. 62, Pl. 43, Fig. 1–13.

Stratigraphic distribution. – Middle Paleocene?

Geographic distribution. – Southern Yugoslavia, Iran.

Remarks. – The only difference between *M. primitiva* and *M. minuta* is a subspherical to oval external shape of the test in *M. minuta*. Therefore it is not suggestive to keep up the separation of the two species.

6. Conclusions

Considering the different *Miscellanea* species and their stratigraphic as well as their geographic distribution, we observe some striking facts. The three early species of Lower Middle Paleocene age (*primaeva* zone), occur as known so far, in Western and Middle Europe (Spain, France, Yugoslavia). The late species, *M. miscella,* of Upper Paleocene age (*cucumiformis* zone) has a geographic distribution extending from the Near to the Far East.

Why are the early species limited to the Western Tethys? Why has the late species never been found in Europe?

An explanation for the first question is an undoubtedly much more incomplete knowledge of the Near to Far East Paleogene compared with the one of the Western Tethys. An explanation for the lack of the late *Miscellanea* species in the Western Mediterranean is the assumption of the existence of a Western and an Eastern faunal province which began to develop at the boundary Middle/Upper Paleocene and which is reflected in the distribution pattern of larger foraminifera (Hottinger 1971). In the Western Tethyan area more groups of larger foraminifera simultaneously arose during Middle and Upper Paleocene than in the Eastern parts with the consequence of hard competition where not all groups could succeed. Here, *Miscellanea* is limited to the Middle Paleocene and is substituted later by operculines, assilines and nummulites. Why it should not be possible that *Miscellanea* appeared in the Eastern faunal province at the same time as in the Western province? Perhaps the appropriate facies solely has not been discovered till now. In this case *Miscellanea* here would have survived till the Upper Paleocene where all these foraminiferal groups coexisted.

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Plate 1

Equatorial sections, macrospheric. – × 50.

Fig. 1 13606, *Miscellanea miscella* (D'ARCHIAC & HAIME), Khairabad, Salt Range, Pakistan.

Fig. 2 73933/61, *M. yvettae* n. sp., Holotype, Petites Pyrénées, France.

Fig. 3 T/XV Basis (8), *M. juliettae villattae* n. ssp., Holotype, Corres, northwestern Spain.

Fig. 4 CT 3(85)11, *M. juliettae pfenderae* n. ssp., Holotype, Sierra de Cantabria, northwestern Spain.

Fig. 5 LH 358 B2, *M. primitiva* RAHAGHI, Budva, southern Yugoslavia.

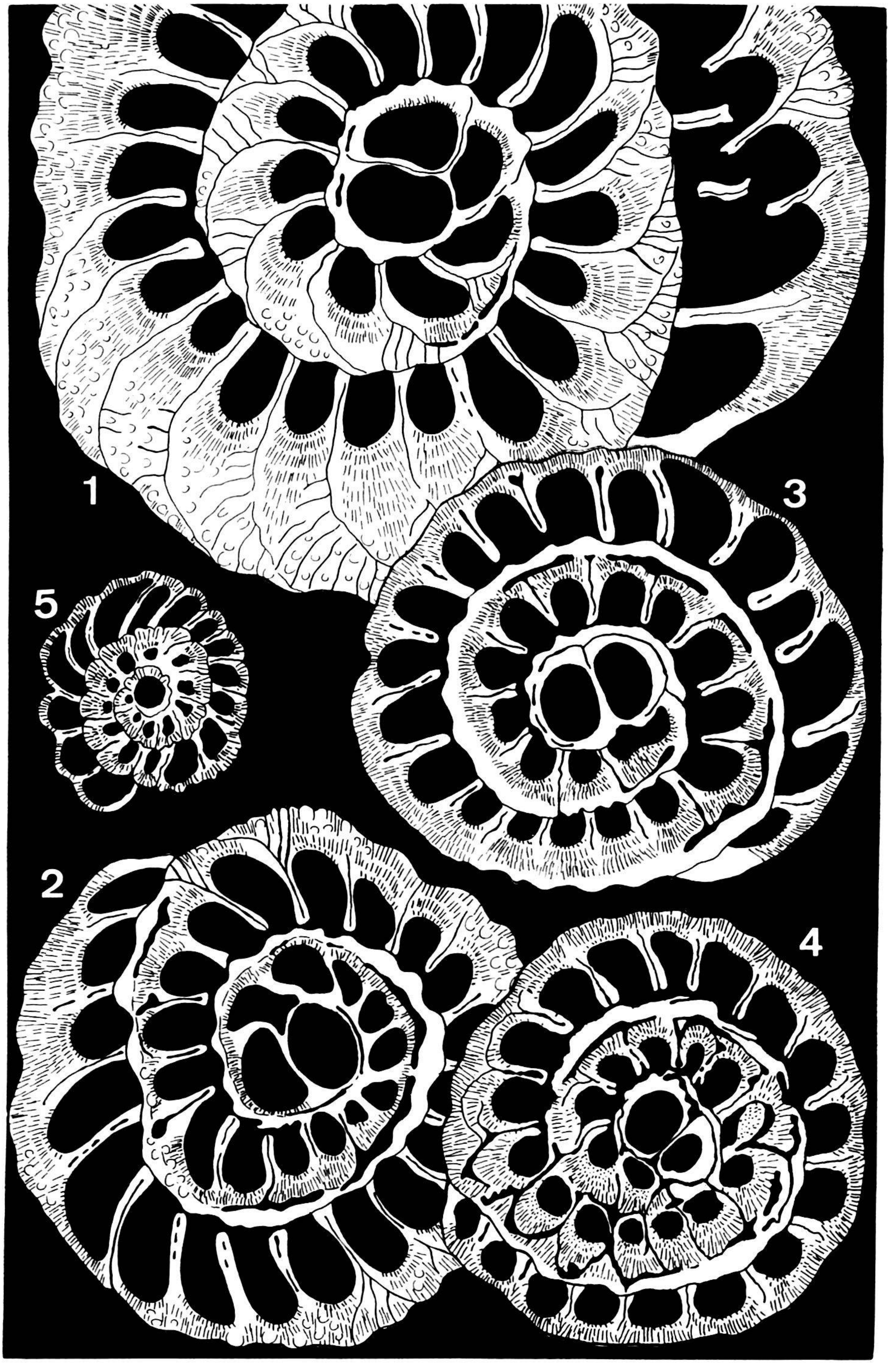
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Plate 2

Axial sections, macrospheric. – × 50.

Fig. 1 13606, *Miscellanea miscella* (D'ARCHIAC & HAIME), Salt Range, Pakistan.

Fig. 2 73933/59, *M. yvettae* n. sp., Petites Pyrénées, France.

Fig. 3 T/XV1/1, *M. juliettae villattae* n. ssp., Corres, northwestern Spain.

Fig. 4 CT 3(85)11, *M. juliettae pfenderae* n. ssp., Sierra de Cantabria, northwestern Spain.

Fig. 5 LH 356 B1, *M. primitiva* RAHAGHI, Budva, southern Yugoslavia.

Fig. 6 LH 358 B2, *M. minuta* RAHAGHI, Budva, southern Yugoslavia.

PLATE 2

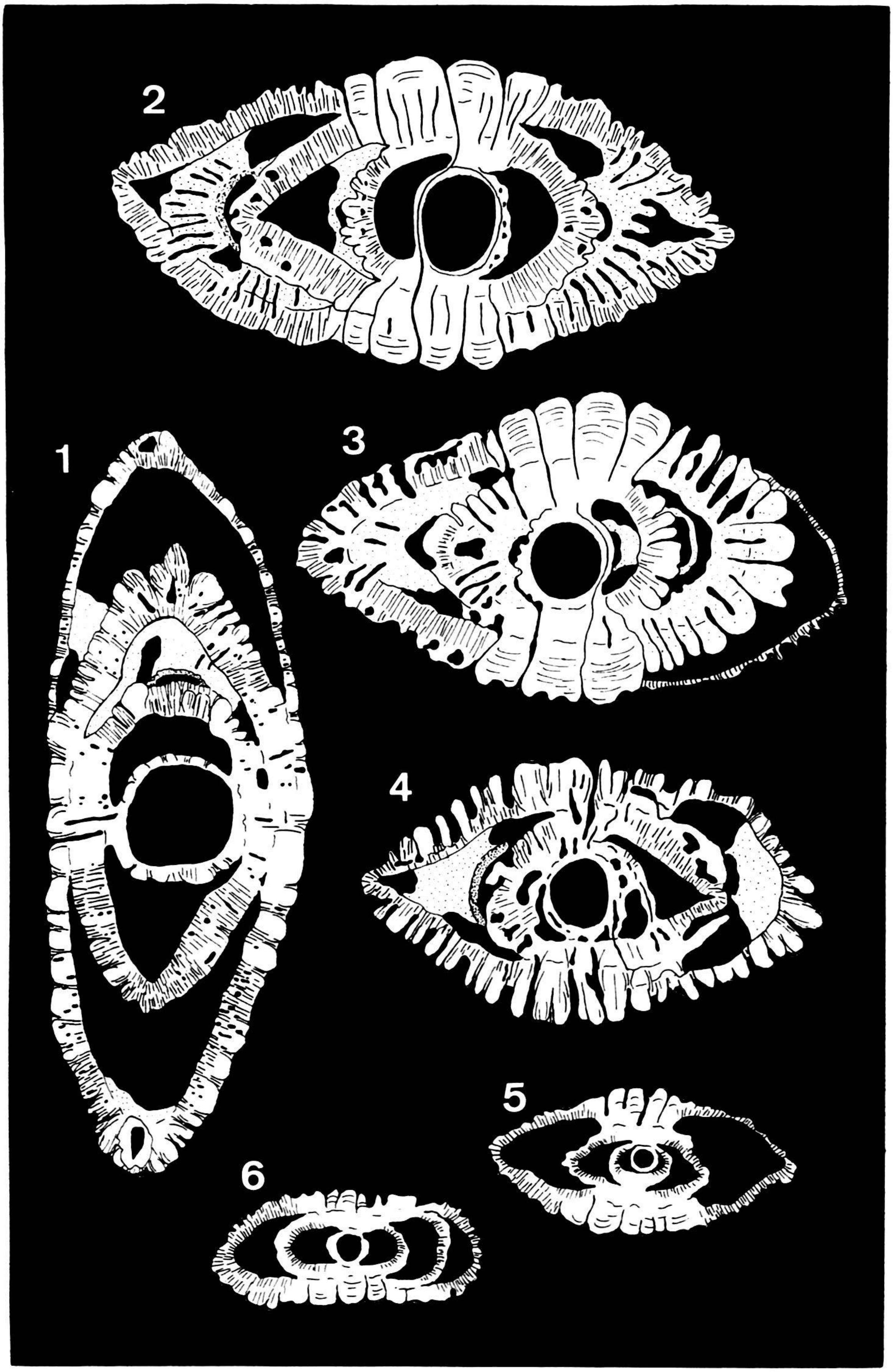

Plate 3

Axial sections, microspheric. – × 33.

Fig. 1 13630, *Miscellanea miscella* (D'ARCHIAC & HAIME), Kala Chitta, Pakistan.

Fig. 2 73933/13598, *M. yvettae* n. sp., Petites Pyrénées, France.

Fig. 3 T/XV 0/6, *M. juliettae villattae* n. ssp., Corres, northwestern Spain.

Fig. 4/1 CT3 (85)10, *M. juliettae pfenderae* n. ssp., Sierra de Cantabria, northwestern Spain.

Fig. 4/2 CT3 (85)11, *M. juliettae pfenderae*, Sierra de Cantabria, northwestern Spain.

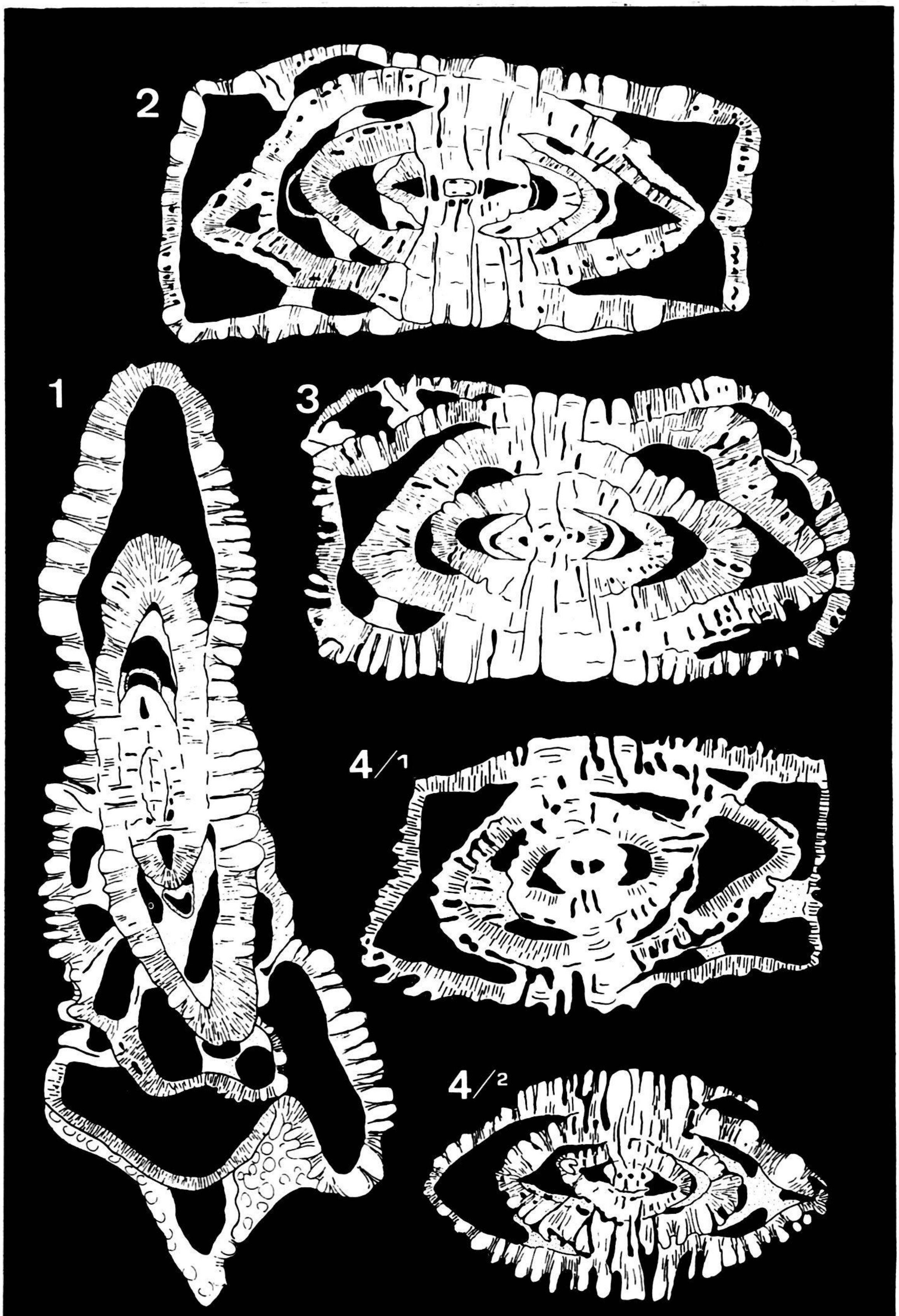
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Plate 4

Miscellanea juliettae pfenderae n. ssp., sample CT3 (85): – × 25. Sierra de Cantabria, Spain

Fig. 1 Holotype, macrospheric, nearly equatorial.
Note spiral canal communicating with intraseptal canals.
Section 11.

Fig. 2 Macrospheric, axial. Note cut septal surface and intercameral foramen with peristome in the left part of the outer whorl.
Section 11.

Fig. 3 Macrospheric, axial. Note umbilical flap on the pennultimate whorl.
Section 8.

Fig. 4 Microspheric, transversal. Note intraseptal canals branching into marginal sutural canals.
Section 11.

Fig. 5 Microspheric, oblique. Note intraseptal canals in the alar prolongations with radial umbilical canals.
Section 15.

Fig. 6 Microspheric, tangential. Note spiral canals communicating with intraseptal canals.
Section 4.

Fig. 7 Microspheric, nearly axial. Note general invagination of the last whorl and cut septal surface with fan-shaped intraseptal canals as well as the intercameral foramen with peristome in the pennultimate whorl on the left side. Umbilical flap on the second whorl on the right.
Section 10.

Fig. 8 Microspheric, nearly axial. No invagination in the last whorl.
Section 8.

Fig. 9 Microspheric, transversal. Note radial umbilical canals and marginal sutural canals branching from intraseptal canals.
Section 15.

Fig. 10 Microspheric, oblique. Note sutural canals on the lateral chamber wall.
Section 11.

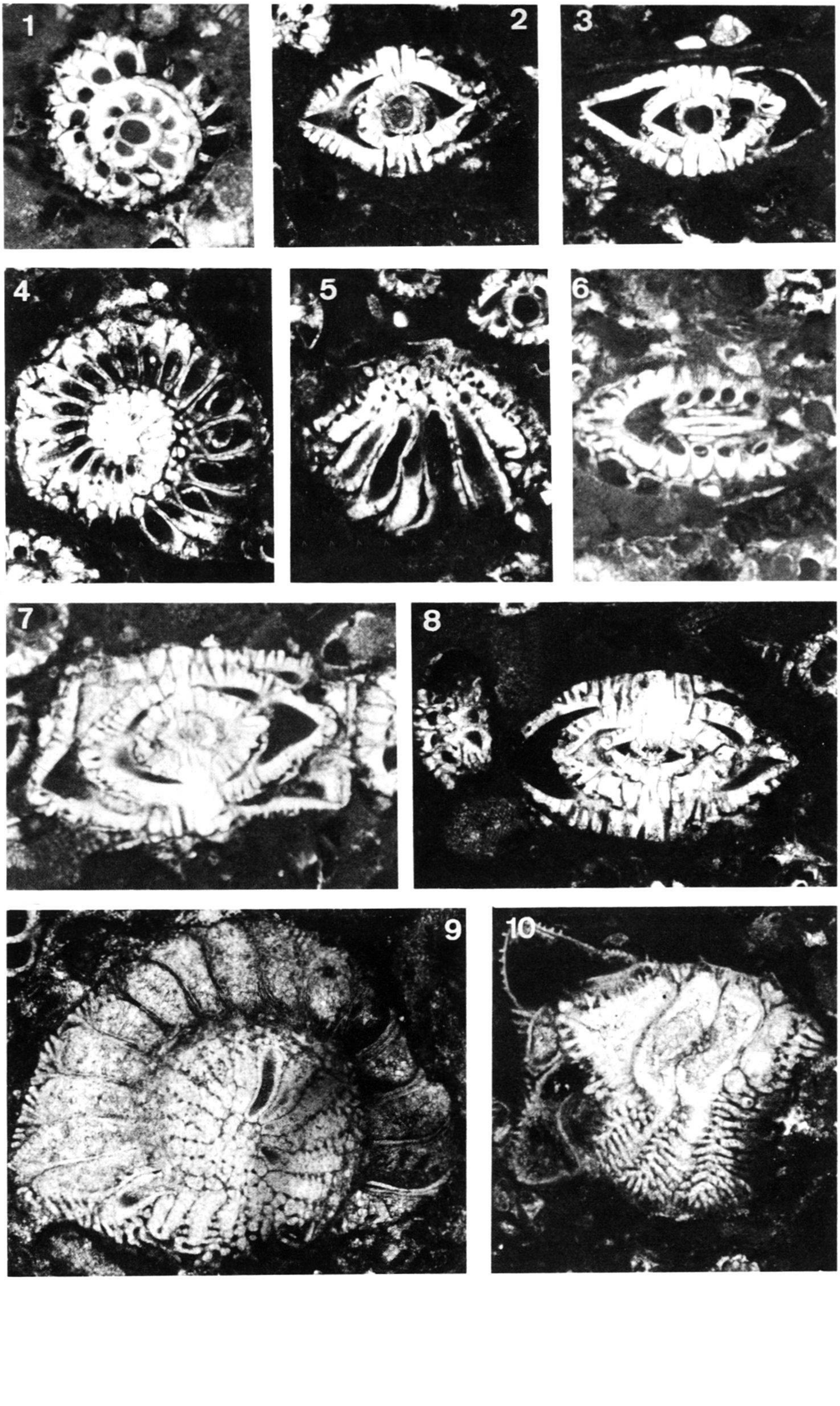

Plate 5

Miscellanea juliettae villattae n. ssp., Corres, north-western Spain. – × 25.

Fig. 1 Holotype, macrospheric, equatorial. Note spiral canal communicating with intraseptal canals. Section T/XV Basis (8).

Fig. 2 Macrospheric, left section slightly transversal, right section oblique centered. Section T/XV Basis (3).

Fig. 3 Macrospheric, axial. Note thick pillars between umbilical radial canals and sutural canals in the lateral chamber wall. Section T/XV 1/1.

Fig. 4 Macrospheric, axial (see 3). Section T/XV 0/11.

Fig. 5 Microspheric, tangential. Note partial invagination of the last whorl. Section T/XV 0/12.

Fig. 6 Microspheric, oblique. Note intraseptal space transformed into intraseptal canals leading into sutural canals. Section T/XV Basis (3).

Fig. 7 Microspheric, slightly transversal. Note general invagination of the last whorl. Section T/XV 0/6.

Fig. 8 Microspheric, axial. No invagination in the last whorl, umbilical flap in the second and third whorl on the right. Section T/XV Basis (1).

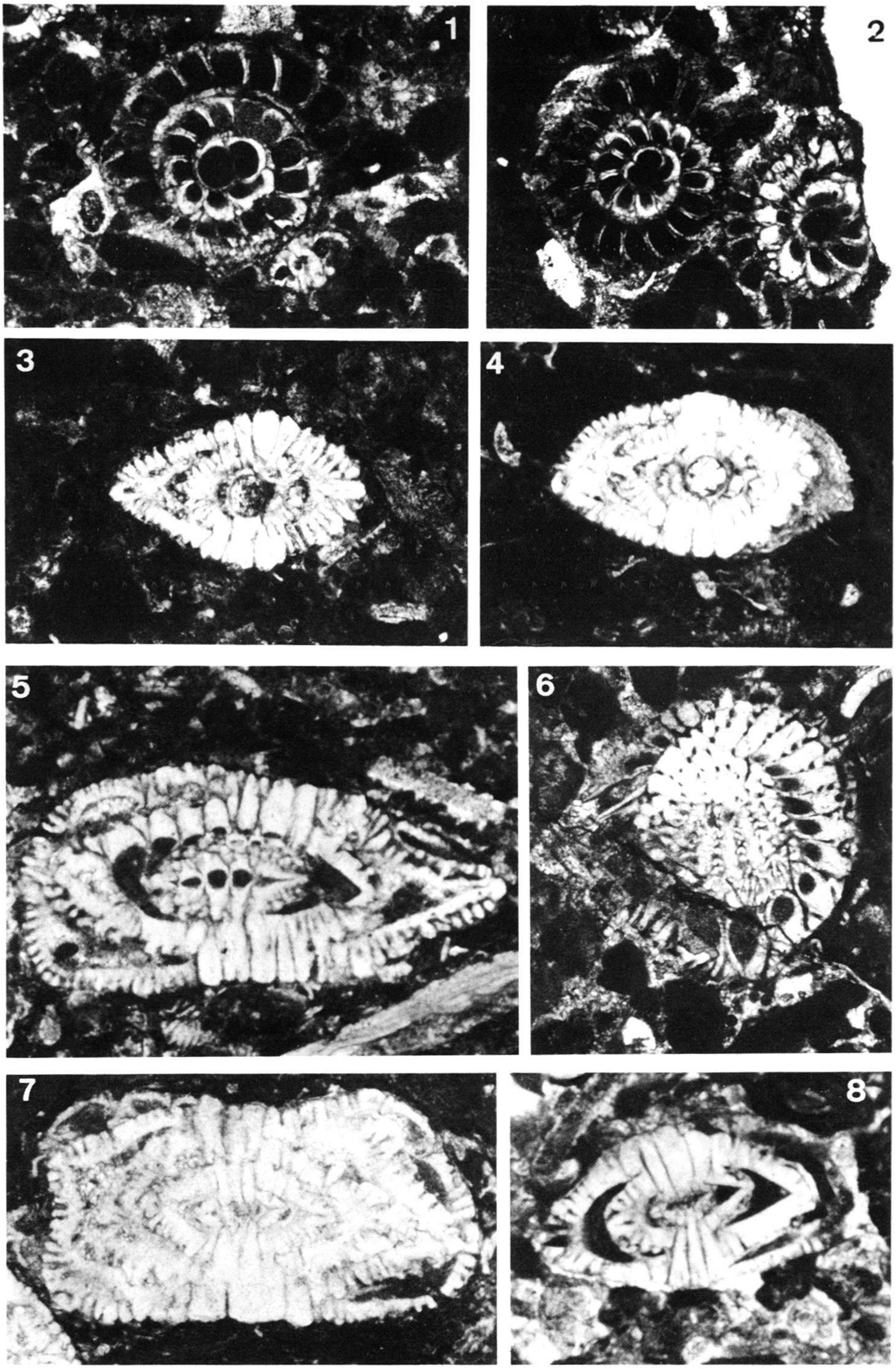
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Plate 6

Miscellanea yvettae n. sp., Petites Pyrénées, France. Sample 73933. – × 25.

Fig. 1 Holotype, macrospheric, equatorial.
Section 11.

Fig. 2 Macrospheric, nearly equatorial. Note "isolepidine" embryo and undulated surface especially in the first and second whorl caused by the corrugated rim of the umbilical flap in the median plane.
Section 13604.

Fig. 3 Macrospheric, tangential. Note cut septal surfaces with fan-shaped intraseptal canals and intercameral foramina. Spiral canal in the pennultimate whorl on the right.
Section 57.

Fig. 4 Macrospheric, axial. Note subspherical protoconch, reniform deuteroconch and "passage" in the equator of the last whorl which is in fact the most peripheral tip of a previous chamber.
Section 50.

Fig. 5 Macrospheric, axial. Note cut septal surfaces with fan-shaped intraseptal canals and intercameral foramina.
Section 59.

Fig. 6 Microspheric, transversal. Note radial umbilical canals.
Section 13605.

Fig. 7 Microspheric, tangential. Note partial invagination of the last whorl, intercameral foramina, umbilical flap and spiral space on the pennultimate whorl on the left.
Section 16.

Fig. 8 Microspheric, nearly axial. Note general invagination of the last whorl.
Section 13598.

Fig. 9 Microspheric, equatorial. Note tiny proloculus.
Section 13594.

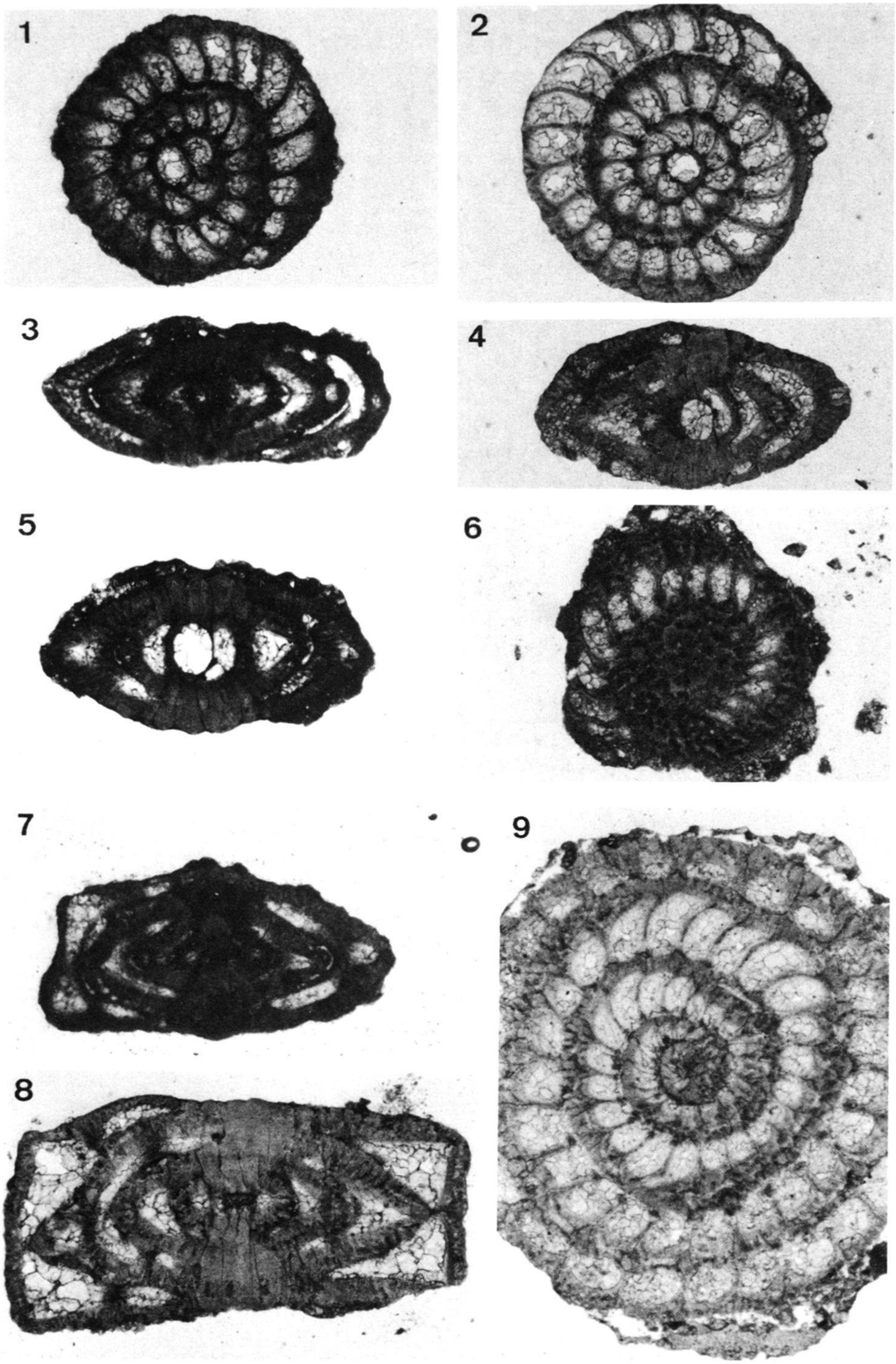
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Plate 7

Miscellanea miscella. – × 20

Fig. 1 Macrospheric, equatorial. Note marginal sutural canals in equatorial direction proceeding from lateral canals.
Ranikot Limestone, Khairabad, Salt Range, Pakistan.
Section 13606.

Fig. 2 Macrospheric, equatorial. Note irregular spiral in the last whorl.
Ranikot Limestone, Dak Pass, Salt Range, Pakistan.
Section 13620.

Fig. 3 Macrospheric, axial. Note intercameral foramen in the second whorl on the left.
Ranikot Limestone, Khairabad, Salt Range, Pakistan.
Section 13606.

Fig. 4 Macrospheric, axial.
Ranikot Limestone, Dak Pass, Salt Range, Pakistan.
Section 13620.

Fig. 5 Macrospheric, transversal. Note sutural canals becoming equatorial in the equatorial region, slightly irregular spiral in the last whorl.
Ranikot Limestone, Hyderabad, Pakistan.
Section Pr 3315.

Fig. 6 Microspheric, slightly tangential. Note intercameral foramen in the first whorl on the left and irregular invagination of the different whorls.
Ranikot Limestone, Kala Chitta, Pakistan.
Section 13630.

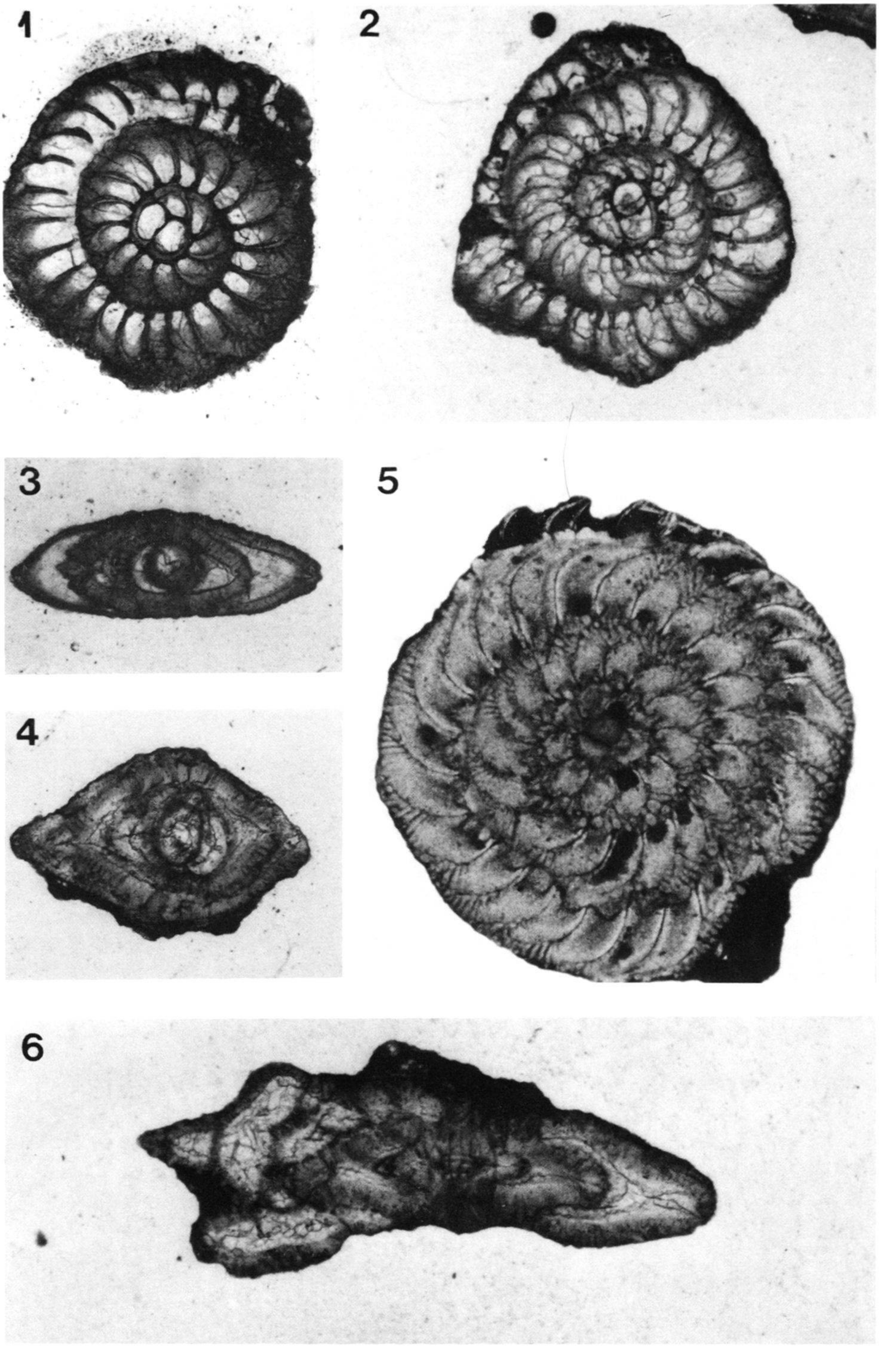
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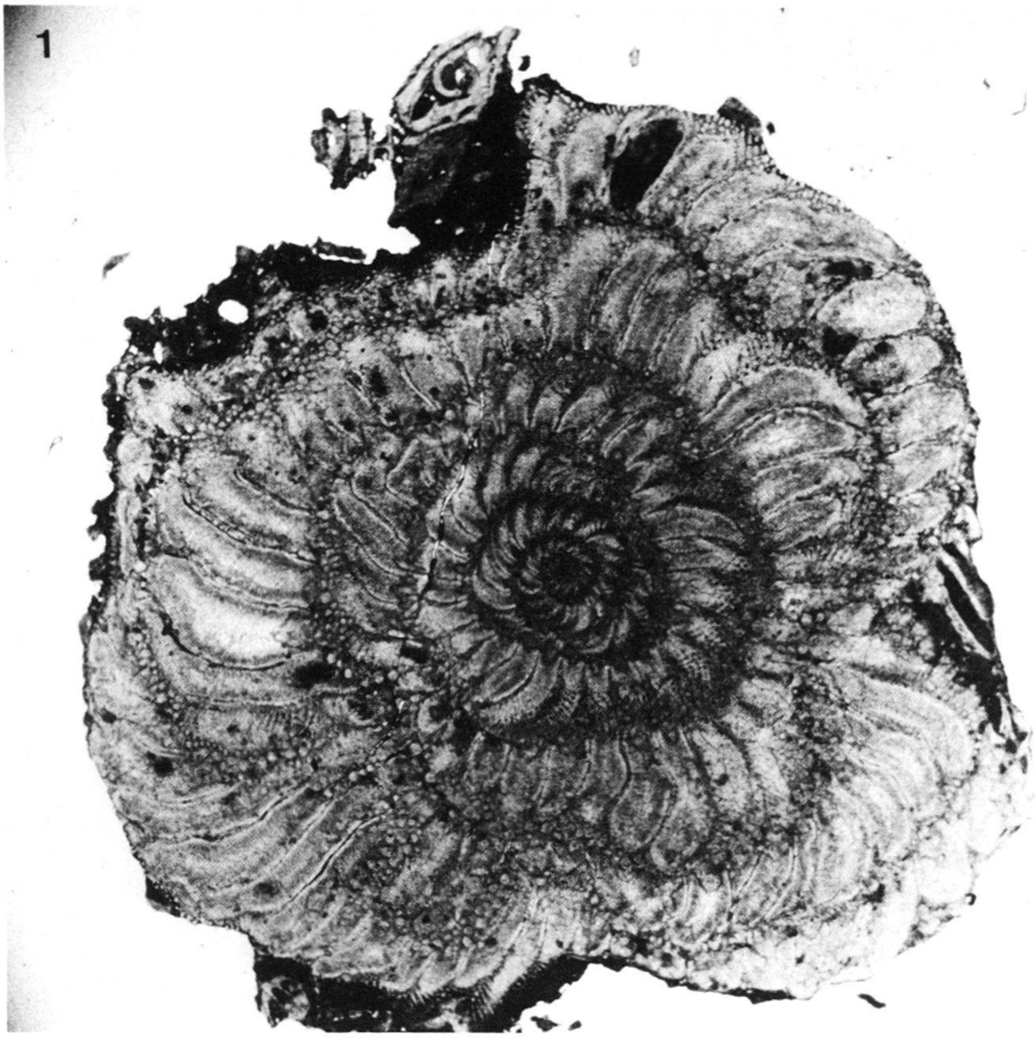
Plate 8

Miscellanea miscella, microspheric. – × 10 × 20

Fig. 1 Equatorial. Note fine pillars and marginal sutural canals (bottom). Invagination of several whorls which results in a very irregular spiral. Ranikot Limestone, Hyderabad, Pakistan. Section Pr 3315.

Fig. 2 Equatorial. Note irregular spiral. Ranikot Limestone, Dak Pass, Salt Range, Pakistan. Section 13624.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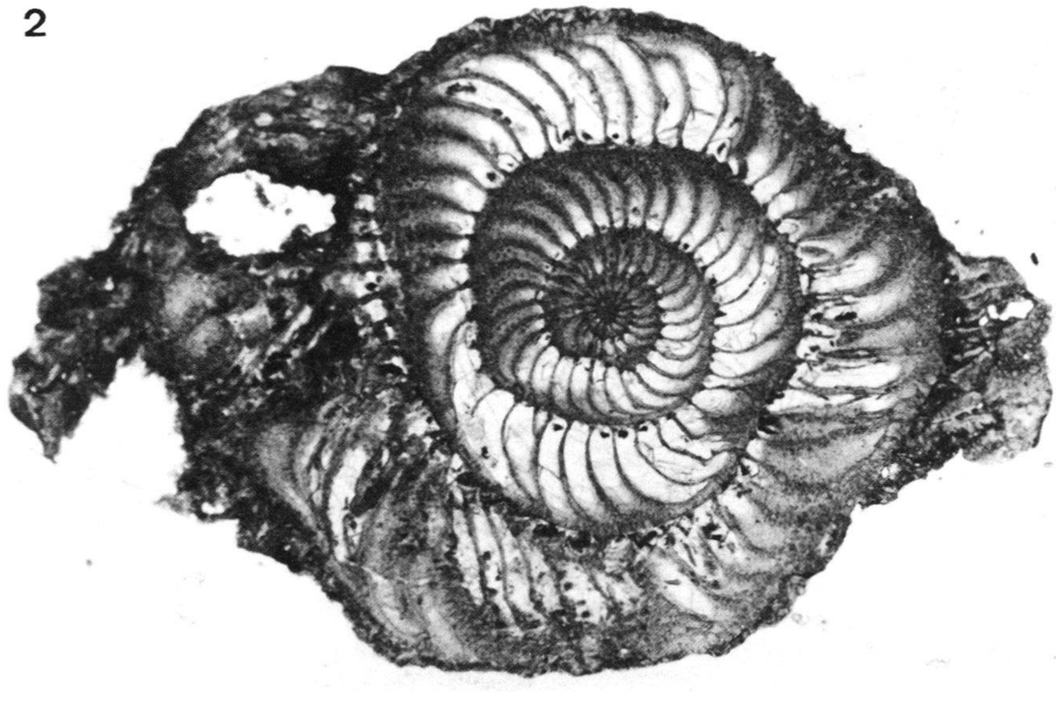
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