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Radiolarian assemblage in the Monte Alpe Cherts at Ponte di Lagoscuro, Val Graveglia (Eastern Liguria, Italy)

By MAURIZIO CONTI[1]) and MARTA MARCUCCI[2])

ABSTRACT

The Jurassic formation of Monte Alpe Cherts is the lowest unit in the sedimentary cover of ophiolites and ophiolite breccias in the Northern Apennines. A section of this formation has been studied at Ponte di Lagoscuro, Val Graveglia (Liguria), and an exceptionally rich radiolarian assemblage of middle Callovian age has been isolated from chert nodules in its lower part. Several new species are described in this assemblage.

RÉSUMÉ

Les jaspes du Monte Alpe, d'âge jurassique, sont la formation pélagique la plus ancienne dans la couverture sédimentaire des ophiolites et des brèches ophiolitiques de l'Apennin du Nord. Une série de cette formation à été étudiée près du Ponte di Lagoscuro, Val Graveglia (Ligurie) et une riche association de radiolaires d'âge Callovian moyen à été isolée d'un nodule silicieux de se partie inférieure. Plusieurs espèces nouvelles ont été réconnues dans cette association.

1. Introduction

The present paper is part of a research on Jurassic radiolarian biostratigraphy in the Apennines, regarding both the oceanic sequences (Ligurid sequences) and the sequence of the continental margin (Tuscan sequence). The purposes of this research are the definition of radiolarian taxonomy and evolution as well as the dating of initial siliceous deposits above carbonate formations (Tuscan Sequence) and ophiolites (Ligurid Sequences); ten sections have been so far examined in the Ligurid Sequences (BONECHI 1980; CONTI et al. 1985; PICCHI 1985; ABBATE et al. 1986; CONTI & MARCUCCI 1986; NOZZOLI 1986; MARCUCCI et al. 1987; CONTI et al. 1988), one in the Tuscan Sequence (CONTI 1986).

The Val Graveglia section belongs to the formation of Monte Alpe Cherts, which is the lowest lithostratigraphic unit in the sedimentary cover of ophiolites and ophiolite breccias in Ligurid Sequences. This formation consists of radiolarian ribbon cherts, generally red, and siliceous shales. The basal section of the formation is often shaly and manganese-bearing, sometimes with thin levels of ophiolite sandstones.

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The Monte Alpe Cherts constitute the oldest dated pelagic deposit in the basin with oceanic crust which developed during Jurassic between the diverging continental plates of Adria and Europe. The floor of this oceanic basin was constituted by largely serpentinized ultramafics discontinuously covered by ophiolitic breccias and discontinuous basalt flows, with thin intercalated lenses of siliceous shales and cherts. The Monte Alpe Cherts rest on top of either basalts or breccias. Basalts often shows pillow structure. Breccias may constitute coarse and thick levels or be reduced to a thin ophicalcite cover on top of serpentinite. The Monte Alpe Cherts show a remarkable lateral variability in both lithology and thickness (0 to above 200 m). The age of their base is also variable (Abbate et al. 1986; Marcucci et al. 1988).

The Monte Alpe Cherts are overlain by the pelagic Calpionella Limestones (Berriasian; see Andri & Fanucci 1973, 1975) and then by the Palombini Shales, a shaly-calcareous-arenaceous turbidite formation whose basal age ranges from Berriasian to Valanginian.

The absence of Calpionella Limestones can make the Palombini Shales to come in contact with the Monte Alpe Cherts. This lateral variability in ophiolites and their sedimentary cover is suggestive of a rugged floor due to oceanic tectonics. For more detailed stratigraphical and tectonic accounts of this areas, reference can be made to Decandia & Elter 1972; Abbate et al. 1980a; Abbate et al. 1980b; also see Cortesogno et al. 1987).

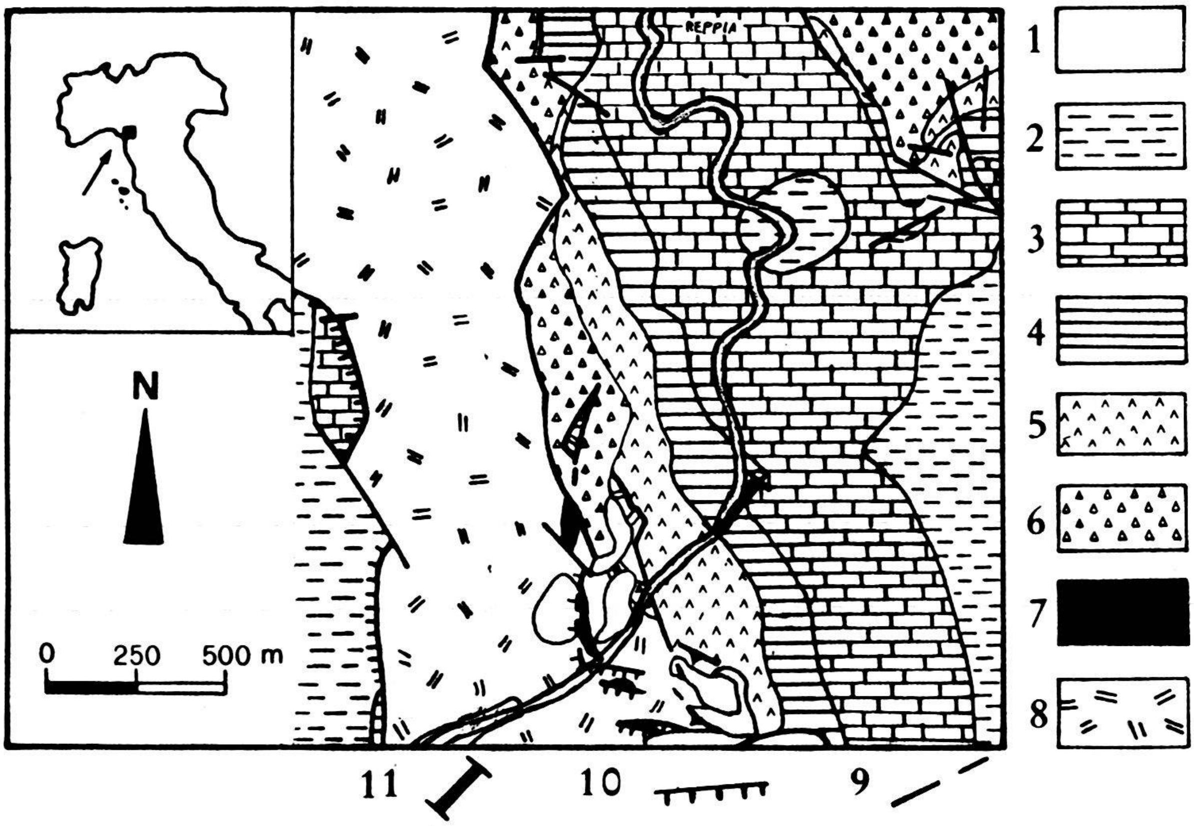

Fig. 1. Schematic geological map of Val Graveglia area (from Abbate et al. 1980a). 1) Alluvium; 2) Palombini Shales; 3) Calpionella Limestones; 4) Monte Alpe Cherts; 5) Basalts: pillow lavas and pillow breccias; 6) Monte Capra Breccias; 7) Gabbros; 8) Serpentinites; 9) Faults; 10) Trust fault; 11) Location of the section.

The section examined at Ponte di Lagoscuro in Val Graveglia (Fig. 1) belongs to the "Internal Ligurids" (Piccardo 1977) and more specifically to the Val di Vara Supergroup (Abbate & Sagri 1970), which locally constitutes the uppermost tectonic unit in the nappe edifice of the Northern Apennines. The Monte Alpe Cherts are here part of a complex pile of eastward verging recumbent folds at the interior of the Vara Supergroup involving ophiolites and their sedimentary cover (Monte Alpe Cherts, Calpionella Limestones and Palombini Shales; see later).

2. Description of the section

The examined section outcrops at Ponte di Lagoscuro (Val Graveglia) along the road from Frisolino to Reppia.

In comparison with the average composition of the Monte Alpe Cherts, this section is particularly poor in typical radiolarian cherts, being mainly constituted by more or less siliceous shales. The latter are generally unfossiliferous. Radiolarians are present in samples from rare cherty levels, but they are badly preserved with the only exception of sample GR 6 in the lower part of the section, which yielded an exceptionally rich and well preserved radiolarian assemblage. This assemblage is the subject of the present paper.

From bottom to top, the section includes (Fig. 2):

1) pillow basalts overlain by basalt breccias;
2) The Monte Alpe Cherts constituted by:
   - 5 m of gray siltstones and/or tuffites with some chert intercalations (GR 21) toward their top;
   - 80 cm of fine breccia made of gabbro clasts;
   - 6 m of reddish siliceous shales with a level of gabbro sandstone in their middle;
   - about 90 m of reddish siliceous shales with scattered levels of radiolarian cherts. The rich radiolarian assemblage of sample GR 6 (see above) comes from a cherty nodule about 6 m from the base of this level. Scattered chert nodules recur in the same zone. Other chert levels yielded unidentifiable radiolaria (GR 22, GR 23), or badly preserved and poorly significant radiolarian assemblages (GR 24). The uppermost 30 meters are partly soil covered. The original thickness of these shales is altered by local isoclinal folding.
   - 40 m of yellowish to reddish siliceous shales with scattered beds of graded silicified arenites, which may have been originally calcareous.
3) The Calpionella Limestones. A transition zone occurs between the Monte Alpe Cherts and the latter formation, where red to green shales alternate with limestones along some meters of thickness. *Calpionella alpina* Lorenz 1902 and *Calpionellopsis oblonga* (Cadisch 1932) from the lower levels of Calpionella Limestones indicate a Middle-Late Berriasian age (CL 6). Tectonic disturbances are present 1.50 m above the lowest limestones layer.

3. Methods

The Radiolarians have been extracted from cherts by attack in hydrofluoric acid (Dumitrica 1970; Pessagno & Newport 1972; De Wever et al. 1979; De Wever

1982). The dilution of hydrofluoric acid most suitable for the local chert lithology proved to be 2%. The attack lasted for 72 hours.

4. Radiolarian assemblages

GR 24 species list: *Andromeda* sp., *Hsuum* sp., *Mirifusus* sp.

GR 6 species list: *Acaenyotile* sp. aff. *A. diaphorogona dentata* BAUMGARTNER 1984, *Acaenyotile diaphorogona variata* OZVOLDOVA 1979, *Acanthocircus suboblongus* (YAO 1972), *Acanthocircus* cf. *A. trizonalis* (RÜST 1898), *Acanthocircus protoformis* (YAO 1972), *Alievium* (?) sp. A, *Andromeda podbielensis* (OZVOLDOVA 1979), *Andromeda* sp. aff. *A. praepodbielensis* BAUMGARTNER 1984, *Angulobracchia* sp. H, *Archaeodyctiomitra* sp., *Archaeospongoprunum* sp., *Archaeospongoprunum imlayi* PESSAGNO 1977, *Bernoullius cristatus* BAUMGARTNER 1984, *Bernoullius* cf. *B. cristatus* BAUMGARTNER 1984, *Bernoullius* sp. A in GORICAN 1987, *Bernoullius* sp. C, *Bernoullius* sp. D, *Bernoullius leporinus leporinus* n. sp., *Bernoullius leporinus rotundus* n. ssp., *Emiluvia hopsoni* PESSAGNO 1977, *Emiluvia premyogii* BAUMGARTNER 1984, *Emiluvia*

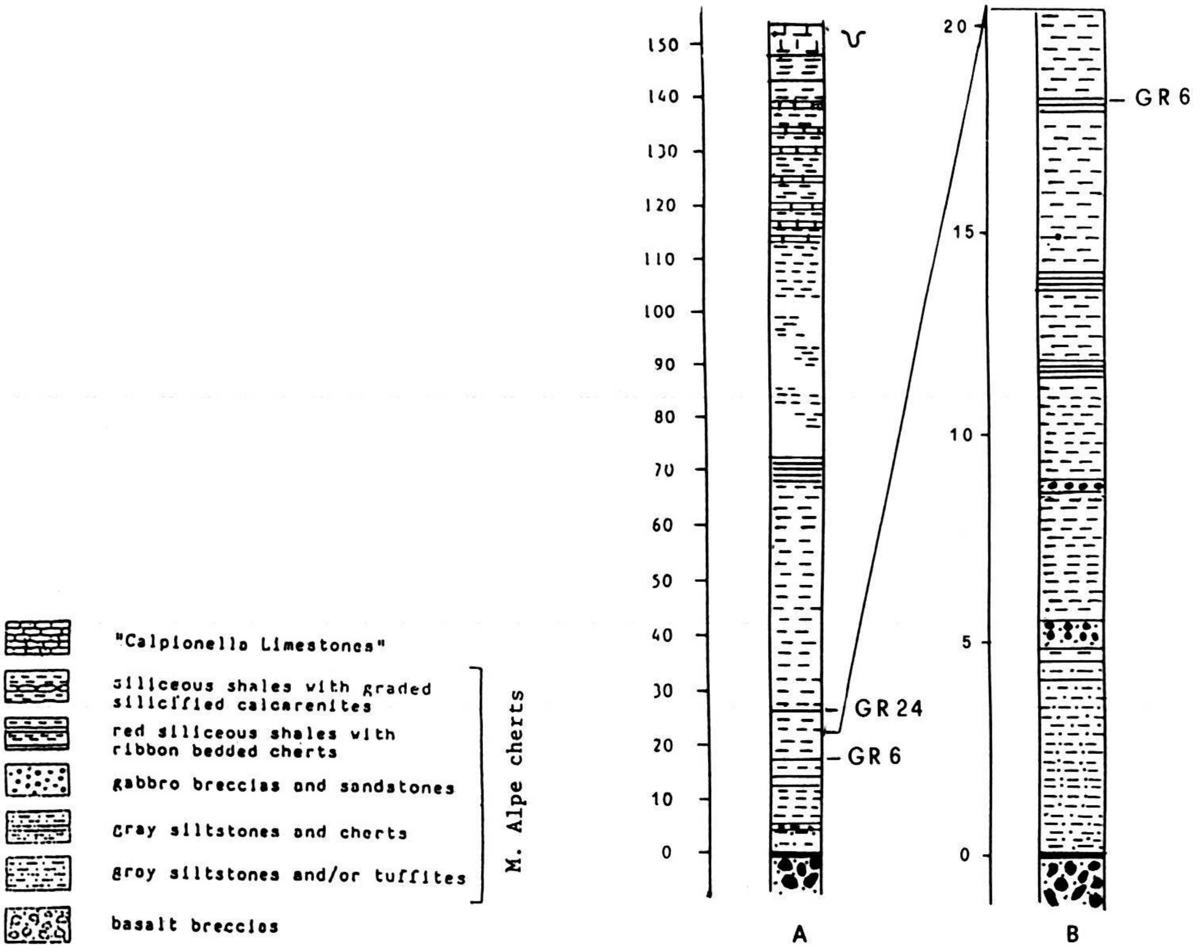

Fig. 2. A) Lithological column of Ponte di Lagoscuro section. B) Detail of the basal part of the section. Isoclinal folding in shales and cherts has not been represented.

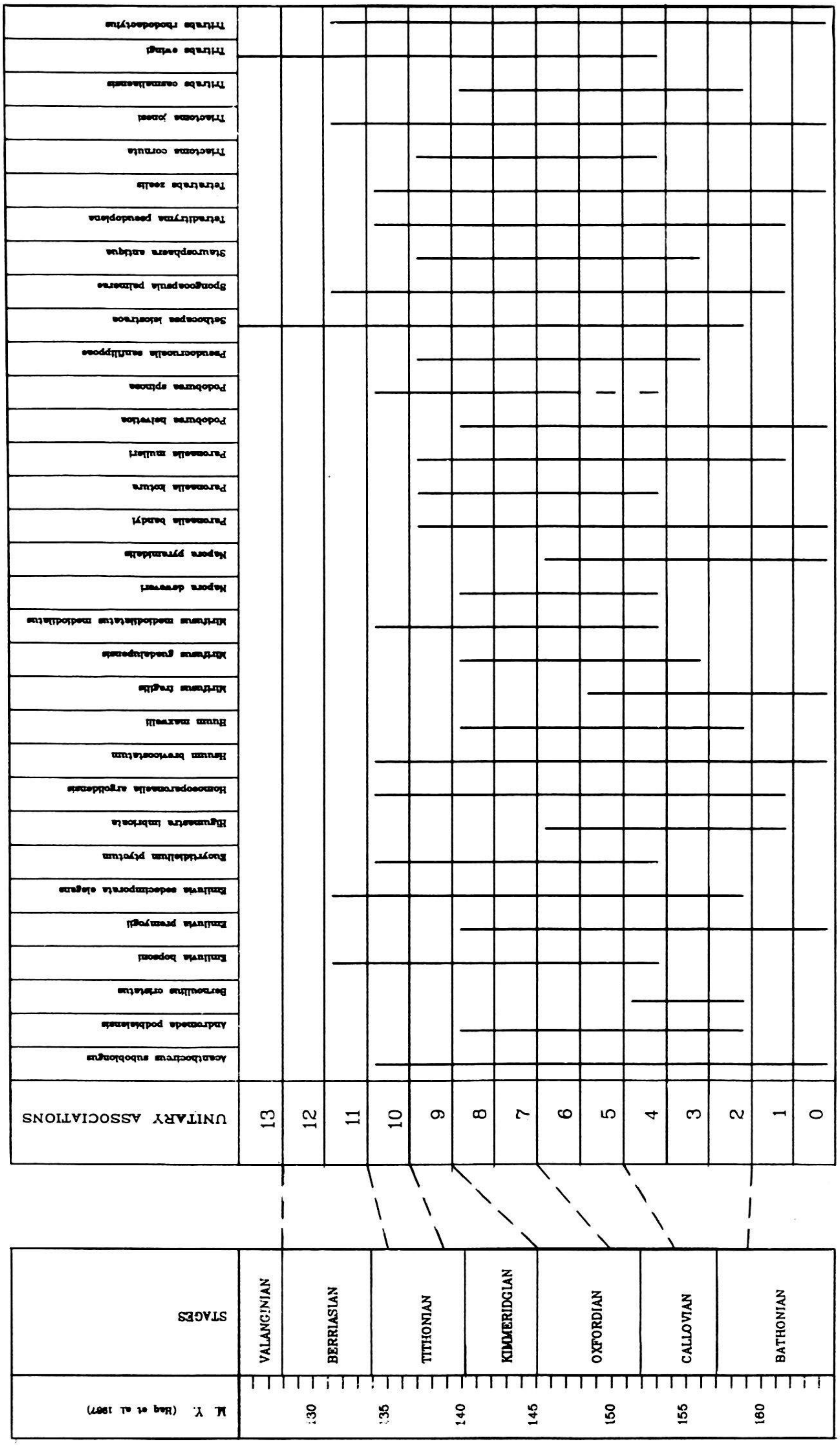

Fig. 3. Stratigraphic range of Radiolaria occurring in GR 6.
Dashed line in *Podobursa spinosa* indicates the interval where its presence is uncertain. Unitary Association and correlation with Stages after BAUMGARTNER 1987.

sedecimporata elegans (Wisniowski 1889), *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo 1974), *Eucyrtis* sp. J, *Eucyrtis* sp. B, *Eucyrtis* sp. C, *Halesium* sp. B in Baumgartner 1980, *Hexalonche* (?) sp. B, *Hexastylus* (?) *tetradactylus* n. sp., *Higumastra imbricata* (Ozvoldova 1979), *Higumastra* aff. *H. imbricata, Higumastra* sp. A in Baumgartner 1980, *Homoeoparonaella argolidensis* Baumgartner 1980, *Hsuum brevicostatum* (Ozvoldova 1975), *Hsuum maxwelli* Pessagno 1977, *Mirifusus fragilis* Baumgartner 1984, *Mirifusus* sp. aff. *M. fragilis* Baumgartner 1984, *Mirifusus guadalupensis* Pessagno 1977, *Mirifusus mediodilatatus mediodilatatus* (Rüst 1885), *Napora deweveri* Baumgartner 1980, *Napora pyramidalis* Baumgartner 1980, *Napora* sp. A aff. *N. pyramidalis* Baumgartner 1984, *Pantanellium* sp., *Paronaella kotura* Baumgartner 1980, *Paronaella* sp. cf. *Paronaella* (?) spp. in Baumgartner 1980, *Paronaella bandyi* (Pessagno 1977, *Paronaella mulleri* Pessagno 1977, *Paronaella pygmaea* Baumgartner 1980, *Perispyridium ordinarium* (Pessagno 1977), *Podobursa helvetica* (Rüst 1885), *Podobursa* sp. 1 De Wever et al. 1986, *Podobursa* sp. 1 aff. *P. helvetica* (Rüst 1885), *Podobursa spinosa* (Ozvoldova 1975), *Podobursa triacantha* group (Fischli 1916), *Podocapsa* (?) *hexaptera* n. sp., *Pseudocrucella* cf. *P. sanfilippoae* (Pessagno 1977), *Septinastrum* sp. in Ozvoldova 1975, *Sethocapsa leiostraca* Foreman 1973, *Sethocapsa trachyostraca* Foreman 1973, *Spongocapsula palmerae* (Pessagno 1977), *Staurosphaera antiqua* (Rüst 1885), *Tetraditryma pseudoplena* Baumgartner 1980, *Tetraditryma* sp. aff. *T. corralitosensis* (Pessagno 1977), *Tetratrabs zealis* (Ozvoldova 1979), *Triactoma cornuta* (Baumgartner 1980), *Triactoma jonesi* (Pessagno 1977), *Triactoma* sp. 1, *Tritrabs casmaliaensis* (Pessagno 1977), *Tritrabs ewingi* (Pessagno 1977), *Tritrabs* gr. *rhododactylus* (Baumgartner 1980), *Tritrabs* sp. *A* aff. *T. rhododactylus* (Pessagno 1977), *Turanta* sp. (Pessagno & Blome 1980).

5. Systematics

All forms are listed in the preceding paragraph; morphotypes belonging to already described species are not described further whereas a complete description is given only for new species; remarks are presented for forms which are atypical or of uncertain attribution.

Genus *Acaeniotyle* Foreman

Acaeniotyle Foreman 1973, p. 258.
Type species. Xiphosphaera umbilicata Rüst 1898.

Acaenyotile sp. aff. *Acaeniotyle diaphorogona* Baumgartner 1984

Plate 1, Fig. 1

Acaeniotyle diaphorogona Foreman 1973, p. 258, Pl. 2, Fig. 2–5. Foreman 1975, Pl. 2F, Fig. 1–3, Pl. 3, Fig. 1–2.
Acaeniotyle sp. aff. *A. diaphorogona* Foreman 1973, Pl. 2, Fig. 6–7, Pl. 16, Fig. 16. Foreman 1975, p. 607, Pl. 1F, Fig. 1. Yao 1984, Pl. 3, Fig. 24.
Tripocyclia sp. aff. *T. trigonium* Rüst, Pessagno 1977, p. 80, Pl. 7, Fig. 8–9.

Acaeniotyle diaphorogona FOREMAN, MUZAVUR 1977, p. 34, Pl. 1, Fig. 1. MIZUTANI 1981, p. 175, Pl. 61, Fig. 1–2. DE WEVER & THIÉBAULT 1981, p. 582, Pl. 2, Fig. 7. KANIE et al. 1981, Pl. 1, Fig. 1. AOKI 1982, Pl. 1, Fig. 1. ORIGLIA, in DE WEVER & ORIGLIA 1982, p. 36, Pl. 1, Fig. 1–2. EL KADIRI 1984, p. 16, Pl. 1, Fig. 10–11. SCHAAF 1984, pag. 36, Fig. 1–5. BAUMGARTNER 1984, Pl. 1, Fig. 1–2.

Remarks. This specimen differs from subspecies *A. diaphorogona dentata* BAUMGARTNER 1984 in having shorter and thicker spines. It may represent a transitional form between *A. diaphorogona diaphorogona* and *A. diaphorogona dentata* (first appearance in Berriasian).

Genus *Alievium* PESSAGNO

Alievium PESSAGNO 1972, p. 297. FOREMAN 1973, p. 262.
Type species. Theodiscus superbus SQUINABOL 1914.

Alievium (?) sp. A

Plate 1, Fig. 6

Remarks. Flattened, subtriangular shell, with three primary spines. Variable number of secondary spines radiating from nodes. Meshwork consisting of four rounded pores comprised of bars connected to massive nodes at vertices. The attribution to genus *Alievium* is uncertain due to the absence of the typical triangular meshwork of pores.

Type locality. Ponte di Lagoscuro (GE).

Occurrence. Middle Callovian (U.A. 4).

Genus *Andromeda* BAUMGARTNER

Andromeda BAUMGARTNER, in BAUMGARTNER et al. 1980.
Type species. Andromeda crassa BAUMGARTNER (in BAUMGARTNER et al. 1980).

Andromeda aff. *A. praepodbielensis* BAUMGARTNER 1984

Plate 1, Fig. 7

Remarks. This specimen is more elongated in the proximal-distal part than *A. praepodbielensis* BAUMGARTNER; it also differs from it in having a convex basal surface.

Genus *Angulobracchia* BAUMGARTNER

Angulobracchia BAUMGARTNER 1980, p. 310.
Type species. Paronaella (?) *purisimaensis* PESSAGNO 1977.

Angulobracchia sp. H

Plate 5, Fig. 1

Remarks. This forms differs from *A. purisimaensis* (PESSAGNO 1977) for the ray tips with two longer spines lying in the plane of shell flattening, and very small secondary spines instead of a true brachiopyle.

Type locality. Ponte di Lagoscuro (GE).

Occurrence. Middle Callovian (U.A. 4).

Genus *Bernoullius* Baumgartner

Bernoullius Baumgartner 1984.
Type species. Eucyrtis (?) *dicera* Baumgartner 1980.

Bernoullius cf. *B. cristatus* Baumgartner 1984

Plate 1, Fig. 9

Remarks. These forms show a variable angle between spines, occasionally smaller than 90°. They do not show the typical teeth of *B. cristatus.*

Bernoullius sp. A in Gorican

Plate 1, Fig. 14, 16

Bernoullius sp. A in Gorican 1987, Pl. 1, Fig. 17.

Remarks. Rectangular test, with two straight spines.

Bernoullius sp. C

Plate 1, Fig. 13

Remarks. These forms show a rounded body, with two upward curved spines.

Bernoullius sp. D

Plate 1, Fig. 15

Remarks. This form has a rounded body and two very short spines.

Bernoullius leporinus leporinus new species

Plate 1, Fig. 10, 12

Bernoullius sp. B in Gorican 1987, Pl. 1, Fig. 18.

Description. Large form with rounded spongy body and two stout straight spines. The spines are triradiate and end with a thinner sting. They form an angle of 80°–110°. In some specimens is developed a system of three primary and three secondary narrower grooves on each spine. A short "neck" is present at the junction of spines with the body.

The body is finely spongy and some elongated pores are present at the base of spines. The spongy body is flat in lateral view and becomes thicker in the distal part, with a bellows-like outline.

Measurement of 20 specimens (μm):	Average	Min.	Max.	Holotype
Width between the end of two spines:	347	239	459	459
Width of spines at base:	57	48	73	64
Length of spines:	244	187	333	312
Length of spongy body:	252	204	300	282
Thickness of spongy body in the distal part:	60	35	87	65
Angle between the two spines:	87°	75°	110°	83°
Width of neck:	178	130	216	167

Remarks. This form differs from *B. dicera* and *B. cristatus* BAUMGARTNER for the two straight spines, the larger size and the round form of the body; from *B. rectispinus* KITO (unpublished, personal communication) for the round form of the body, the width of the neck and the larger size. It also differs from *Spongiostoma saccideum* CARTER et al. 1988 for the presence of a neck instead of a short hinge, the shape and the width of the two spines always markedly triradiate. The genus *Spongiostoma* CARTER et al. 1988 may be an ancestor of *Bernoullius.*

Etymology [latin]. *Leporinus (lepus, leporis* = hare), with two spines like ears of hare.

Type locality. Ponte di Lagoscuro.

Specimen number of holotype. IGF 3375E (Paleontologic Museum, University of Florence), Holotype deposited in Marcucci Collection, University of Florence.

Occurrence. Middle Callovian (U.A. 4).

Bernoullius leporinus rotundus new subspecies

Plate 1, Fig. 11

This form is similar to *B. leporinus leporinus* n. sp., but differs from it for a rounded outline rather than a bellow-like one.

Measurement of 5 specimens (µm):	Average	Min.	Max.	Holotype
Width between the end of two spines:	373	318	416	336
Width of spines at base:	64	55	75	75
Length of spines:	247	200	300	245
Length of spongy body:	243	215	293	225
Thickness of spongy body in the distal part:	87	75	120	75
Angle between the two spines:	96°	88°	102°	96°
Width of neck:	135	100	190	100

Remarks. This subspecies differs from *B. leporinus leporinus* for the following characters: in lateral view the spongy body shows a rounded outline rather than a bellow-like one; the size is smaller; the neck at the junction of spines is narrower and the base of each spine is nearer the other.

Etymology [latin]. *Rotundus, -a, -um,* = rounded, due to the rounded outline.

Type locality. Ponte di Lagoscuro.

Specimen number of holotype. IGF 3376E (Paleontologic Museum, University of Florence), Holotype deposited in Marcucci Collection, University of Florence.

Occurrence. Middle Callovian (U.A. 4).

Genus *Eucyrtis* HAECKEL

Eucyrtis HAECKEL 1881.

Type species. Eucyrtis hexagonatum HAECKEL 1882.

Eucyrtis sp. J aff. *E. micropora*

Plate 2, Fig. 1, 2

Remarks. This form presents thin spines at the segmental divisions. Pores are round and regularly spaced in transverse rows.

Pores of the distal part are larger than those of the proximal part; in the median part of the shell, where the diameter begins to diminish in the distal direction, there is a row of still larger, round pores.

This form differs from *E. micropora* (FOREMAN 1973) in having thin spines arranged in transverse rows, probably corresponding to the segmental division, and for the more regular arrangement of pores.

Occurrence. Middle Callovian (U.A. 4).

Eucyrtis sp. B aff. *E. tenuis*

Plate 2, Fig. 3, 4

Remarks. In this species, segmentation is not expressed in the outline. The cephalis bears a horn. Maximum diameter is markedly shifted towards the proximal part. Pores in the proximal part show an irregular pattern, giving place in distal direction to two transverse rows and then to sinuous axial rows. The size of this form (1,000 µm) is double than that of *E. tenuis* (Hauterivian-Aptian, FOREMAN 1975; SANFILIPPO & RIEDEL 1985), to which this form is comparable from other points of view.

Occurrence. Middle Callovian (U.A. 4).

Eucyrtis sp. C

Plate 2, Fig. 5

Remarks. The shell is short and inflated, with long spines.

Genus *Hexalonche* HAECKEL, emend. KOZUR & MOSTLER

Hexalonche HAECKEL 1882, emend. KOZUR & MOSTLER 1979.
Type species. Hexalonche.

Hexalonche (?) sp. B

Plate 4, Fig. 16

Remarks. The central shell consists of an outer layer and an inner layer both with irregular polygonal meshes with large pores and thick bars. Six triradiate spines arise from the central body with large, irregular pores and strong bars at the junction with the outer layer.

Type locality. Ponte di Lagoscuro (GE).

Occurrence. Middle Callovian (U.A. 4).

Genus *Hexastylus* HAECKEL

Hexastylus HAECKEL 1881.
Type species. Hexastylus primaevus RÜST 1885.

Hexastylus (?) *tetradactylus* new species

Plate 3, Fig. 10, 11

Description. Central spherical shell constituted by an outer layer with an irregular network of large pores and an inner layer with smaller pores; these are visible through the larger pores of the outer layer. The test bears six large radial spines with longitudinal grooves and ridges; these principal spines terminate with three thinner lateral secondary spines and a still shorter axial one.

Measurement of 4 specimens (µm):	Average	Min.	Max.	Holotype
Maximum diameter of the central shell:	218	200	230	215
Length of principal spines:	140	125	150	140
Length of lateral spines:	100	60	130	130

Remarks. The double-layer pore meshwork of *Hexastylus* (?) *tetradactylus* distinguishes this species from *H. grandiporus* SQUINABOL 1902, in which a simple meshwork of pores is present. The termination of spines in these two species cannot be compared since they are not preserved in the specimen of *H. grandiporus* described by SQUINABOL.

Hexastylus (?) *tetradactylus* is comparable with *H. ombonii* SQUINABOL 1902 for the double layer pore meshwork, but it differs from this species in the length and shape of spines.

The assignement to genus *Hexastylus* is provisional, since most species of this genus show a simple meshwork of pores (BLUEFORD 1982).

Etymology [greek]. *Tetra* (prefix from *tétteres* = four) + *dàktylos* = finger.

Type locality. Ponte di Lagoscuro.

Specimen number of holotype. IGF 3084E (Paleontologic Museum, University of Florence), Holotype deposited in Marcucci Collection, University of Florence.

Occurrence. Middle Callovian (U.A. 4).

Genus *Mirifusus* PESSAGNO, emend. BAUMGARTNER

Mirifusus PESSAGNO 1977, p. 83 emend. BAUMGARTNER 1984, p. 769.
Type species. Mirifusus guadalupensis PESSAGNO 1977.

Mirifusus fragilis BAUMGARTNER

Plate 2, Fig. 10, 11, 15, 16

?*Mirifusus* (?) sp. aff. *M.* (?) *mediodilatatus* RÜST, PESSAGNO 1977, p. 84, Pl. 11, Fig. 3.
Mirifusus aff. *guadalupensis* PESSAGNO, YAO et al. 1982, Pl. 4, Fig. 24. YAO 1983, Fig. 3, 8.
?*Mirifusus* sp. A KIDO et al. 1982, Pl. 3, Fig. 1–2, 4. AITA 1982, Pl. 2, 13.
Mirifusus fragilis BAUMGARTNER 1984, p. 770, Pl. 5, Fig. 12, 16–17, 20–21. DE WEVER & MICONNET 1985, p. 387, Pl. 5, Fig. 3.

Remarks. A specimen shows irregularities in the distribution of transverse ridges and pore rows, possibly due to an accidental fracture and imperfect sealing of the shell (as suggested by De Wever and Miconnet, 1985).

Mirifusus sp. aff. *M. fragilis*

Plate 2, Fig. 13, 14, 17, 18

Remarks. These forms show an inner layer with three rows of circular pores and an outer layer with diagonal bars forming a triangular pattern. According to BAUMGARTNER (1984), this structure of the external layer is better developed in the late forms of *M. fragilis*. This form cohexist with typical *M. fragilis*.

Genus *Napora* PESSAGNO

Napora PESSAGNO 1977, p. 94.
Type species. Napora bukryi PESSAGNO 1977.

Napora sp. A aff. *N. pyramidalis*

Plate 3, Fig. 3

Remarks. This form differs from *N. pyramidalis* for the feet longer and more curved inward. The long triradiate horn ends with one central and three lateral points and a smaller central area.

Genus *Podobursa* RÜST, emend. FOREMAN

Podobursa WISNIOWSKI 1889, p. 686, emend. FOREMAN 1973, p. 266.
Type species. Podobursa dunikowskii WISNIOWSKI 1889.

Podobursa sp. 1 aff. *P. helvetica*

Plate 3, Fig. 8

Remarks. These forms (5 specimen) are distinguished from the typical form by the presence of spines irregularly scattered rather than aligned along the equatorial circle. Moreover these spines are longer and more numerous than in the typical form.

Podobursa spinosa (OZVOLDOVA)

Plate 3, Fig. 6

Indeterminatum in HEITZER 1930, p. 309, Pl. 27, Fig. 7.
Podobursa pantanellii (PARONA), RIEDEL & SANFILIPPO 1974, p. 779, Pl. 8, Fig. 5, Pl. 13, Fig. 6.
Heitzeria spinosa OZVOLDOVA 1975, p. 78, Pl. 101, Fig. 2.
Podobursa berggreni PESSAGNO 1977, p. 90, Pl. 12, Fig. 1–5.
Podobursa spinosa (OZVOLDOVA), OZVOLDOVA 1979, p. 256, Pl. 2, Fig. 4. BAUMGARTNER et al. 1980, p. 60, Pl. 3, Fig. 10. KOCHER 1981, p. 85, Pl. 15, Fig. 18.
Not *Podocapsa pantanellii* PARONA 1890, p. 164, Pl. 5, Fig. 8.

Remarks. Different ages are given for the appearance of this species by different authors (DE WEVER et al. 1986 and KOCHER 1981, Late Callovian; BAUMGARTNER 1984 and 1987, U.A. 6 Callovian-Oxfordian boundary). The coexistence of this species with *Bernoullius cristatus* in the examined sample indicates its presence already in the Middle Callovian. The appearance of *P. spinosa* in Callovian is confirmed by its association with *M. fragilis* (U.A. 0–5).

Podobursa sp. 1 De Wever et al. 1986

Remarks. This specimen presents very short spines.

Genus *Podocapsa* Rüst

Podocapsa Rüst 1885, p. 304, emend. Foreman 1973, p. 267.
Type species. Podocapsa guembeli Rüst 1885.

Podocapsa (?) *hexaptera* new species

Plate 3, Fig. 12, 13, 14, 16, 17, 18

Description. The shell shows two distinct parts: a hemispherical small proximal part without apparent segmental division but possibly including cephalis and thorax, and a large and flat abdomen with six porous wings, lacking a terminal tube. None of the available specimens show a horn on the proximal part referable to cephalis. The proximal part presents loosely scattered pores smaller than those of the abdomen and wings. The abdomen shows circular uniformly distributed pores. Six conical wings are seated along the equatorial zone of the abdomen; they show pores similar to those of abdomen.

Measurement of 5 specimens (µm):	Average	Min.	Max.	Holotype
Maximum measured length of wings*:	120	90	160	100
Width of wings:	38	30	50	35
Diameter of abdomen:	140	125	200	135
Approximate length of distal + proximal parts:	80	79	81	80

* generally partially broken

Remarks. This species differs from *P. amphitreptera* in the flat rather than globose shape of the distalmost segment, in having six equatorial wings and lacking a terminal tube.

Its tentative assignement to genus *Podocapsa* is based on the presence of porous wings and of a broad distalmost segment.

Etymology [greek]. *Hexa* = six, + *pteron* = wing.

Type locality. Ponte di Lagoscuro.

Specimen number of holotype. IGF 3083E (Paleontologic Museum, University of Florence), Holotype deposited in Marcucci Collection, University of Florence.

Occurrence. Middle Callovian (U.A. 4).

Genus *Septinastrum* Gorbovec

Septinastrum Gorbovec, in Kozlova & Gorbovec 1966.
Type species. Septinastrum.

Septinastrum sp., Ozvoldova

Plate 4, Fig. 13

Septinastrum sp. Ozvoldova 1975.

Discoidal form with seven unequal arms. The central body is spongy; the arms show pores at their base with axial alignment which in the distal portions of the arms give rise to longitudinal ridges. A horn terminates arms.

Genus *Tetraditryma* BAUMGARTNER

Tetraditryma BAUMGARTNER 1980, p. 296.
Type species. Tetraditryma pseudoplena BAUMGARTNER 1980.

Tetraditryma corralitosensis corralitosensis (PESSAGNO 1977)

Crucella (?) *corralitosensis* PESSAGNO 1977, p. 72, Pl. 2, Fig. 10–13.
Tetraditryma corralitosensis (PESSAGNO) BAUMGARTNER 1980, p. 296, Pl. 7, Fig. 12–15, Pl. 11, Fig. 13. KOCHER 1981, p. 98, Pl. 16, Fig. 31. DE WEVER & CABY 1981, Pl. 2, Fig. 2G. ISHIDA 1983, Pl. 11, Fig. 8.
Tetraditryma sp. cf. *T. corralitosensis* (PESSAGNO), WAKITA 1982, Pl. 5, Fig. 9–10.

Tetraditryma corralitosensis bifida new subspecies

Plate 4, Fig. 4, 5

Remarks. This form differs from *T. corralitosensis corralitosensis* (PESSAGNO 1977) by the shorter and less massive ray tips, terminating with two lateral short spines.

Etymology [latin]. *Bifidus, -a, -um* = forked.

Type locality. Ponte di Lagoscuro.

Specimen number of holotype. IGF 3377E (Paleontologic Museum, University of Florence), Holotype deposited in Marcucci Collection, University of Florence.

Occurrence. Middle Callovian (U.A. 4).

Genus *Triactoma* RÜST

Triactoma RÜST 1885, p. 289.
Type species. Triactoma tithonianum RÜST 1885.

Triactoma sp. 1

Remarks. This form differs from *T. jonesi* (PESSAGNO 1977) in having shorter spines.

Genus TRITRABS BAUMGARTNER

Tritrabs BAUMGARTNER 1980, p. 293.
Type species. Paronaella (?) *casmaliaensis* PESSAGNO 1977.

Tritrabs sp. A aff. *T. rhododactylus* (PESSAGNO 1977)

Plate 4, Fig. 12

Remarks. This form differs from *T. exotica,* in the size and distribution of the terminal spines at ray tips: these spines are longer and thinner than in *T. exotica,* and alternate with smaller ones; moreover their terminations are less inflated. The difference from *T. rhododactylus* consists of the regularity of the angles between the three rays.

Undetermined form

Plate 4, Fig. 14, 15

Discoidal form with 16 spines radiating from the equatorial circle. Small and randomly distributed pores give the shell a spongy appearance.

6. Conclusions

The radiolarian assemblage of sample GR 6 shows an exceptionally high taxonomic diversity.

Several new forms belong to genera *Bernoullius, Hexastylus* (?) and *Podocapsa* (?). The new species *Bernoullius leporinus leporinus, Bernoullius leporinus rotundus, Hexastylus* (?) *tetradactylus* and *Podocapsa* (?) *hexaptera* are established.

This assemblage belongs to the U.A. 4 of Baumgartner (1984, 1987). This attribution is based on the coexistence of *Bernoullius cristatus,* which ranges from U.A. 2 to the end of U.A. 4, with *Emiluvia hopsoni, Eucyrtidiellum ptyctum, Mirifusus mediodilatatus, Napora deweveri, Paronaella kotura, Triactoma cornuta* and *Tritrabs ewingi,* all appearing at the beginning of U.A. 4.

In the most recent adjustement of the radiolarian time scale given by BAUMGARTNER (1987) for the Jurassic, the U.A. approximately corresponds to the middle Callovian.

The deposition of a continuous siliceous sequence marks the end of basalt extrusion in the section at Ponte di Lagoscuro as well as in many other ophiolite sections. The middle Callovian age determined here is the oldest upper age limit so far set to basalt extrusion in a section of the Apennines.

In the Alps a similar age (U.A. 4–5) is reported by DE WEVER, BAUMGARTNER & POLINO (1987) from the cherts on the ophiolites of the Traversiera Massif.

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Plate 1

Sample GR 6

(1) *Acaeniotyle diaphorogona* aff. *A. diaphorogona dentata* 125 ×
(2) *Acaeniotyle diaphorogona variata* 70 ×
(3) *Acanthocircus suboblongus* 70 ×
(4) *Acanthocircus protoformis* 100 ×
(5) *Acanthocircus* cf. *trizonalis* 70 ×
(6) *Alievium* (?) sp. 100 ×
(7) *Andromeda* aff. *A. praepodbielensis* 80 ×
(8) *Bernoullius cristatus* 100 ×
(9) *Bernoullius* cf. *cristatus* 100 ×
(10) *Bernoullius leporinus leporinus* n. ssp. 60 ×
(11) *Bernoullius leporinus rotundus* n. ssp. 60 ×
(12) *Bernoullius leporinus leporinus* n. ssp. 90 ×
(13) *Bernoullius* sp. C 100 ×
(14) *Bernoullius* sp. A 100 ×
(15) *Bernoullius* sp. D 100 ×
(16) *Bernoullius* sp. A 125 ×
(17) *Turanta* sp. 90 ×
(18) *Emiluvia premyogii* 75 ×
(19) *Emiluvia* sp. 75 ×
(20) *Emiluvia hopsoni* 100 ×
(21) *Emiluvia hopsoni* 75 ×

Plate 1

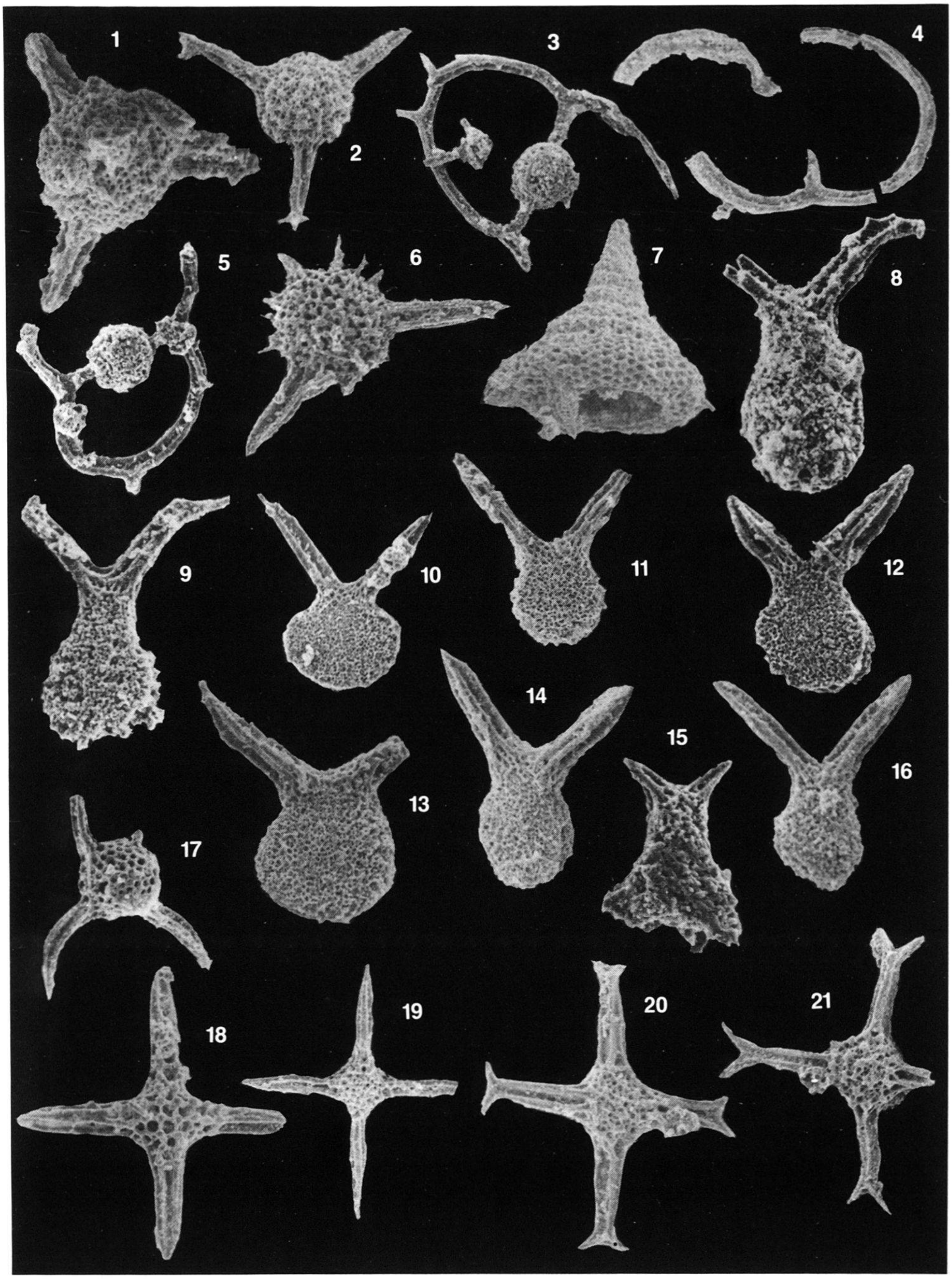

Plate 2

Sample GR 6

(1) *Eucyrtis* sp. J 100 ×
(2) *Eucyrtis* sp. J 80 ×
(3) *Eucyrtis* sp. B 60 ×
(4) *Eucyrtis* sp. B 100 ×
(5) *Eucyrtis* sp. C 200 ×
(6) *Halesium* (?) sp. B 80 ×
(7) *Higumastra* aff. *H. imbricata* 50 ×
(8) *Higumastra imbricata* 75 ×
(9) *Higumastra* sp. A 85 ×
(10) *Mirifusus fragilis* 60 ×
(11) *Mirifusus fragilis* 60 ×
(12) *Mirifusus guadalupensis* 85 ×
(13) *Mirifusus* sp. A aff. *M. fragilis* 100 ×
(14) *Mirifusus* sp. A aff. *M. fragilis* 75 ×
(15) *Mirifusus fragilis* 300 ×
(16) *Mirifusus fragilis* 200 ×
(17) *Mirifusus* sp. A aff. *M. fragilis* 300 ×
(18) *Mirifusus* sp. A aff. *M. fragilis* 200 ×

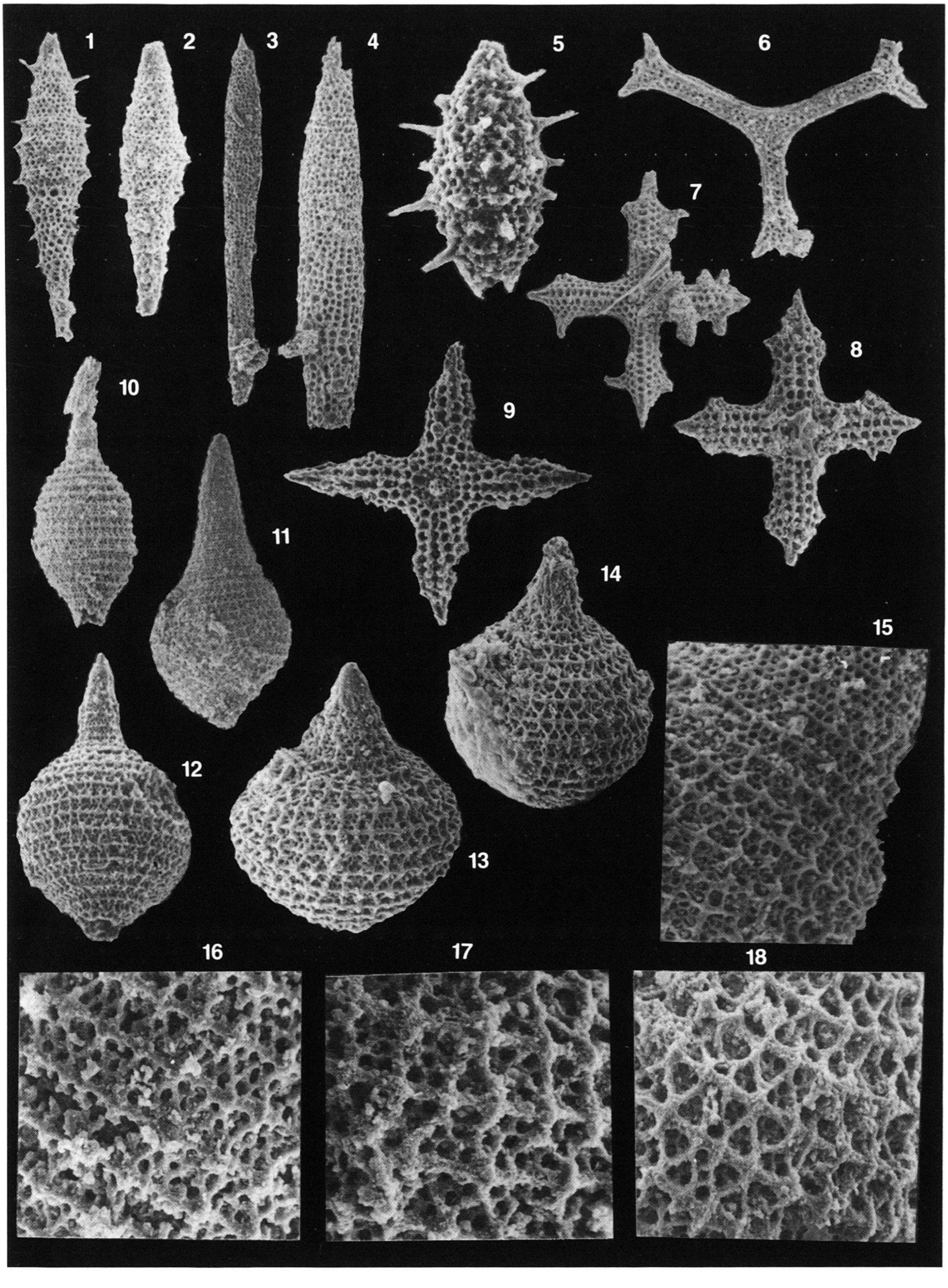
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Plate 3

Sample GR 6

(1) *Napora deweveri* 150 ×
(2) *Napora deweveri* 150 ×
(3) *Napora* sp. A aff. *N. pyramidalis* 125 ×
(4) *Napora pyramidalis* 125 ×
(5) *Paronaella kotura* 60 ×
(6) *Podobursa spinosa* 60 ×
(7) *Podobursa* group *triacantha* 100 ×
(8) *Podobursa* sp. 1 aff. *P. helvetica* 60 ×
(9) *Podobursa helvetica* 75 ×
(10) *Hexastylus* (?) *spinosus* n. sp. holotype 65 ×
(11) *Hexastylus* (?) *spinosus* n. sp. holotype 100 ×
(12) *Podacapsa* (?) *hexaptera* n. sp. holotype 150 ×
(13) *Podacapsa* (?) *hexaptera* n. sp. holotype 150 ×
(14) *Podacapsa* (?) *hexaptera* n. sp. holotype 300 ×
(15) *Podocapsa* (?) sp. aff. *P.* (?) *hexaptera* 125 ×
(16) *Podocapsa* (?) *hexaptera* n. sp. 150 ×
(17) *Podocapsa* (?) *hexaptera* n. sp. 150 ×
(18) *Podocapsa* (?) *hexaptera* n. sp. 600 ×

Plate 3

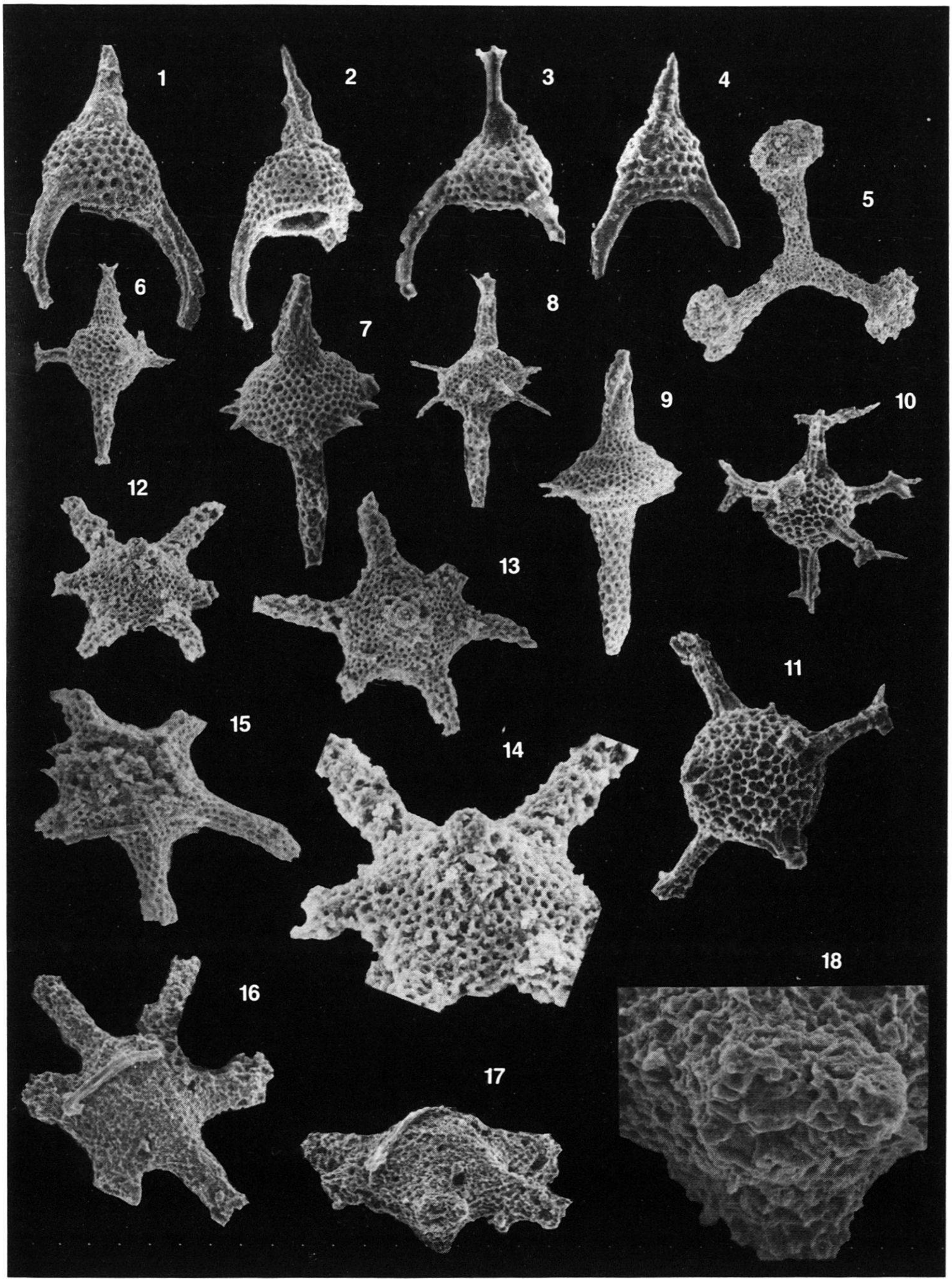
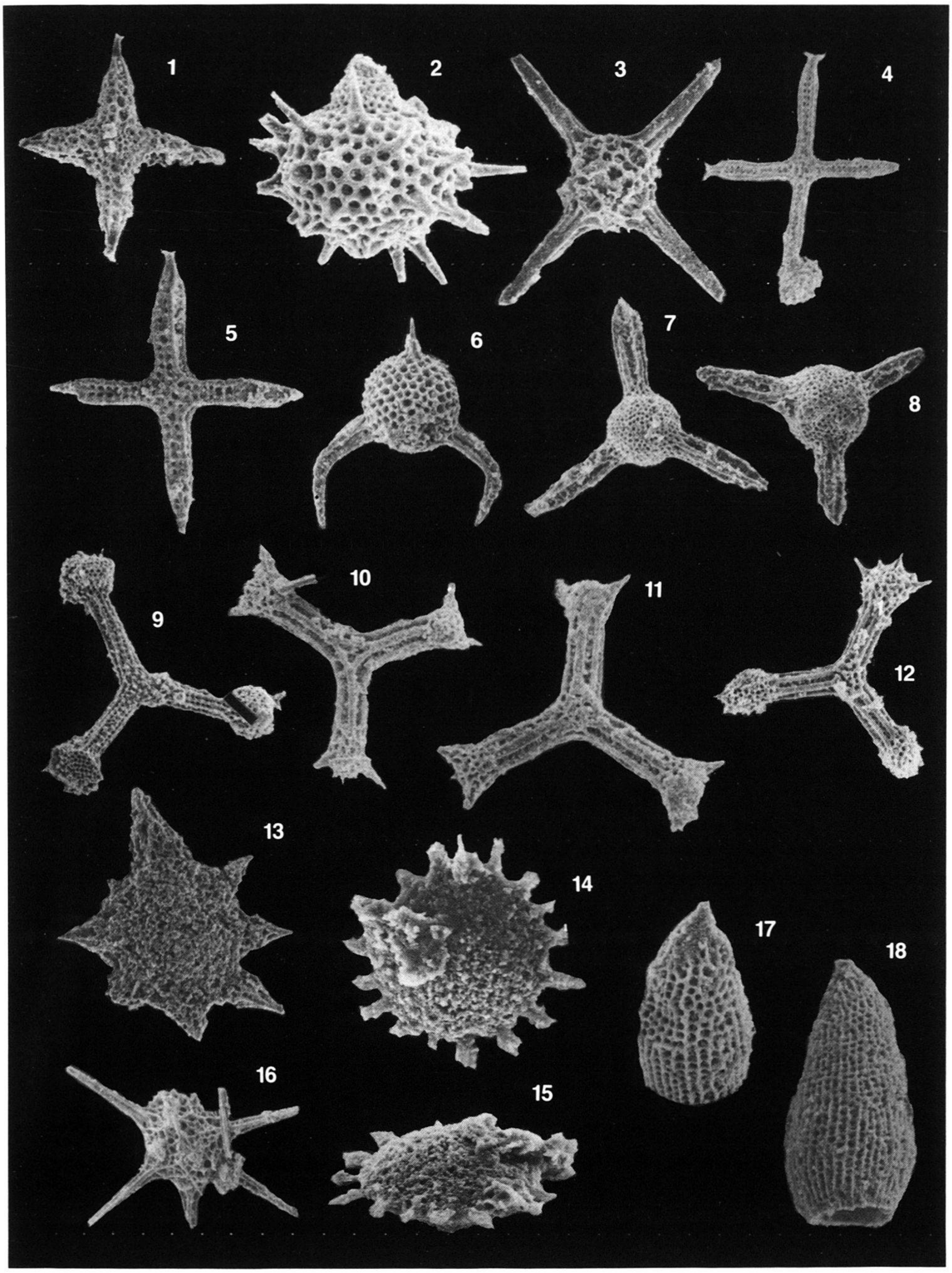


Plate 4

Sample GR 6

(1) *Pseudocrucella* cf. *sanfilippoae* 80 ×
(2) *Sethocapsa leiostraca* 150 ×
(3) *Staurosphaera antiqua* 60 ×
(4) *Tetraditryma corralithosensis bifida* n. ssp. 70 ×
(5) *Tetraditryma corralithosensis bifida* n. ssp. 100 ×
(6) *Triactoma cornuta* 70 ×
(7) *Triactoma jonesi* 60 ×
(8) *Triactoma jonesi* 60 ×
(9) *Tritrabs ewingi* 60 ×
(10) *Tritrabs rhododactylus* 80 ×
(11) *Tritrabs casmaliaensis* 90 ×
(12) *Tritrabs* sp. aff. *T. rhododactylus* 75 ×
(13) *Septinastrum* sp. 125 ×
(14) Undetermined form 175 ×
(15) Undetermined form (lateral view) 175 ×
(16) *Hexalonche* sp. B 50 ×
(17) *Parashuum* (?) sp. 200 ×
(18) *Parashuum* (?) sp. 150 ×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