Bollettino della Società Paleontologica Italiana	23 (2)	1984	149-160	4 pls.	Modena, Settembre 1985

Middle Cambrian Foraminifera and other microfossils from SW Sardinia

Antonietta CHERCHI
Dipartimento di Scienze della Terra
Università di Cagliari

Rolf SCHROEDER
Geologisch-Paläontologisches Institut
Universität Frankfurt

KEY WORDS — Foraminifera, Algae, Sponge spicules, Echinoderms, Microproblematica, Middle Cambrian, Sardinia.

ABSTRACT — A micropaleontological study of the Nodular Limestone Member of the Middle Cambrian Cabitza Formation near Iglesias (SW Sardinia) yielded the oldest foraminifera (Astrorhizidae, Psammosphaera, Hemisphaerammina, *Ammodiscidae) known until now from Sardinia; they occur together with* Girvanella, *Chancelloriidae, hexactinellid sponge spicules and echinoderm plates. The presence of* Hadimopanella *Gedik, known from the Lower to Middle Cambrian of Turkey, the Siberian Platform and N Spain, is the first proof of this phosphatic microproblematicum in Sardinia.*

RIASSUNTO — [Foraminiferi e altri microfossili del Cambriano medio della Sardegna sud-occidentale] *— Lo studio micropaleontologico del membro del Calcare Nodulare della Formazione di Cabitza (Cambriano medio) ha messo in evidenza la presenza dei più antichi foraminiferi (Astrorhizidae,* Psammosphaera, Hemisphaerammina, *Ammodiscidae) finora conosciuti della Sardegna, associati a* Girvanella, *Chancelloriidae, spicole di spugne hexactinellidi, placche di echinodermi e di numerosi microproblematici fosfatici appartenenti al genere* Hadimopanella *Gedik, già noto nel Cambriano inferiore-medio della Turchia, della Piattaforma siberiana e della Spagna settentrionale.*

INTRODUCTION

This paper is a first and preliminar report on the discovery of foraminifera and other microfossils from the Middle Cambrian of Sardinia. Hitherto our knowledge of Sardinian Cambrian microfossils was limited on occasional quotations of Early Cambrian algae (mainly *Epiphyton* and *Renalcis*; see Cherchi & Schroeder 1985) and Early to Middle Cambrian Chancelloriidae and echinoderm remains, but no special micropaleontological investigations have been carried out.

During the preparation of the 19th European Micropaleontological Colloquium (Sardinia, 1985) a series of samples was taken in the Nodular Limestone Member of the Middle Cambrian Cabitza Formation near Iglesias (SW Sardinia). After a treatment with acetic acid (5-10%), these samples yielded a considerable quantity of microfossils, whose description is the subject of this paper.

The main results were the discovery af the hitherto oldest foraminifera from Sardinia and of the phosphatic microproblematicum *Hadimopanella,* known until now from the Early to Middle Cambrian of Turkey, of the Siberian Platform and northern Spain. The residues contain also *Girvanella* aggregates and chancelloriid archiasters. This latter group has been found also in thin sections together with hexactinellid sponge spicules and echinoderm remains.

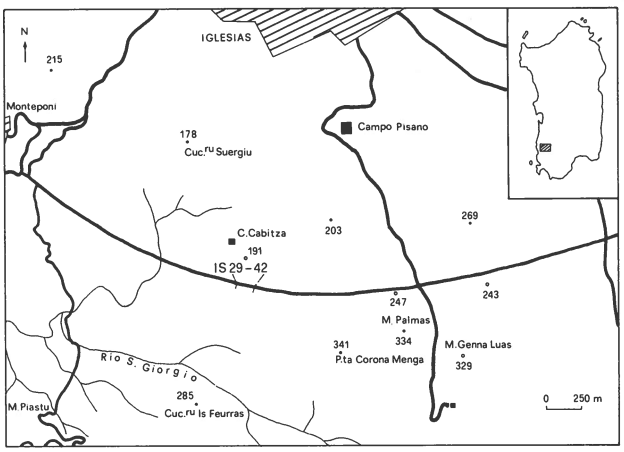
All material described and figured in this paper is deposited at the Institute of Geology and Paleontology of Frankfurt University (Cherchi-Schroeder collection).

STRATIGRAPHIC POSITION OF THE SAMPLES

The studied samples (IS-29 to IS-42) come from the Middle Cambrian Nodular Limestone Member (« Calcescisti » Auct.) of the Cabitza Formation. They

Research financially supported by the Consiglio Nazionale delle Ricerche and the Ministero alla Pubblica Istruzione.

have been taken near Casa Cabitza (approx. 2 kms to the south of Iglesias, SW Sardinia), at the northern board of the new by-pass road joining the roads SS 130 and SS 126 [sheet 233 IV N.W. (Iglesias) of the Carta d'Italia 1:25.000; see also text-fig. 1]. The sampling has begun near the boundary with the underlying Gonnesa Formation (= « Metallifero » *Auct.*) (Rasetti 1972). For exact location of the different samples see Cherchi & Schroeder (1985b).



Text-fig. 1 - Geographic position of the Middle Cambrian Cabitza section (Iglesias, SW Sardinia).

The road section shows that the Nodular Member of the Cabitza Formation developes rather abruptly from the underlying Gonnesa Formation. The Nodular Limestone (approx. 80 m thick) is lithologically characterized by an alternation of grey-reddish biomicritic nodular layers and red to green sandy clays. Mainly in the upper part of the sequence massive limestones (1-2 m thick) are intercalated. The sedimentology of this member has been studied in detail by Gandin (1979).

According to Rasetti (1972, p. 12), the Nodular Limestone Member, which he regarded as the uppermost part of the Gonnesa Formation, yielded well-preserved trilobite fragments belonging to the genera *Ptychagnostus, Peronopsis, Corynexochus, Paradoxides* and *Pardailhania*. This faunula can be rather accurately correlated with known faunas of the Middle Cambrian of southern France and Spain.

SYSTEMATIC DESCRIPTION

Phylum SCHIZOPHYTA (Falkenberg & Engler, 1892 or CHLOROPHYCOPHYTA Papenfuss, 1946
« Section » POROSTROMATA Pia, 1927
Genus GIRVANELLA Nicholson & Etheridge, 1878

GIRVANELLA PROBLEMATICA
Nicholson & Etheridge, 1878

Pl. 2, figs. 7-11

Material — 5 isolated aggregates, found in sample IS-29.

Description — The tubes are vermiform and irregularly twisted in loosely aggregated masses (pl. 2, figs. 7, 11). Other tubes are closely aggregated and probably sometimes contorted like a pigtail (pl. 2, fig. 9).

Dimensions (in mm)
External diameter of tubes: 0.020-0.025
Diameter of aggregates: 0.3-0.6

Remarks — The taxonomic problems concerning *Girvanella* have been thoroughly discussed by Mamet & Roux (1975). These authors came to the conclusion that the arrangement of tubes, which is regarded as an important characteristic by some previous authors, is without taxonomic value. On the other hand, they stress the taxonomic importance of the internal diameter of the tubes. The external diameter is less important, because the precipitation of calcium carbonate on the surface of *Girvanella* threads can be very variable (Wood 1957, p. 26).

Unfortunately, the internal diameter could not be measured in our material. However, the external diameter of tubes agrees well with that of topotypes of *G. problematica*, coming from the Late Ordovician of Girvan (South Scotland) and studied by Wood (1957). According to this author, the average external diameter of tubes is 0.021-0.022 mm, ranging from 0.018-0.025 (rarely 0.030) mm; the average internal diameter is 0.015-0.016 mm, ranging from 0.013-0.020 (rarely 0.022) mm.

The presence of *G. problematica* in the Cambrian has already been reported by several authors (e.g. Edhorn 1979, from the Early Cambrian of western Newfoundland).

Phylum SARCODINA Schmarda, 1871
Class RHIZOPODA von Siebold, 1845
Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage & Hérouard, 1896
Family ASTRORHIZIDAE Brady, 1881

Genus and species uncertain

Pl. 2, figs. 2-4

Material — 6 isolated specimens, found in sample IS-42.

Description — The test is tubular, apparently non-septate, irregularly cylindrical and open on both ends.

The wall is fine-grained with sometimes coarser agglutinated particles (pl. 2, fig. 2). The outer surface of the tubes is rough.

Dimensions (in mm)
Length: 1-2
External diameter: 0.32-0.58
Internal diameter of tube: 0.12-0.15

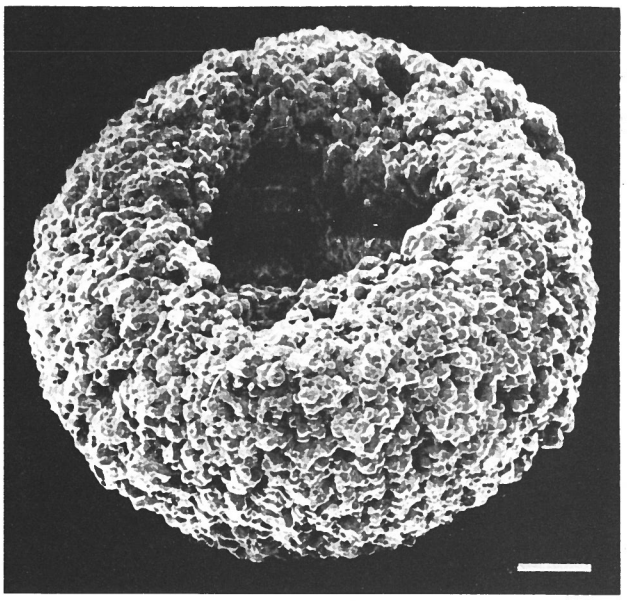
Remarks — It is uncertain wether these short tubular remains are complete specimens or fragments of a more complex taxon (e.g. postembryonic stages of representants of the subfamily Hippocrepininae Rhumbler, 1895). If the studied specimens are complete, then they should be assigned to the subfamily Rhizammininae Rhumbler, 1895.

Family SACCAMMINIDAE Brady, 1884
Subfamily PSAMMOSPHAERINAE Haeckel, 1894
Genus PSAMMOSPHAERA Schulze, 1875
PSAMMOSPHAERA sp.

Pl. 2, fig. 1

Material — 6 isolated specimens, found in sample IS-40.

Description — The subspherical tests, which are assigned to this genus, are fine-grained and without any recognizable aperture. The surface is relatively smooth.



Text-fig. 2 - *Hemisphaerammina* cf. *cecillalickeri* Conkin & Conkin, 1981. Sample IS-40. Scale bar =0.05 mm.

Dimensions — The diameter of the specimens ranges from 0.25 to 0.28 mm.

Remarks — Some authors (e.g. Ireland 1939, p. 194; Mound 1961, p. 27; Langer 1969, p. 42) have pointed out that simple spherical forms like *Psammosphaera* are difficult to separate into species. According to Mound (1961, p. 27), the variations of grain size result primarily from the particular material available to the organism. This opinion is supported by studies of Höglund (1947) on the recent *Psammosphaera bowmanni* Heron-Allen & Earland.

Eisenack (1954) and Kristan-Tollmann (1971) pointed out that the diameter of test, the character of the surface and the selection of agglutinated material depend on ecological factors; these features are not suitable for characterizing the species. Therefore, Kristan-Tollmann regarded all Early Paleozoic globular forms of *Psammosphaera* as synonyms of *P. cava* Moreman, 1930. We believe, however, that before such a decision, a careful revision of all Early Paleozoic *Psammosphaera* will be necessary. Particularly the variability of the wall thickness should be studied, which is regarded by Mound (1968) as a feature of great taxonomic value.

Subfamily HEMISPHAERAMMININAE
Loeblich & Tappan, 1957
Genus HEMISPHAERAMMINA
Loeblich & Tappan, 1957
HEMISPHAERAMMINA cf. CECILLALICKERI
Conkin & Conkin, 1981

Text-fig. 2

Material — One isolated specimen, found in sample IS-40.

Description — The agglutinated test consists of a lowly planoconvex, more or less hemispherical chamber showing on the ventral side a large cavity, which is surrounded by a very broad and thick flange. The ventral side with which the specimen was attached on a substratum, is without a floor.

Dimensions (in mm)
Diameter of test: approx. 0.4
Height: approx. 0.25
Diameter of cavity on the ventral side: approx. 0.15.

Remarks — The specimen studied is very similar to *H. cecillalickeri* described by Conkin & Conkin (1981) from the McCraney Limestone (Early Mississippian) of Missouri and Illinois (U.S.A.). According to these authors, *H. cecillalickeri* differs from all known species of *Hemisphaerammina* by its very

broad and thick flange (see Conkin & Conkin, pl. 1, figs. 18-20). The test diameter of the American specimens ranges from 0.40 to 0.91 mm.

Family AMMODISCIDAE Reuss, 1862
Subfamily AMMODISCINAE Reuss, 1862
? Genus AMMODISCUS Reuss, 1862

Pl. 3, figs. 1-2

Material — 3 isolated specimens, found in sample IS-40.

Description — The specimens are conserved as secondarily phosphatized moulds. The free test consists of a more or less planispirally coiled tube (2-2½ whorls), whose diameter does not increase during the ontogenesis. The outline of the tube cross-section is approximately circular. An initial swelling indicating the presence of a proloculus has not been observed.

Dimensions (in mm)
Diameter of test: 0.3-0.4
Diameter of tube: 0.045

Gen. et sp. indet.
Pl. 3, figs. 3-10

Material — 30 isolated specimens, found in sample IS-40.

Description — The specimens are conserved as secondarily phosphatized inner moulds, which have a more or less oval outline. The tube is planisprirally coiled (1-1½ whorls), but the last part of the tube leaves nearly always the coiling plane (pl. 3, figs. 4-5). The relatively thick tube mould is sometimes covered by more or less distinct wrinkles, which are directed transversally to the growth direction.

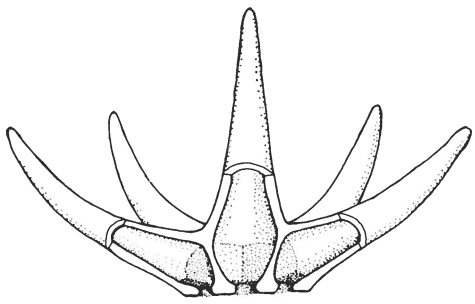
Dimensions (in mm)
Diameter of test: 0.22-0.36
Diameter of tube: 0.045-0.090

Phylum PORIFERA Grant, 1872
Class HETERACTINIDA Hinde, 1887
Order CHANCELLORIIDA Walcott, 1920
Family CHANCELLORIIDAE Walcott, 1920

Genus and species uncertain

Pl. 1, figs. 2, 8-10, pl. 2, fig. 6

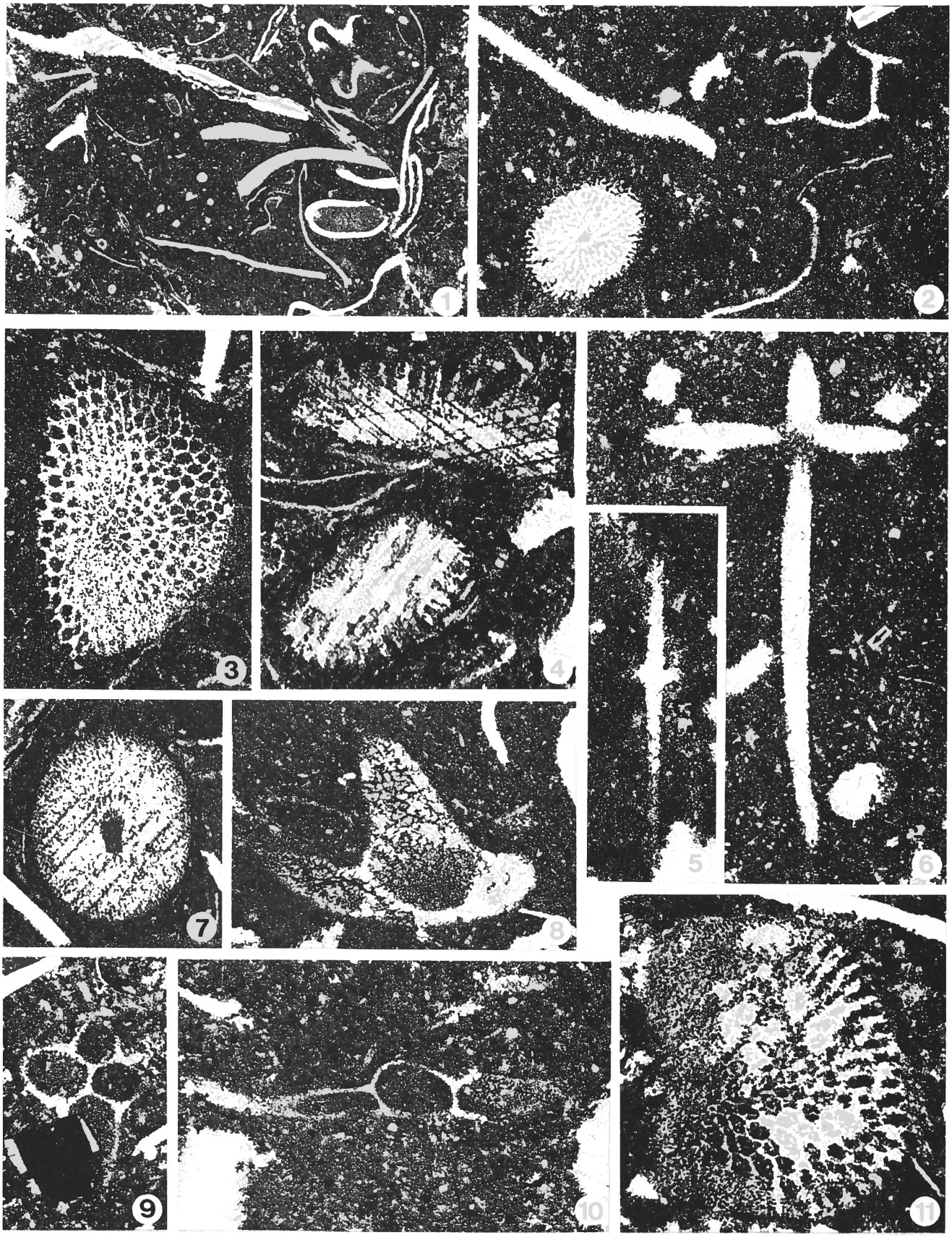
Chancelloriid Porifera are relatively frequent not only in the Middle Cambrian Cabitza Formation but also in the Early Cambrian Nebida Formation. Already Bornemann (1886, pl. 25, fig. 2) figured from the archaeocyathid limestone of Cuccuru Contu (Iglesias) a transverse section of *Coscinocyathus pandora,* whose sedimentary cavity filling contains numerous foreign bodies described by him as « einfache Zellen und Zellgruppen » (fig. 2e-i) or « Radiolarienähnliche Körper » (fig. 2k,i). Zuravleva & Korde (1955) firstly interpreted these bodies as chancelloriid remains. This interpretation was confirmed by Sdzuy (1969, p. 131) who



Text-fig. 3 - Morphology of a chancelloriid spicule (*Chancelloria maroccana* Sdzuy, 1969). After Sdzuy (1969, text-fig. 1).

EXPLANATION OF PLATE 1

Fig. 1 - Trilobite fragment (in the upper right angle: a section through a glabella). x 15.
Fig. 2 - Oblique section of a cylindrical echinoderm rest (lower left quadrant), of a fragment of a chancelloriid spicule showing a basal pore (marked by an arrow; upper right quadrant), and of trilobite fragments. IS 33-3. x 40.
Fig. 3 - Section parallel to the surface of an echinoderm plate showing ornamentation. IS 35-1. x 40.
Fig. 4 - Transversal section (above) and oblique section (below) of echinoderm plates showing strong ornamentation. IS 34-3. x 40.
Fig. 5 - Stauract of lyssakid Porifera (? *Protospongia*). IS 31-4. x 40.
Fig. 6 - Large and small (arrow!) stauracts of lyssakid Porifera (? *Protospongia*). IS 31-5. x 30.
Fig. 7 - Oblique section of a cylindrical echinoderm element. IS 33-1. x 40.
Fig. 8 - Oblique section of a chancelloriid spicule cutting three rays. IS 33-2. x 40.
Fig. 9 - Oblique basal section of a chancelloriid spicule cutting four rays. IS 33-1. x 40.
Fig. 10 - Vertical section of a chancelloriid spicule cutting three rays. IS 33-2. x 40.
Fig. 11 - Section parallel to the surface of an echinoderm plate showing ornamentation. IS 34-3. x 40.


1
2
3
4
5
6
7
8
9
10
11

had studied and refigured (pl. 16, fig. 2) part of the original material of Bornemann.

The skeleton of the chancelloriid Porifera consists of isolated rosette-like calcite spicules, the so-called archiasters (Sdzuy 1969, p. 118). Every archiaster shows a different number (2-10) of radially directed and mostly curved rays which are arranged like the spokes of a wheel. A vertical ray may be present as additional and systematically important structural element (text-fig. 3). All rays are characterized by a very large axial cavity, probably filled with organic material, and by a relatively thin wall. Every axial cavity is connected to the exterior via a basal pore, which is situated in the central part of the spicule base.

Sdzuy (1969) has subdivided the order Chancelloriida into the two families Chancelloriidae Walcott, 1920 and Archiasterellidae Sdzuy, 1969, The first family, characterized by the presence of a vertical ray, includes the genus *Chancelloria* Walcott, 1920 and very probably also *Eiffelia* Walcott, 1920. The central vertical ray is lacking in the family Archiasterellidae including the genera *Archiasterella* Sdzuy, 1969 and *Allonia* Doré & Reid, 1965.

It is nearly impossible to prove the presence or absence of a vertical ray in random thin sections through chancelloriid spicules. Some sections showing a long central and apparently « vertical » element (pl. 1, fig. 8; Sdzuy 1969, pl. 14, fig. 34) could also be interpreted as oblique sections near the base of the spicule cutting a horizontal curved ray. However, we have found in the residue of sample IS-33 two more or less complete isolated spicules, one of them showing a vertical ray. This is a hint that the chancelloriid remains of the Cabitza section belong to the family Chancelloriidae Walcott.

Numerous authors have assigned the chancelloriid spicules of the Sardinian Early and Middle Cambrian to the genus *Chancelloria* Walcott (e.g. Debrenne *et al.*, 1979, p. 383; Cocozza 1979, p. 177). These generic determinations are, however, without any foundation, because (1) the presence of a central vertical ray has apparently not be proved, and (2) an assignment of the material to the genus *Eiffelia* Walcott cannot be excluded. According to Sdzuy (1969, p. 132), *Eiffelia* Walcott distinguishes from *Chancelloria* by the presence of a very regular skeleton composed of spicules with exclusively six horizontal rays (see Rietschel 1968, text-fig. 2). However, in the skeleton of *Chancelloria* (e.g. *C. maroccana* Sdzuy, 1969) spicules with likewise six rays are predominantly occurring together with spicules having 4, 5 or 7 rays. Consequently, an indubitable generic assignment of isolated spicules with six rays to *Chancelloria* or *Eiffelia* is not possible.

The two isolated spicules of our material show six horizontal rays (pl. 2, fig. 6). In thin sections, chancelloriid spicules can be easily recognized by its large axial cavity and the very thin wall (0.02-0.03 mm) (pl. 2, figs. 2, 8-10). The spicule fragment in the upper right angle of pl. 1, fig. 2 shows a basal pore (arrow).

Finally, it is worth mentioning that, according to some authors, the taxonomic position of the Chancelloriidae is unclear. Rigby (*in* James & Klappa 1983, p. 1057) suggests that, on present evidence, they are not sponge spicules.

Class HEXACTINELLIDEA Schmidt, 1870
Order LYSSAKIDA Zittel, 1887
?Family PROTOSPONGIIDAE Hinde, 1887
?Genus PROTOSPONGIA Salter, 1864

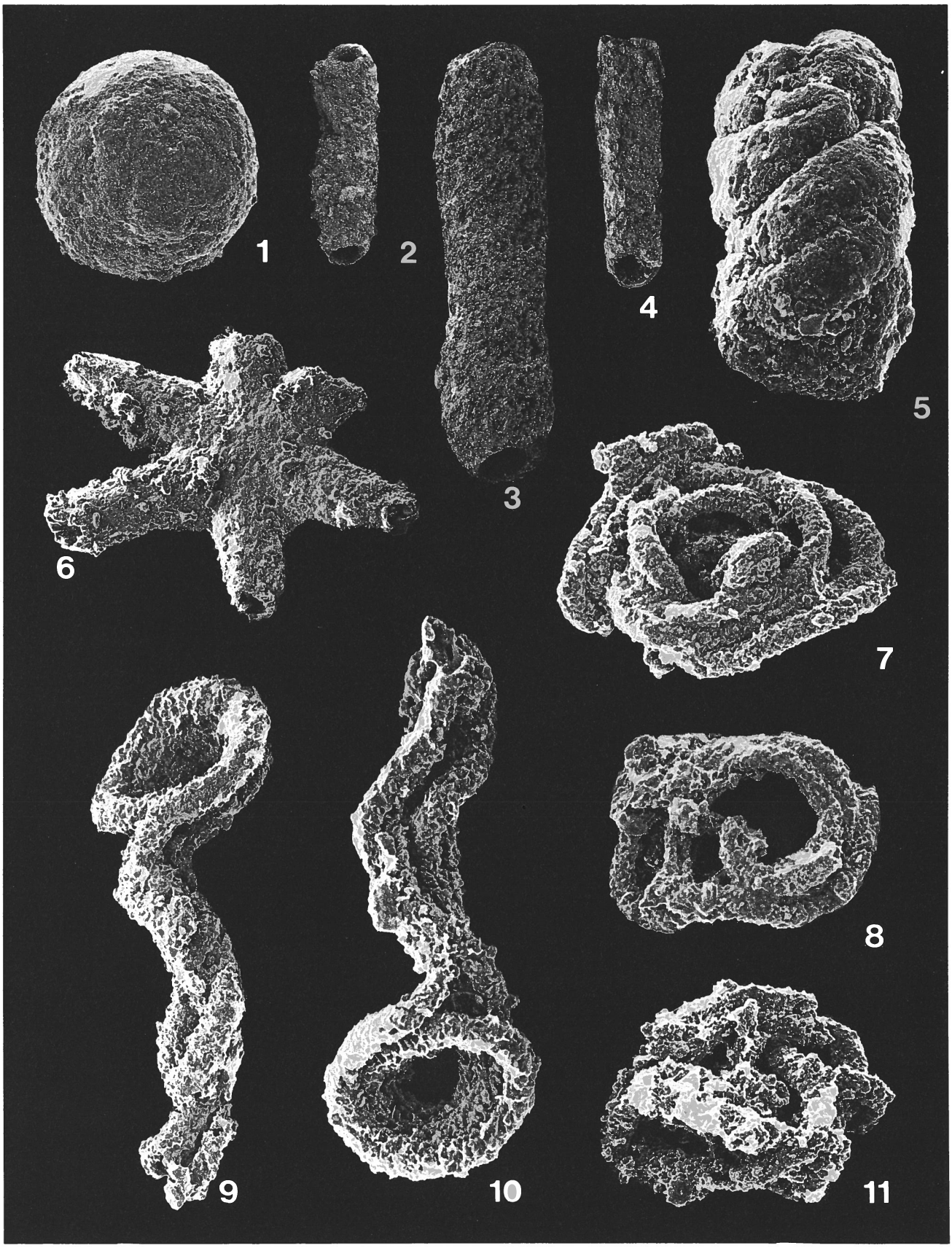
Pl. 1, figs. 5-6

Description — Thin sections of some samples (particularly IS-33) contain numerous stauract cruciform spicules. The thin and straight rays lie within a plane. There is no evidence of a fifth ray. An axial channel has never been observed; it was probably destroyed by secondary recrystallisation.

Several orders of spicules are recognizable, originally probably arranged in a single layer and forming a

EXPLANATION OF PLATE 2

Fig. 1 - *Psammosphaera* sp. IS-40. x 210.
Fig. 2 - Astrorhizid foraminifer. IS-42. x 44.
Fig. 3 - Astrorhizid foraminifer. IS-42. x 47.
Fig. 4 - Astrorhizid foraminifer. IS-42. x 50.
Fig. 5 - Phosphatic microproblematicum. IS-40. x 230.
Fig. 6 - Chancelloriid spicule (basal side). IS-33. x 110.
Fig. 7 - *Girvanella problematica* Nicholson & Etheridge, 1878. Irregurarly and loosely twisted aggregate. IS-29. x 195.
Fig. 8 - *Girvanella problematica* Nicholson & Etheridge, 1878. Irregularly and loosely twisted aggregate. IS-29. x 215.
Fig. 9 - *Girvanella problematica* Nicholson & Etheridge, 1878. Contorted aggregate. IS-29. x 200.
Fig. 10 - *Girvanella problematica* Nicholson & Etheridge, 1878. Same specimen as in fig. 9. x 200.
Fig. 11 - *Girvanella problematica* Nicholson & Etheridge, 1878. Irregularly and loosely twisted aggregate. IS-29. x 210.


1
2
3
4
5
6
7
8
9
10
11

rectangular net like in the Middle Cambrian *Protospongia hicksi* (Rigby 1966, text-fig. 2; pl. 66, fig. 2). The rays of the largest spicules (pl. 1, fig. 6) are more than 2.4 mm in length and 0.2 mm thick; the rays of the smallest spicules (pl. 1, fig. 6, arrow) are only approx. 0.16-0.2 mm long.

Phylum, class, order and family uncertain
Genus HADIMOPANELLA Gedik, 1977
HADIMOPANELLA cf. OEZGUELI Gedik, 1977

Pl. 4, figs. 1-9

Material and occurrence — *Hadimopanella* cf. *oezgueli* is very frequent (some hundred isolated sclerites) in the levels IS-34, IS-36, IS-38, IS-41 and IS-42 of the Cabitza section.

Description — The Sardinian sclerites are minute disc-like or low conical phosphatic bodies being circular to oblong in outline. One side of the disk is flat to slightly convex and smooth (pl. 4, figs. 1, 8-9). The opposite side consists of a low conical surface showing smooth flanks (pl. 4, fig. 8). The surface of the peak region of the cone is always cleft, probably caused by pressure solution.

Cone surfaces of strongly etched specimens (pl. 4, fig. 2) show sometimes two zones characterized by a different arrangement of crystallites. Within a relatively large central part the crystallites are arranged very irregularly. This central zone is surrounded by a small annular zone, in which the crystallites are radially arranged (pl. 4, fig. 2).

Transversal sections through the sclerites show, that these bodies are massive, but their internal structures are still unknown.

Dimensions (in mm)
Diameter: 0.14-0.16 (min.: 0.12; max.: 0.18)
Height: 0.04-0.06
Apical angle of the convex side: 110°-120°.

Discussion — The only morphologically similar forms are the button-shaped phosphatic microproblematica *Hadimopanella oezgueli* Gedik, 1977, described from the Middle or Late Cambrian of the Middle Taurus (Turkey), and *Lenargyrion knappologicum* Bengtson, 1977 from the uppermost Atdabanian (Early Cambrian) of the Siberian Platform (U.S.S.R.). Bengtson (1977, p. 760) already pointed out the similarity between the two taxa but stated that the two species are clearly different.

Van den Boogaard (1983) described well preserved specimens from the Middle Cambrian limestones of the Griotte Member of the Lancara Formation (Cantabrian Mountains, NW Spain). He pointed out that the genus *Lenargyrion* Bengtson has to be considered as a junior synonym of *Hadimopanella* Gedik regarding, however, the two species *knappologicum* and *oezgueli* as different taxa. He assigned the Spanish material to *H. oezgueli*.

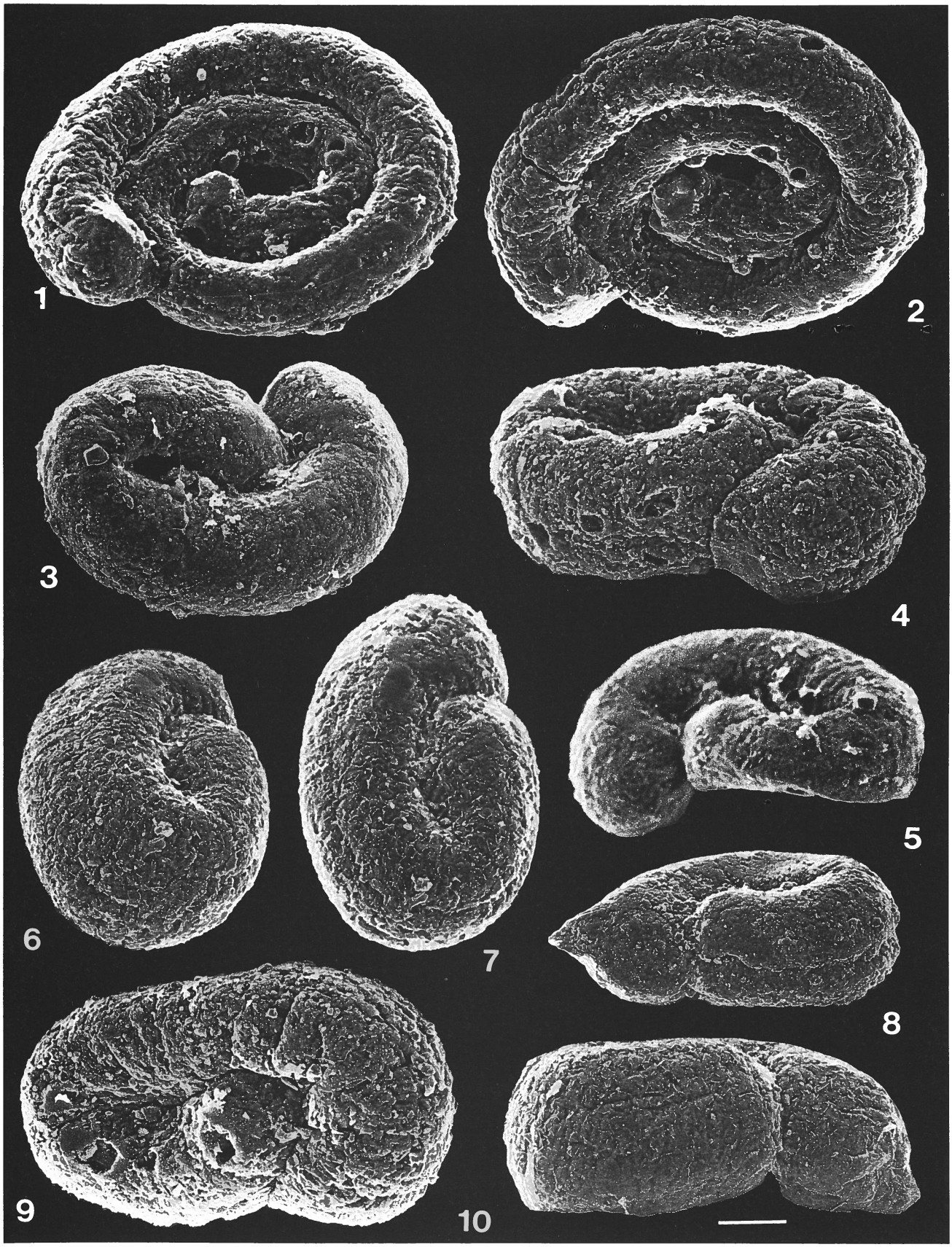
The morphology and internal structures of *Hadimopanella* have been studied in detail by Bengtson (1977) and Van den Boogaard (1983). Well preserved specimens show externally a smooth and slightly convex « basal » side and a more or less conical opposite side. The latter side shows (1) a central flat crest on which are set minute nodes and (2) an almost straight to somewhat conical surface, called the girdle. The inner part of the girdle is smooth, the outer part is covered with radial striae. The internal structure of *Hadimopanella* is double-layered: (1) a thick porous core containing small canals is covered on its conical side by a (2) thin and dense layer, called the capping (Bengtson 1977, text-fig. 5). The external surface of the capping corresponds to the nodular face and the smooth internal part of the girdle; the surface of the core corresponds to the striated part of the girdle and the « basal » face of the sclerite.

Bengtson (1977) had already noted that specimens of *H. knappologica* may have some or all of the nodes effaced and that in few cases the whole nodular face is almost smooth, although the nodular pattern may still be faintly visible (Bengtson 1977, text-fig. 1 G). The same phenomenon was observed by Van den Boogaard (1983, p. 339) in *H. oezgueli*. Also the Sardinian specimens show a smooth conical side, which is sometimes cleft in the peak-region. Bengtson (1977) interpreted the smooth conical side of some specimens as the result of mechanical abrasion during the life of the animal. However, Van den Boogaard (1983) considers it difficult to conclude wether this is due to mechanical abrasion or to chemical corrosion.

The boundary between the zone characterized by radially arranged crystallites and the zone showing irregularly arranged crystallites, being visible on a

EXPLANATION OF PLATE 3

Figs. 1-2 - ?*Ammodiscus* sp. IS-40.
Figs. 3-10 - Ammodiscinae gen. and sp. indet. IS-40.
Scale bar = 0.05 mm.


1
2
3
4
5
6
7
8
9
10

strongly etched conical side (pl. 4, fig. 2), corresponds to the boundary between the capping and the core of the sclerite. Well preserved specimens of *H. knappologica* show that the capping reaches or almost reaches to the brim of the sclerite. On the contrary, the capping of *H. oezgueli* is more reduced and, consequently, the core surface being visible on the conical side is larger. Considering this feature, the Sardinian specimens could be assigned to *H. oezgueli*, but, on the other hand, it cannot be excluded, that the reduced capping resp. the relatively large « marginal zone » (= core surface) of the specimen figured on pl. 4, fig. 2 is an effect of the strong etching. Therefore, we assign our specimens only with a certain reservation to *H. oezgueli*.

Lenargyrion knappologicum has been interpreted by Bengtson (1977, p. 758) as external dermal sclerites, distributed more or less evenly over the body surface of an unknown organism.

Repetski (1981, p. 399) pointed out that *L. knappologicum* has a general shape and surface morphology similar to the sculpture elements of the microproblematicum *Utaphospha* Müller & Miller, 1976 (type: *U. sequina*), which was described from the Late Cambrian of western Utah (U.S.A.). The outer surface of this phosphatic cone-shaped fossil is adorned with evenly spaced sequin- or scale-like round to polygonal plates of about equal size. These plates may show a bowl-like upper surface with an indented rim. According to Müller & Miller, *Utaphospha* may be the remains of a reproduction cyst. A second species, *U. cassiniana,* has been described by Repetski (1981) from the Early Ordovician of the El Paso Group in western Texas.

According to Repetski (1981, p. 399), *Lenargyrion* may be a junior synonym of *Utaphospha.*

REFERENCES

Bengtson, S., 1977, Early Cambrian button-shaped phosphatic microfossils from the Siberian Platform: Palaeont., v. 20 (4), pp. 751-762, text-figs. 1-7, Oxford.

Bornemann, J.G., 1886, Die Versteinerungen des Cambrischen Schichtensystems der Insel Sardinien nebst vergleichenden Untersuchungen über analoge Vorkommnisse aus anderen Ländern. Erste Abtheilung: Nova Acta Ksl. Leop.-Carol. Deutsch. Akad. Naturforscher, v. 60 (1), pp. 1-148, pls. 1-33, Halle.

Brasier, M.D., 1984, Microfossils and small shelly fossils from the Lower Cambrian *Hyolithes* Limestone at Nuneaton, English Midlands: Geol. Mag., v. 121 (3), pp. 229-253, text-figs. 1-3, Cambridge.

Cherchi, A. & Schroeder, R., 1985a, Intergrowth of the Early Cambrian algae *Epiphyton* Bornemann and *Renalcis* Vologdin from SW Sardinia: Boll. Soc. Paleont. Ital., v. 23 (2), pp. 141-147, pls. 1-2, 1 text-fig., Modena.

—, & —, 1985b, Guide book 19th E.M.C., *ed.* A. Cherchi.

Cocozza, T., 1979, The Cambrian of Sardinia: Mem. Soc. Geol. Ital., v. 20, pp. 163-187, text-figs. 1-11, Roma.

Conkin, J.E. & Conkin, B.M., 1981, Early Mississippian (Kinderhookian) smaller foraminifera from the McCraney Limestone of Missouri and Illinois: Univ. Louisville Stud. Paleont. Stratigr., v. 15, pp. 1-39, pls. 1-3, Louisville.

Debrenne, F., Gandin, A. & Simone, L., 1979, Studio sedimentologico comparato di tre « lenti » calcaree ad archeociati dell'Iglesiente e Sulcis (Sardegna sud-occidentale): Mem. Soc. Geol. It., v. 20, pp. 379-393, text-figs. 1-14, Roma.

Edhorn, A.-S., 1979, *Girvanella* in the « button algae » horizon of the Fourteau Formation (Lower Cambrian), Western Newfoundland: Bull. Cent. Rech. Explor. - Prod. Elf - Aquitaine, v. 3 (2), pp. 557-567, pls. 1-4, Pau.

Eisenack, A., 1954, Foraminiferen aus dem baltischen Silur: Senckenberg. leth., v. 35, pp. 51-72, pls. 1-5, text-fig. 1, Frankfurt a.M.

Gandin, A., 1979, Analisi sedimentologica preliminare della parte superiore della Formazione di Gonnesa e della parte inferiore della Formazione di Cabitza (Cambriano inferiore e medio della Sardegna): Mem. Soc. Geol. It., v. 20, pp. 395-404, text-figs. 1-6, Roma.

Gedik, I,, 1977, Orta Toroslav'da konodont biyostratigrafisi [Conodont biostratigraphy of the Middle Taurus]: Türk. Jeol. Kurumu Bül., v. 20, pp. 35-48, Ankara [In Turkish, with an English summary].

—, 1981, *Hadimopanella* Gedik, 1977 'nin stratigrafik dagilimi ve mikroyapisi konusunda bazi gözlemler: Black Sea Techn. Univ. Earth Sci. Bull. Geol., v. 1 (2), pp. 159-163.

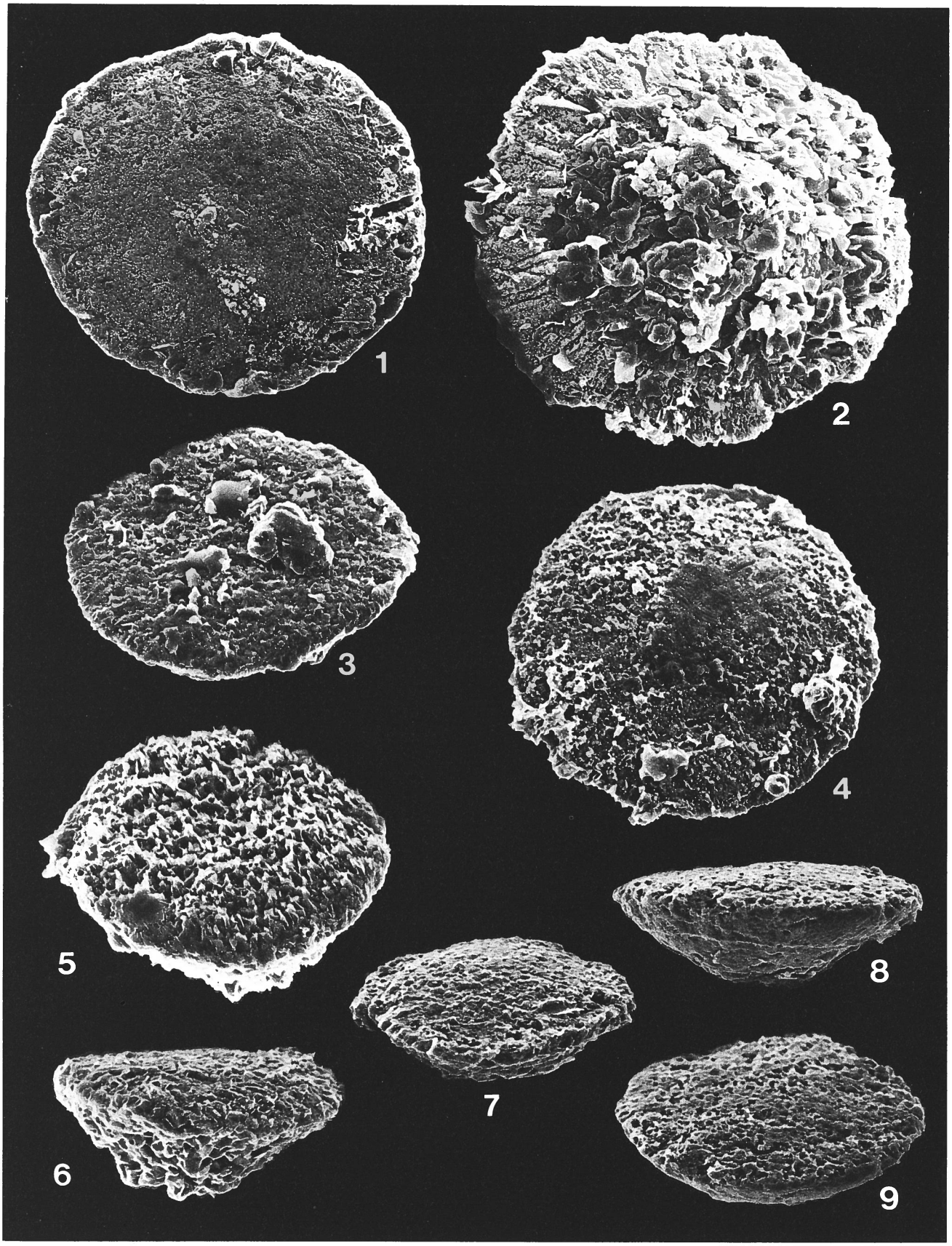
Höglund, H., 1947, Foraminifera in the Gullmar Fjord and the Skagerak: Zool. Bidrag Uppsala, v. 26, pp. 1-328, pls. 1-32, Uppsala.

Ireland, H.A., 1939, Devonian and Silurian Foraminifera from Oklahoma: J. Paleont., v. 13, pp. 190-202, pls. 1-3, Tulsa.

EXPLANATION OF PLATE 4

Hadimopanella cf. *oezgueli* Gedik, 1977.

Fig. 1 - Flat side. IS-42. approx. x 600.
Fig. 2 - Convex side. Note the boundary between the capping and the core. IS-42. approx. x 600.
Fig. 3 - Oblique view showing the flat side. IS-34. approx. x 600.
Fig. 4 - Flat side. IS-34. approx. x 600.
Fig. 5 - Oblique view showing the strongly etched flat side. IS-34. approx. x 600.
Fig. 6 - Lateral view. IS-34. approx. x 560.
Fig. 7 - Oblique view showing the flat side. IS-34. approx. x 520.
Fig. 8 - Lateral view showing parts of the flat and the convex side. IS-34. approx. x 550.
Fig. 9 - Oblique view showing the flat side. Same specimen as in fig. 8. IS-34. approx. x 550.


1
2
3
4
5
6
7
8
9

James, N.P. & Klappa, C.F., 1983, Petrogenesis of Early Cambrian reef limestones, Labrador, Canada: J. Sediment. Petrol., v. 53 (4), pp. 1051-1096, text-figs. 1-21, Chicago.

Kristan Tollmann, E., 1971, Sandschalige Foraminiferen aus dem Silur der Nördlichen und Südlichen Grauwackenzone Österreichs: N. Jb. Geol. Paläont. Abh., v. 137, pp. 249-283, text-figs. 1-7, Stuttgart.

Langer, W., 1969, Foraminiferen aus dem Alt-Paläozoikum der karnischen Alpen: Carinthia II, v. 79, pp. 34-60, pls. 1-3, text-fig. 1, Klagenfurt.

Mamet, B. & Roux, A., 1975, Algues dévoniennes et carbonifères de la Téthys occidentale. Troisième partie: Rev. Micropaléont., v. 18 (3), pp. 134-187, pls. 1-15, text-figs. 1-4, Paris.

Mound, M.C., 1961, Arenaceous foraminifera from the Brassfield Limestone (Albion) of Southeastern Indiana: Indiana Dep. Conserv., Geol. Surv., v. 23, pp. 1-38, pls. 1-3, text-figs. 1-5, Bloomington (Ind.).

—, 1968, Arenaceous Foraminiferida and zonation of the Silurian rocks of Northern Indiana: Bull. Indiana Geol. Surv., v. 38, pp. 1-126, pls. 1-7, text-figs. 1-6, Bloomington (Ind.).

Müller, K.J. & Miller, J.F., 1976, The problematic microfossil *Utaphospha* from the Upper Cambrian of the western United States: Lethaia, v. 9 (4), pp. 391-395, text-figs. 1-5, Oslo.

Rasetti, F., 1972, Cambrian trilobite faunas of Sardinia: Mem. Acc. Naz. Lincei, ser. 8, v. 11, pp. 1-98, pls. 1-19, text-figs. 1-4, Roma.

Repetski, J.E., 1981, An Ordovician occurrence of *Utaphospha* Müller & Miller: J. Paleont., v. 55 (2), pp. 395-400, pl. 1, text-fig. 1, Lawrence (Kansas).

Rietschel, S., 1968, Die Octactinellida und ihnen verwandte paläozoische Kalkschwämme (Porifera, Calcarea): Paläont. Z., v. 42 (1-2), pp. 13-32, pl. 1, text-figs. 1-4, Stuttgart.

Rigby, J.K., 1966, *Protospongia hicksi* Hinde from the Middle Cambrian of Western Utah: J. Paleont., v. 40 (3), pp. 549-554, pl. 66, text-figs. 1-7, Tulsa.

Sdzuy, K., 1969, Unter- und mittelkambrische Porifera (Chancelloriida und Hexactinellida): Paläont. Z., v. 43 (3-4), pp. 115-147, pls. 14-16, text-figs. 1-9, Stuttgart.

Van Den Boogaard, M., 1983, The occurrence of *Hadimopanella oezgueli* Gedik in the Lancara Formation in NW Spain: Proc. Koninkl. Nederl. Akad. Wetensch., ser. B, v. 86 (4), pp. 331-341, text-figs. 1-5, Amsterdam.

Wood, A., 1957, The type-species of the genus *Girvanella* (calcareous algae): Palaeont., v. 1 (1), pp. 22-28, pls. 5-6, London.

Žuravleva, I.T. & Korde, K.B., 1955, Nachodka gubki *Chancelloria* Walcott v otloženijach nižnego kembrija sibiri: Dokl. Akad. Nauk SSSR, v. 104 (3), pp. 474-477, pl. 1, Moskva.

(manuscript received April 30, 1985
accepted May 2, 1985)

Antonietta Cherchi

Dipartimento di Scienze della Terra,
Università di Cagliari,
Via Trentino 51, I-09100 Cagliari, Italia

Rolf Schroeder

Geologisch-Paläontologisches Institut
Universität Frankfurt, Senckenberg-Anlage 32-34,
D-6000 Frankfurt a.M., Federal Republic of Germany