



**Rendiconti della Società Paleontologica Italiana**

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# The Silurian of Sardinia

volume in honour of  
Enrico Serpagli

*Edited by*  
Carlo Corradini  
Annalisa Ferretti  
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Società Paleontologica Italiana  
2009

## Minor fossil groups in the Silurian of Sardinia

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ABSTRACT - Fossil groups rarely documented from the Silurian of Sardinia as well as Problematica are here briefly described and illustrated. Occurrences of eurypterid remains, silicispongia spiculae and *Scyphocrinites* loboliths are presented. Systematic affinity of *Kolihaia sardiniensis* is discussed, as well as that of peculiar problematic micro-sphaerules.

KEY WORDS - Silurian, Sardinia, Eurypterids, *Kolihaia*, Loboliths, Silicispongia, Problematica.

### INTRODUCTION

Fossil remains are abundant and well known from the Silurian of Sardinia since mid-nineteen century. Starting from Meneghini (1857), several authors investigated this variegated fauna, producing a large number of papers. Most of these contributions were focused on the more abundant or spectacular fossil groups, or on those useful for biostratigraphical or palaeoenvironmental purposes. It results that cephalopods, graptolites, conodonts, bivalves and chitinozoans are described and illustrated in numerous papers, whereas reports on other fossil groups are quite rare.

This paper deals with these minor groups, which are rarely found during palaeontological investigations on the Silurian of Sardinia: eurypterids, crinoid loboliths, sponge and other fossils with uncertain affinities. Beside these forms, it is important to note that some taxa, quite common in the Silurian rocks around the world, are almost absent in Sardinia: gastropods are seldom found as internal moulds in the cephalopod limestones, and trilobites are rarely observed, mainly in thin section.

### EURYPTERID REMAINS

[*Maurizio Gnoli*]

Eurypterids are aquatic Palaeozoic chelicerates that have been found mostly in Silurian and Lower Devonian deposits of North America and Europe. Outside Avalonia, Armorica, Baltica, Iberia and Laurentia, occurrences of these organisms are very scarce (Tetlie et al., 2007). In North Gondwana, remnants of eurypterids have been reported only from Bohemia (Barrande, 1872), Morocco (Depitout, 1962) and Sardinia (Gnoli, 1992a).

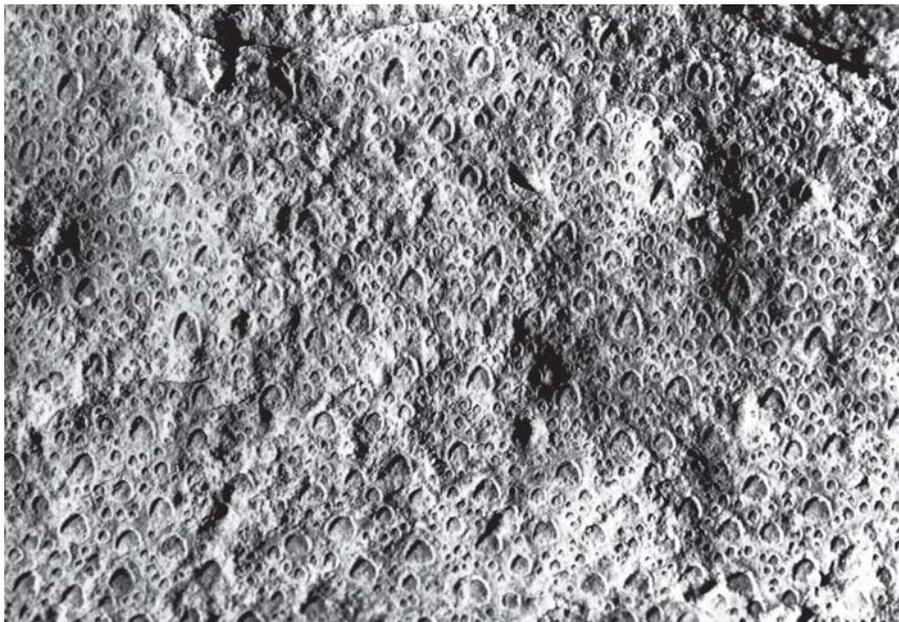


Fig. 1 - Close up of the external side of the eurypterid fragment (IPUM 21731) from Sardinia to show the ornamentation in form of distinct sub-triangular and/or smaller crescent-like scales as well as their arrangement, x6 (refigured after Gnoli, 1992a).

The only evidence of eurypterids in Sardinia is represented by a small fragment from the base of the Homerian (*lundgreni* Zone) in the Fluminimaggiore area (Fig. 1). It consists of a piece of carapace, 3x4 cm wide, having a peculiar outer ornamentation in form of two orders of narrow lunules (0.5 mm long and 0.125-0.625 mm wide), closely spaced on the surface (Gnoli, 1992a). Any generic and specific assignment is impossible for such a small fragment, however the ornamentation is very similar to that described and illustrated by Barrande (1872) in two species from Bohemia (*Pterygotus divers* and *Eurypterus pugio*) and by Depitout (1962) in one specimen, left in open nomenclature, found in Morocco.

#### LOBOLITHS (CRINOIDEA) [Carlo Corradini]

Loboliths are the result of a peculiar evolution of crinoids belonging to the family Scyphocrinitidae which developed balloon-like holdfasts. This structure, as a gas filled buoy, allowed the crinoid a pelagic mode of life. After the death of the animal, the lobolith got detached, due to biostratinomical physical parameters, and fossilized separately from crowns.

Two different morphologies have been discriminated on the basis of the balloon architecture: the cirrus-loboliths and the plate-loboliths (Haude, 1972). Cirrus-loboliths have walls built of a dense network of rootlets, named “cirri”, and a cavity partitioned into several chambers of various size. Plate-loboliths have the wall paved by a double-layer of polygonal ossicles, and the cavity may be subdivided in a few large chambers, each one with a small opening near the distal end of the stem. Constructional-

morphological considerations allow to explain that the plate-loboliths derived from the cirrus-loboliths (Haude, 1972, 1992).

Loboliths are widely distributed in the North Gondwana area (Morocco, Spain, Montagne Noire, Sardinia, Carnic Alps, Bohemia), and are reported also from North America, Baltica, Siberia, China and Kazakhstan. Their stratigraphical range is restricted to a very short interval across the Silurian-Devonian boundary. Therefore Scyphocrinoidea is one of the few crinoid groups with an important biostratigraphical meaning.

In Sardinia, Silurian loboliths (Fig. 2) are documented from some sections in the Ockerkalk limestone of the southeastern part of the island (Helmcke, 1973; Barca & Jaeger, 1990; Barca et al., 1995; Corradini et al., 1998, 2001, 2002; unpubl. data). Several cirrus-loboliths occur in a well defined horizon dated by conodonts to the base of the *detortus* Zone; isolated crinoidal stems are present since the uppermost Ludlow.

Loboliths occur also at the very base of the Devonian both in southeastern and southwestern Sardinia. In the Southeast, poorly preserved specimens have been reported by Barca & Jaeger (1990) and Piras & Paschina (2009) from the Upper Graptolitic Shales of the Villaputzu area, where also isolated calyces are present; in the Southwest, well preserved plate-loboliths occur in a few localities and have been illustrated from the Mason Porcus Section by Gnoli et al. (1988).

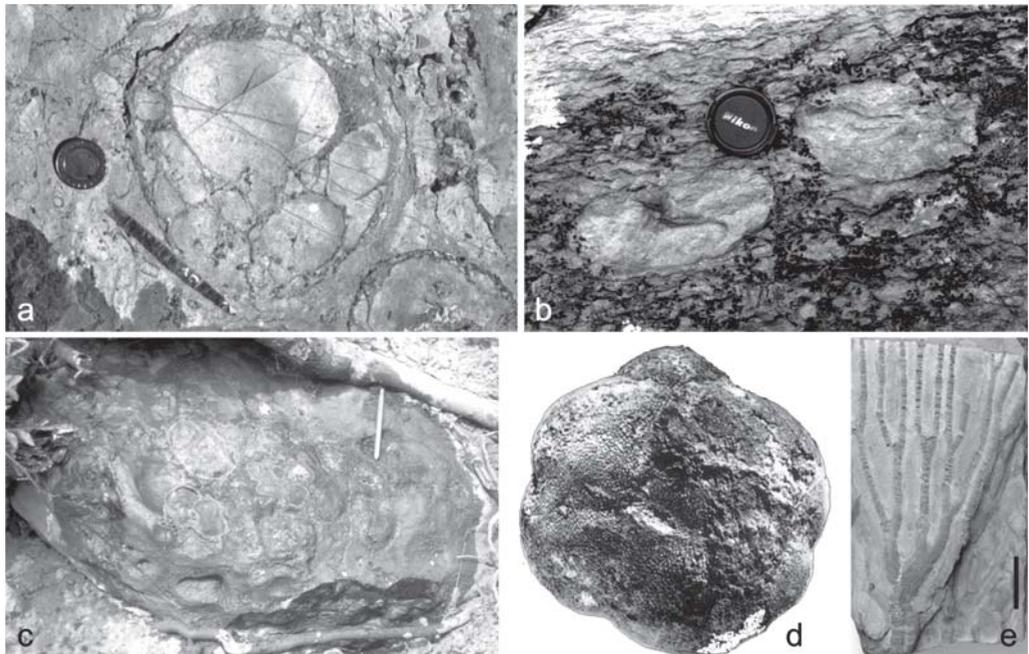


Fig. 2 - a) Slab exposing nicely preserved cirrus loboliths, San Basilio Fenugu section, southeastern Sardinia; *detortus* Zone, latest Pridoli; coin for scale=25 mm. b) Bed with two loboliths, Baccu Scottis section, southeastern Sardinia; *detortus* Zone, latest Pridoli; lens cap for scale=55 mm. c) Block with several plate loboliths, Fluminimaggiore, southwestern Sardinia; *woschmidti* Zone, base of Lochkovian; pencil for scale=17 cm. d) Upper view of an isolated plate-lobolith (after Gnoli et al., 1988, pl. 1, fig. 1b), Mason Porcus section, southwestern Sardinia; *woschmidti* Zone, base of Lochkovian; diameter of the specimen=12 cm. e) Crinoidal calyx, Baccu Scottis, southeastern Sardinia; Lochkovian; scale bar: 20 mm.

*KOLIHAIA* PRANTL, 1946  
[Maurizio Gnoli]

*Kolihaia eremita* was originally described by Prantl (1946) from the Silurian of the Barrandian as a new form of the phylum Annelida (Fam. Serpulidae Burmeister, 1837). Fisher (1962) included the genus *Kolihaia* Prantl, but with uncertain phylum, class and order relationship, in the new family Cornulitidae. In the same family, also the genera *Cornulites* Schlotheim, 1820, *Conchicolites* Nicholson, 1872 and *Cornulitella* Howell, 1952 were included.

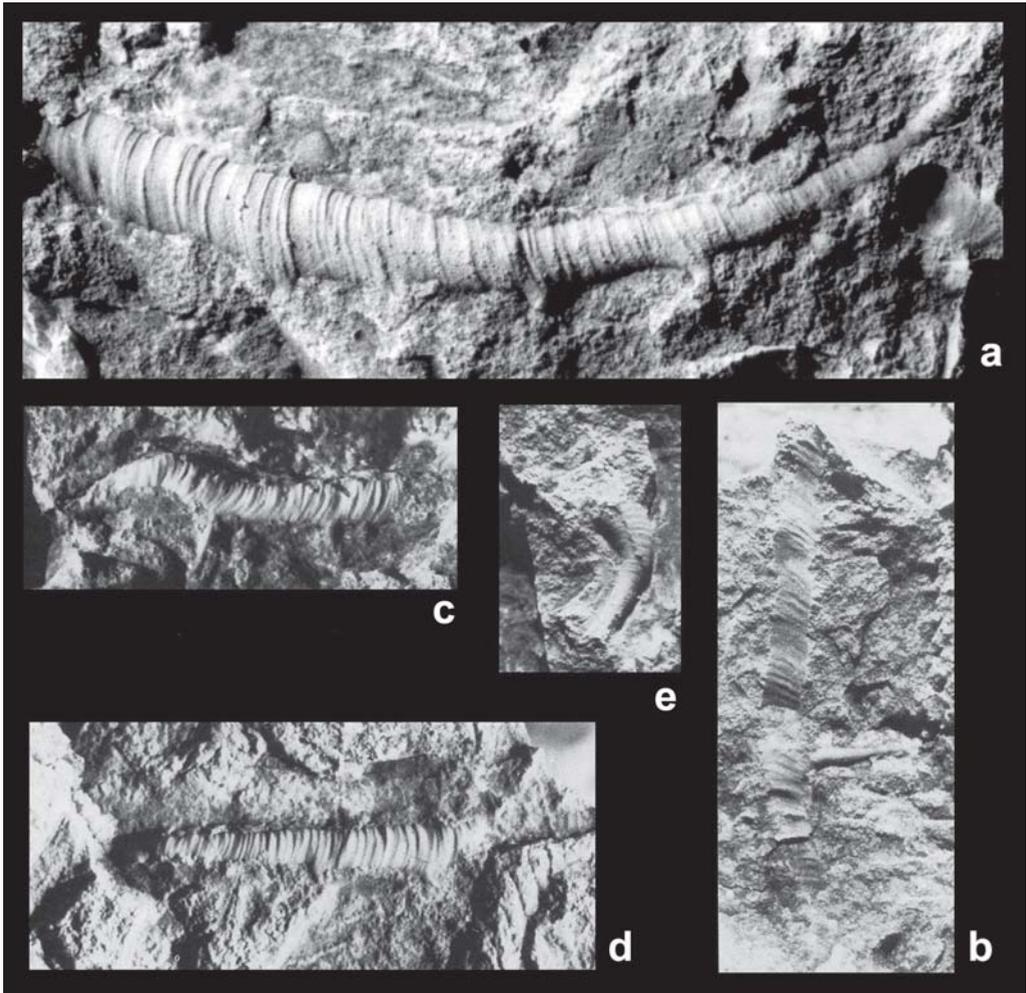


Fig. 3 - *Kolihaia sardiniensis* Gnoli, 1992. Lateral views of different specimens at various magnification: a) holotype IPUM 23551 (x18); b) IPUM 23552 (x12); c) IPUM 23553 (x16); d) IPUM 23554 (x12). e) Enlargement of a single spine: the smooth surface is probably the portion buried in the sediment, whereas the proximal ornamented part shows the same type of the ribbed ornamentation of the main body external wall. IPUM 23555 (x24). All refigured after Gnoli (1992b).



Fig. 4 - Hypothetical reconstruction of the mode of life of *Kolihaia sardiniensis* with its spines partially inserted in the sediment.

Gnoli (1992b) described and figured the new species *Kolihaia sardiniensis* (Fig. 3) from the uppermost Wenlock and lowermost Ludlow respectively of Argiola and Fluminimaggiore (southwestern Sardinia). He interpreted *K. sardiniensis* as a problematic organism belonging to the family Cornulitidae Fisher, 1962 but with uncertain higher taxonomic definition. A possible mode of life was suggested for the organism. The general features and the location of the spines only on one side of the tube, with the exception of the bifurcate last one closest to the distal opening, would indicate a certain bilateral symmetry (Gnoli, 1992b). A benthic, probably epibenthic, way of life was proposed (Fig. 4), with the organism laying on the sea floor with the smooth, distal portions of the spines buried into the soft sediment in contrast with the proximal, ornamented portions of the spines that bear the same type of ornamentation as that occurring on the main tube (Gnoli, 1992b). The presence of a smaller posterior sub-circular and a larger anterior sub-circular aperture is consistent with the animal having been a filter feeder using nutrient particles provided by near bottom currents. Affinities and differences of *K. sardiniensis* with *K. eremita* are remarkable. The former has in fact the spines on almost its body-length and not only closest to distal opening, smaller dimensions and a distal part only gently bent (and not «abruptly») as in the Bohemian species).

The analysis of a rich fauna of more than 1000 well-preserved specimens of *Kolihaia eremita* Prantl from the upper Wenlock of Bohemia, led Kriz et al. (2001) to interpret this organism as an epiplanktic anthozoan, having radiceform processes for attaching to floating or buoyant object, probably algae. The authors left open the possibility to assign this small fossil animal dubitatively to either Rugosa or Tabulata. The presence in *K. sardiniensis* of processes regularly distributed along the corallite would indicate, on the contrary, an adaptation to a benthic mode of life (Kriz et al., 2001).

By a micro and ultra structure shell analysis approach, Vinn & Mutvei (2004, 2005) present cornulitids as a possible polyphyletic taxon, with *Cornulites* having strong affinities with lophophorates and tentaculitids. A further recent contribution on Palaeozoic (mainly Wenlock) cornulitids is that of Herringshaw et al. (2007) where an up to date unambiguous terminology of the shell structure, systematics and affinities are reported.

Following Vinn's suggestion (pers. comm., September 2007) to investigate on the shell's micro and ultrastructure of *K. sardiniensis*, several thin-sections have been carried out at this purpose to check possible vesicles, apical septa and so on, for a better understanding of the taxonomic position of this fossil organism. Unfortunately, the bad preservation of the material has prevented so far to reach any sure answer.

## SILICISPONGIA

[Paola Pittau, Myriam Del Rio]

The only finding of siliceous sponges from the Silurian of Sardinia is represented by some spiculae collected from the Lower Graptolitic Shales in the Rio Ollastu area (southeastern Sardinia). They belong to several sponge taxa referable to two poriferan classes: Demospongiae and Hexactinellida.

Demospongiae is characterized by siliceous spicules, on monoaxons and tetraxons in which the rays do not meet at right angles, whereas the Hexactinellida group is represented by siliceous spicules, basically hexactines, hexactine-derived spicules, or stauractines, with rays at right angles. Significant is the record of monaxon clavulate and anchorate “root tuft” spicules (*Nabaviella* spp.) (Fig. 5a). These kinds of spicules are generally located in the dermal layer, protruding outwards in the basal part, allowing the sponge to stabilize in a soft substrate. Remarkable are also the specialized follipinule (Fig. 5b-d) and pulvinusactine spicules of *Thoracospongia ichnussiella* Pittau et al., 2003 (Fig. 6), which probably formed a part of an armoured dermal layer like that reconstructed by Mehl (1998). This finding indicates that the group of hexactinellid sponges having these peculiar spicules existed at least up to the early Silurian and ranged geographically from Australia to the northern peri-Gondwana.

Inasmuch as these discrete elements are conservative in their skeletal morphology, sponge spicules rarely provide decisive biostratigraphical information. Sometimes, however, sponge spicules may be biostratigraphically useful (Mehl & Mostler, 1993). The sponge spicule assemblages were recovered from the Lower Graptolitic Shales of southeastern Sardinia, in the *L. convolutus*, *S. turriculatus* and *Str. crispus* zones in black graptolitic silty shales intercalated with massive lydite beds. Centimeter-thick quartz lenses (radiolarites) are commonly embedded in the lydite layers and they contain large numbers of capsular tests of *Spumellaria*.

The Llandovery strata are believed to have been deposited in a distal platform environment, characterized by limited water circulation and anoxic – dysoxic bottom conditions, as indicated by the sediment type and fossil content (Schneider, 1972; Helmcke, 1973; Jaeger, 1976, 1991; Barca & Jaeger, 1990) which is characterized by epipelagic

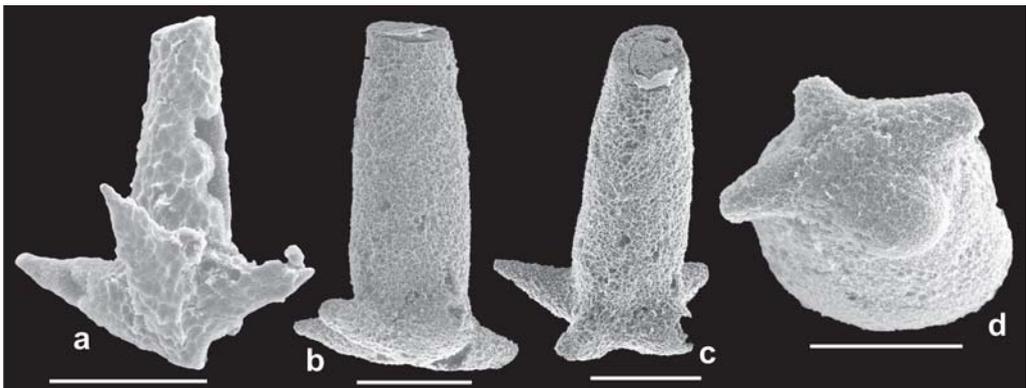


Fig. 5 - Silicispongia spiculae from the Rio Ollastu area. a) Class Hexactinellida: *Nabaviella?* sp. A; sample CP 2769, *Streptograptus crispus* Zone. b-d) Class Hexactinellida: *Thoracospongia ichnussiella* Pittau et al., 2003, follipinules; sample CP 2769, *Streptograptus crispus* Zone. Scale bar=200µm.

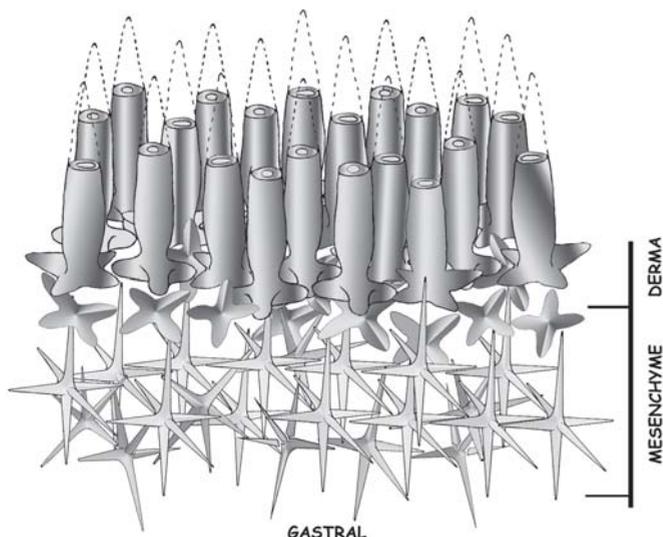


Fig. 6 - Hypothetical reconstruction of *Thoracospongia ichnussiella* Pittau et al., 2003 (after Pittau et al., 2003).

communities: graptolites, chitinozoans, radiolarians. Palaeoecological interpretation rules out that the spicules were deposited at the site they inhabited. An allochthonous or para-allochthonous origin seems more likely, the spicules originating in a high energy and well-oxygenated shelf not far from the black shale depositional basin.

GONI'S SPHERULES: ORGANIC WALLED *PROBLEMATICA* MICROFOSSILS  
[Paola Pittau, Myriam Del Rio]

Organic walled hemi-spheres and spherules (60 to 180  $\mu\text{m}$  of diameter) are present in some horizons of the Goni section. They are in full relief and show traces of pyritization. Stratigraphically, they are distributed from the *Cyrtograptus rigidus* to the *Cy. lundgreni* zones (middle Wenlock) and, after a disappearance ("eclipse") encompassing several biozones (*P. parvus*, *P. dubius*-*G. nassa*, *C. praedeubeli* and *C. deubeli* zones), they reappear in the *C. vulgaris*-*C. gerhardi* Zone (Pittau et al., 2006).

*MORPHOLOGY*

The test wall consists of amorphous organic material; the surface may be smooth or of diverse texture: wrinkled, reticulated, dome-shaped protuberances, spirally rolled raised ridges, undulating basal membranes, may have pores, around 1-1.5  $\mu\text{m}$  in diameter (Pl. 1, Fig. 3), that are frequently rimmed, on the surface; or main(?) apertures, of the order of 10  $\mu\text{m}$ , always flushing with the test surface (Pl. 1, Fig. 1). Surface reticulation may be related to the outlines of the agglutinated mineral used in an outer wall by organisms such as arenaceous foraminifera (Pl. 1, Fig. 1), whilst a "blocky" reticulation (Pl. 1, Figs. 1, 2) is likely effect of a (post?) diagenetic mineralization (pyritization). Dome-shaped protuberances are very frequent in these microfossils, particularly in the spherical ones and in those with a small invaginated region in the test (Pl. 1, Figs. 1, 3, 10).

The assemblages comprise an assortment of morphologies ranging from hemispherical, to spherical ovate and subspherical with invaginated area. Four different morphological

types have been discriminated (Pittau et al., 2002): spheres with circular opening and 'reticulate' surface (morphotype A; Pl. 1, fig. 1); hemispheres with basal flange and dome-shaped protuberances (morphotype B; Pl. 1, figs. 2-3); globular test with dome-shaped protuberances and depression areas (morphotype C; Pl. 1, fig. 10) and with globular test, spirally arranged raised ridges and other features (morphotype D; Pl. 1, fig. 6).

#### MICROPALAEONTOLOGICAL AFFINITY

The size indicates they were unicellular, but their biological affinity and palaeoecological role is unknown; presumably they are of polyphyletic origin, perhaps related to classes such as Sarcodina and Radiolaria (Pittau et al., 2002).

Globular "reticulate" form (morphotype A) is comparable with organic linings of the agglutinated foraminifer *Saccamina*, in particular with species recorded in the Devonian limestones of Australia (Bell & Winchester-Seeto, 1999).

Specimens similar to morphotypes B, C and D, have been recorded in the Llandovery deep sediments of Wales (Lloydell *et al.*, 1988) and they were tentatively referred to internal moulds of radiolaria. The living radiolarian *Rizoplegma radicum* (Pl. 1, fig. 8) and some other Spumellaria possess a capsular membrane that during ontogenesis increases in volume forcing club-shaped protuberances through the pores of the shell, which is extracapsular, of similar shape to Goni's spherules. Radiolarian soft bodies, in fact, can be fossilized and this may happen irrespective of the siliceous skeletons (Dumitrica, 1999). In *Cenosphaerocapsula gibbulosa* the presence of «small inflations» or «tubercles» in the spherical shell is a diagnostic feature (Dumitrica, 1999).

The hemispherical forms are comparable with two different fossil types: firstly, test linings of agglutinated foraminifera like *Hemisphaerammina*; secondly, central capsules of radiolaria lying eccentrically with respect to the cortical shell (Dumitrica, 1999). The presence in most of the specimens of a basal flange supports the first hypothesis.

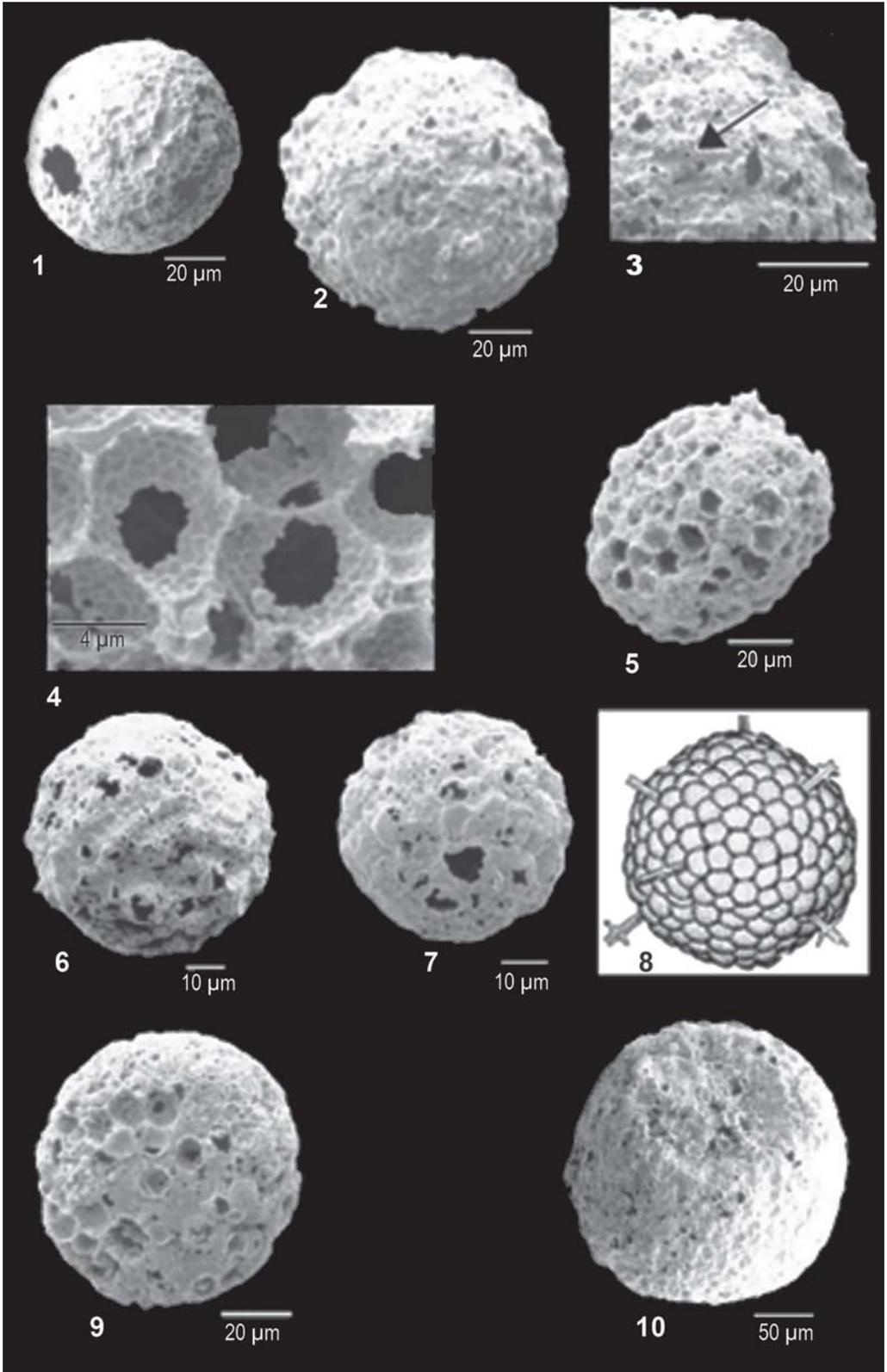
The life style of the main group with spherical test similar to the agglutinated foraminifer *Saccamina* and to the radiolarian *Coenosphaerocapsula* probably was planktonic. A minor

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## Plate 1

Organic-walled Problematika from Goni.

- Fig. 1 - Morphotype A. The specimens are similar to *Saccamina mea* Bell & Winchester-Seeto, 1999.
- Figs. 2-3 - Morphotype B. All the illustrated specimens display the basal flange and numerous holes in the surface. 3: detail of fig. 2 showing the equatorial rim and holes in the surface.
- Figs. 4-5 - Morphotype C. SEM magnification of the moulds left after dissolving minerals grown during diagenetic or postdiagenetic processes in the dome-shaped protuberances. Minerals smaller than 1  $\mu\text{m}$ .
- Fig. 6 - Morphotype D.
- Figs. 7, 10 - Morphotype C. Microfossils showing a depression area and the pattern surface broken by dome-shaped protuberances.
- Fig. 8 - Capsule of *Rizoplegma radicum*, living radiolarian with numerous club-shaped protrusion showing a dome shaped outer morphology (after Dumitrica, 1999, fig. 2).
- Fig. 9 - Morphotype C.



group composed of flattened, hemispherical forms, resembling the agglutinated foraminifer *Hemisphaerammina* was most likely benthonic. The assessment of their palaeoecological preferences will be helpful for a better understanding of the biotic signal and the interpretation of the palaeoceanographic conditions during the Silurian black-shale deposition.

#### ACKNOWLEDGEMENTS

Thanks are due to Dr. Olev Vinn (Tartu University, Estonia) and Dr. Jiri Kriz (Czech Geological Survey in Prague, Czech Republic) for useful suggestions and advises on *Kolihaia*.

Funding for this work was provided by MIUR-PRIN 2007 (*Analysis of stratigraphic, palaeontological and structural features of the Hercynian basement and the Tertiary cover in Sardinia and Calabria, as a contribution to the geodynamic reconstruction of the central-western Mediterranean basin*).

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