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Palaeoscolecid sclerites from the Upper Cambrian Mila Formation of the Shahmirzad section, Alborz Mountains, northern Iran

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ABSTRACT:

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Phosphatic, discoidal sclerites with prominent nodes on the external surface have been found in Upper Cambrian inter-reef calcareous grainstone of the Mila Formation in the Shahmirzad section, Alborz Mountains, northern Iran. This is the first record of a palaeoscolecid worms from Iran. Isolated sclerites demonstrate a complex ornamentation characteristic of the widely known species *Hadimopanella oezgueli* GEDIK, 1977 and are interpreted as dermal plate elements of Palaeoscolecida. *Hadimopanella* sclerites are known outside Iran from adjacent areas including Turkey, Kirgizia and China and from the more distant continents of Australia, Antarctica, Siberia, Baltica (Sweden, Estonia) and peri-Gondwanan Europe (Spain). The Iranian palaeoscolecid worms were probably infaunal constituent of bentic marine community in inter-reef environment. The utility of isolated sclerites for Cambrian biozonation is still rather low.

Key words: Palaeoscolecida, Priapulida, Worms, *Hadimopanella*, *Milaculum*, Cambrian, Iran.

INTRODUCTION

The systematic affinities of certain, enigmatic, button-shaped phosphatic microfossils have been widely discussed since their first descriptions from Turkey (GEDIK 1977) and Siberia (BENGTSON 1977). This group of isolated sclerites includes the problematic microfossils *Hadimopanella* GEDIK, 1977, *Kaimenella* MÄRSS, 1988 and *Milaculum* MÜLLER, 1973 and has been recently demonstrated to belong to the wormlike organisms Palaeoscolecida CONWAY MORRIS & ROBISON, 1986, which have their outer surface covered with tightly arranged dermal sclerites in transverse rows on narrow annuli (see KRAFT & MERGL 1989; HINZ & *al.* 1990; MÜLLER & HINZ-SCHALLREUTER 1993). The morphology and taxonomy of palaeoscolecid worms and their isolated sclerites was reviewed in detail by MÜLLER & HINZ-SCHALLREUTER (1993), HOU & BERGSTRÖM (1994) and CONWAY MORRIS (1997).

Different palaeoscolecid worms possessed different kinds of dermal elements that are widely known as quite diverse, isolated ornamented sclerites (hadimopanella-like) with a time range from the Early Cambrian to the Early Silurian. Their morphological variability and stratigraphic range have been considered to have biostratigraphic potential (WRONA 1982, GEDIK 1989; MÜLLER & HINZ-SCHALLREUTER 1993).

In this stratigraphic context we describe and illustrate the variability of sclerites ornamentation extracted from a single sample of fossiliferous limestone of the

Upper Cambrian Mila Formation, from the best known section in Iran (HAMDI 1995, 1996).

GEOLOGICAL SETTING

The Mila Formation was defined by STÖCKLIN & *al.* (1964). Its type section is exposed on the southern slope of Mila Kuh, 50 km west-southwest of Damghan, eastern Alborz Mountains (coordinates: 35°59'N, 53°47'30"E; Text-fig. 1). The formation is well exposed in several localities of the Alborz Mountains (HAMDI 1995, Fig. 1) and is divided into five informal 'members' consisting of dolostone, trilobite-bearing limestone, shale and sandstone. These range in age from late Early Cambrian to Early Ordovician (ASSERETO 1963; STÖCKLIN & *al.* 1964; HAMDI 1995, 1996). Trilobite biostratigraphic zones have been distinguished for the Mila Formation and neighboring units of the Mila Group (KUSHAN 1973; FORTEY & RUSHTON 1976; WOLFART 1983; WITTKE 1984) and a conodont zonation has been established (RUTTNER & *al.* 1968; MÜLLER 1973a). The trilobite biostratigraphy, taxonomy and international correlation have been recently revised by PENG & *al.* (1999) on the basis of newly collected material from the section at Shahmirzad, which is 50 km west of the type section and which was also sampled for this study.

Fig. 1. Map of Iran showing location of the studied outcrops (asterisks) at Shahmirzad (1) and the Mila Formation type section at Mila Kuh (2)

The Shahmirzad section of the Mila Formation is located 3 km north of Shahmirzad town along a road cutting on the southern flank of Kuh-e-Kahesh (coordinates: 35°48'40"N, 53°16'59"E; Text-figs 1-4). The white to pinkish, crossbedded and rippled sandstone and quartzite on the eastern side of the road is assigned to the uppermost Lalun Formation. These strata pass conformably into a dolostone assigned to 'Member' 1 of the Mila Formation. The lithostratigraphic profile of the Shahmirzad section presented by HAMDI (1996) is here slightly modified (Text-fig. 2) and its fossil content is updated after PENG & *al.* (1999).

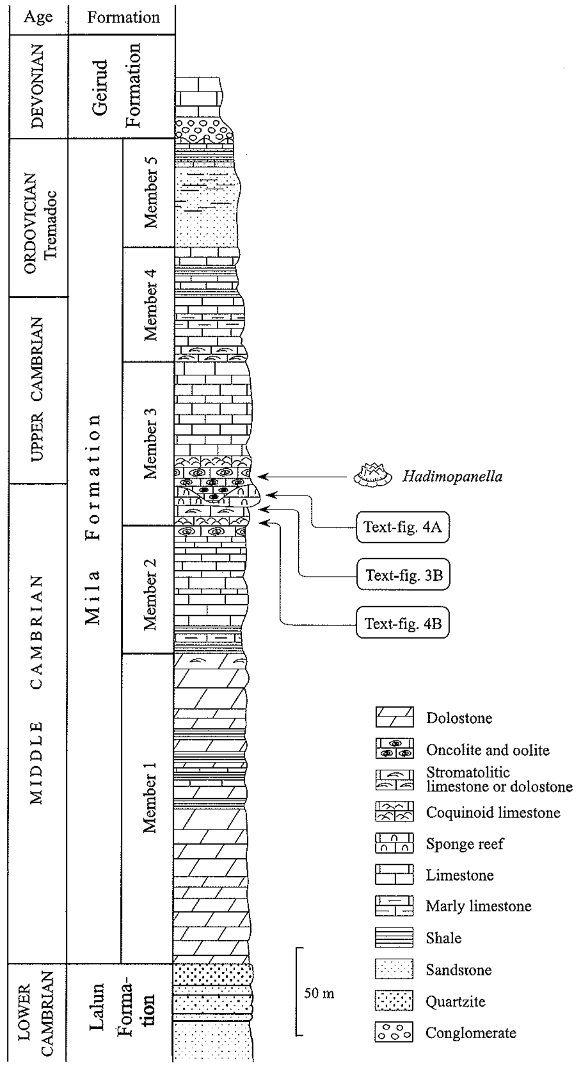

Fig. 2. Stratigraphic column of the Mila Formation at the Shahmirzad section, Alborz Mountains, northern Iran, showing relative position of the studied samples in 'Member' 3

'Member' 1 is a 171 m-thick unit of yellow to yellowish-grey, well-bedded dolostone with common stromatolitic lamination. This is intercalated with yellowish-green shale, marlstone or marly dolostone. These strata appear to have been deposited in calm, shallow water.

'Member' 2 is a 69 m-thick unit of yellowish and dark grey, thin-bedded limestone and marly shale, with

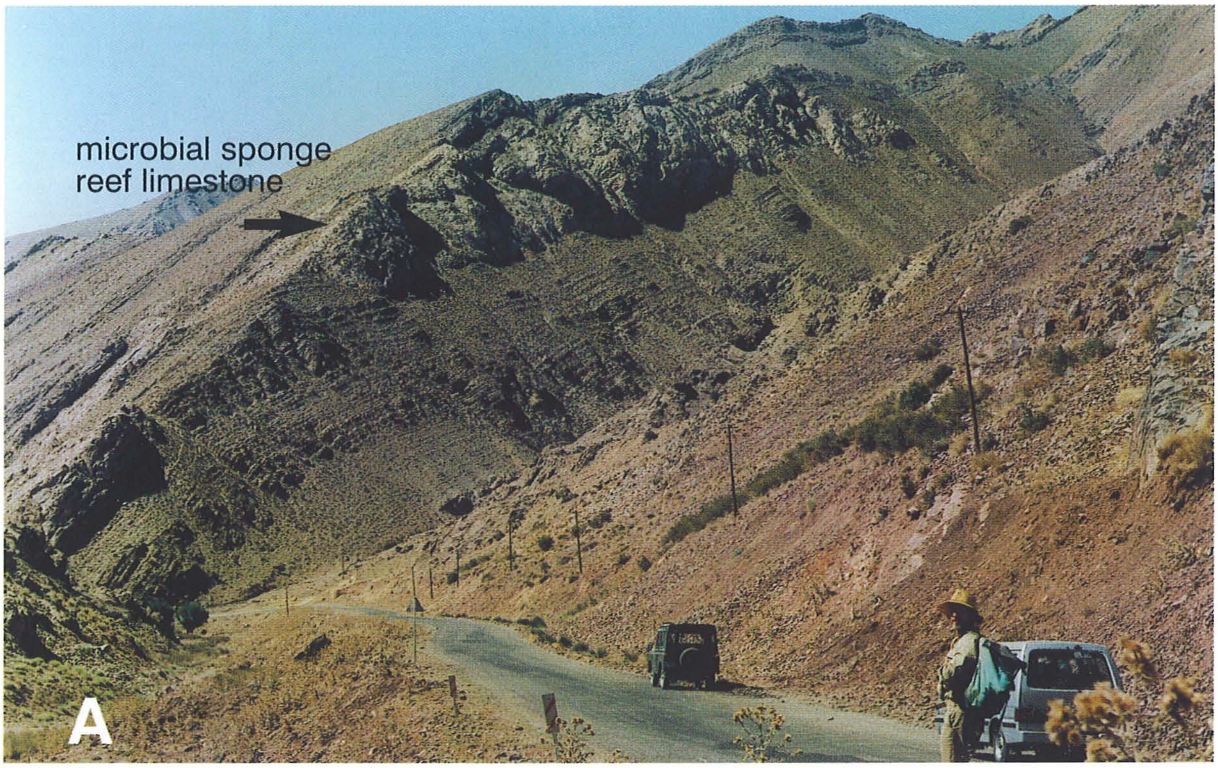

Fig. 3. A – Exposure of the Mila Formation on the southern side of Kuh-e-Kahesh in Alborz Mountains; view is to the west side of the road to Shahmirzad town. Prominent microbial-sponge reef limestone ('Member' 3) is visible as massive, light-coloured rocks in the upper part of the section, underlain and overlain by thin-bedded limestone. B – Detail of microbial-sponge (lithistid) reef, resting upon hard substrate of brachiopod coquinoid limestone. Note irregular structure of the reef (bafflestones, *in*: Hamdi et al. 1998), with deep pockets infilled by bioclastic grainstone

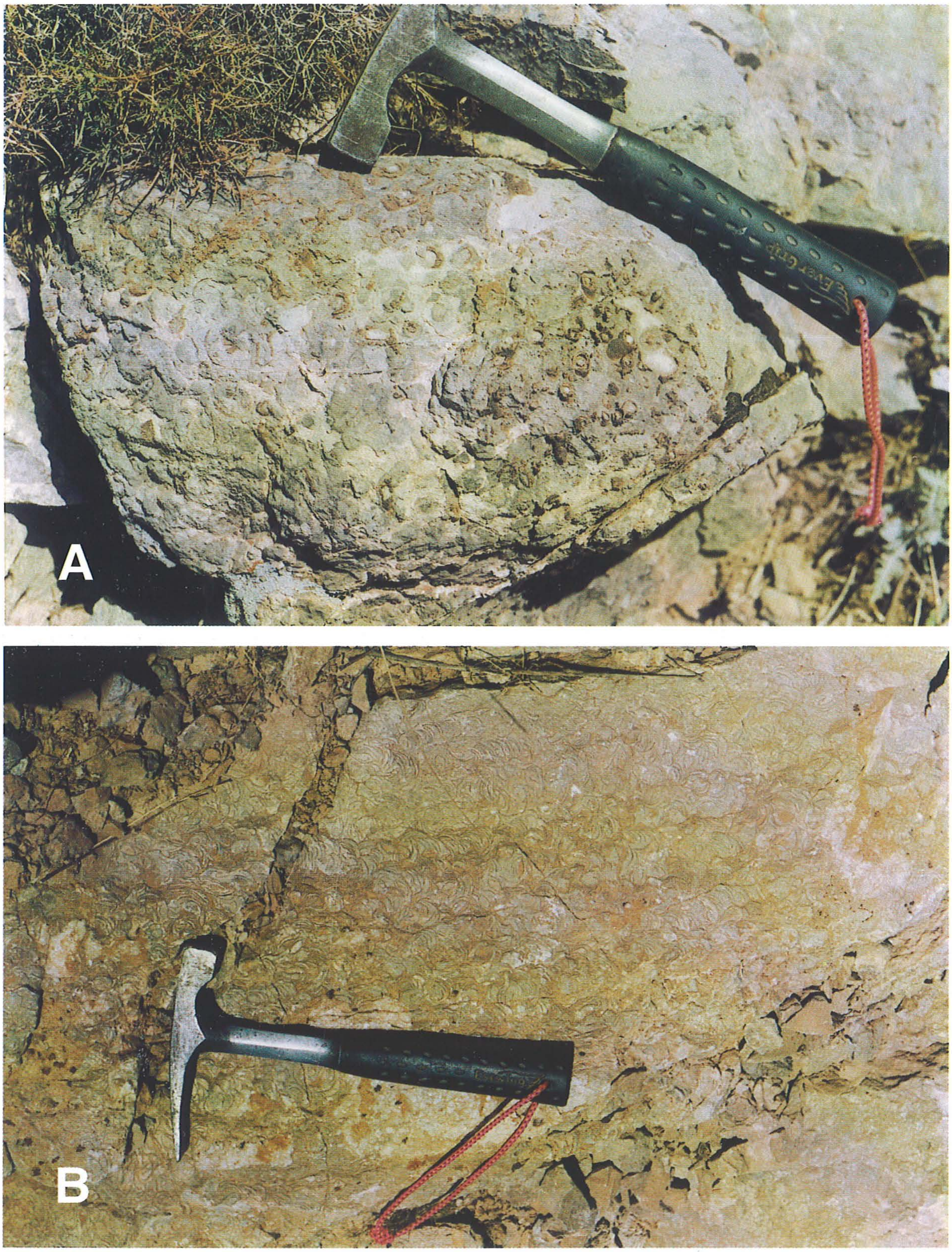

Fig. 4. A– Detail of microbial-sponge reef framework consisting of the branching anthaspidellid lithistid *Rankenella mors* and microbial micrite encrustations; B – Bedding plane surface of brachiopod coquinoid limestone composed of *Billingsella* valves

common syneresis cracks, probably caused by erthquake-induced dewatering (PRATT 1998), and salt pseudomorphs, ripples, trace fossils and abundant trilobites *Iranoleesia pisiformis*, *Dorypyge iranensis*, *Peronopsis* sp., *Chelidonocephalus alifrons, Iranochresterius shahmirzadensis* and *I. falconi.* Dark-grey to black grainstones, 18 m thick, contain trilobite debris of *Neoagnostus* sp., *Peronopsis* sp. and *Parakoldinia* sp., disarticulated ossicles of the echinoderm *Eocrinus*? sp. and packed hyolith conchs. The topmost 12 m of the unit consists of greenish-grey, slightly glauconitic marl and thin-bedded fossiliferous limestone with lingulate brachiopods and abundant trilobites belonging to *Anomocarella* sp., *Dorypyge khademi khademi*, *Lioparella* sp. and *Proasaphiscus*? sp., which indicate a late Middle Cambrian age.

'Member' 3 is 90 m thick. The lower interval comprises 12 m of light grey, coarse-grained bioclastic limestone rich in the trilobites *Pseudoagnostus*? sp., *Hadragnostus convexus, Stigmatoa* sp., *Pagodia verrucosa, Prochuangia leiosephala* and *Paracoosia* sp., and interbedded with a brachiopod coquinoid limestone composed of *Billingsella* shells (Text-fig. 3D). The middle part is a 10 m interval of white, coarse-grained bioclastic limestone containing a large patch reef (Text-fig. 3A-B), constructed primarily of a framework of the branching anthaspidellid demosponge (Text-fig. 4A) *Rankenella* ex gr. *mors* (Gatehouse) encrusted and overgrown by microbial stromatolite-like sheaths (HAMDI & *al.* 1995, 1998; KRUSE 1998). This sponge reef exhibits deep pockets infilled by bioclastic grainstone containing Upper Cambrian trilobites *Palaeadotes*? *erbeni*, *Chelidonocephalus* sp., *Prochuangia granulosa, P. leiocephala, P. pachycephala* and *Sailoma* sp., together with palaeoscolecid *Hadimopanella* sclerites. The reef is overlain by a 17 m-thick white, coarse-grained, slightly glauconitic limestone with intraformational breccia (intraclasts up to 5-10 cm size), ooids and large *Girvanella* oncoids (up to 3 cm size), repeatedly interbedded with *Billingsella* coquinas (Text-fig. 4B). These beds contain the trilobites *Prochuangia* sp. and *Chelidonocephalus* sp. The upper 51 m consists of dark-grey limestone and subordinate calcareous shale with the trilobites *Kaolishania* sp., *Prochuangia* sp. and *Chuangia* sp. of Late Cambrian age.

'Member' 4 in its lower 35 m is a coarse-grained, greenish-grey, thin-bedded fossiliferous limestone, alternating with brownish platy limestone. In this part the Late Cambrian trilobites *Alborsella* sp. and *Pagodia*? have been found. The upper 28 m of 'member' 4 comprises alternations of thin-bedded brown limestone and shale bearing the trilobites *Saukia rotunda, Micragnostus chiushuensis, Neoagnostus sp., Akoldinioidia iranensis, Pseudoaphelaspis scutalis, Taoyuania*? sp. and *Platypeltoides*? (*Troedssonia*) sp., the brachiopod *Paurorthis* sp. and hyolith shells.

'Member' 5 in its lower 41 m consists of interbedded grey-green quartzose sandstone and arenitic shale with the abundant *Phycodes* trace fossils, while in its upper 20 m it consists of green shale and quartz-sandy limestone containing the trilobite *Pagodia* sp. of Early Ordovician (Tremadoc) age.

The Mila Formation in this locality is unconformably overlain by basal conglomerate of the Geirud Formation, of Late Devonian age (Text-fig. 2).

MATERIAL AND METHODS

58 limestone samples from the Shahmirzad section were collected for micropalaeontological investigation and the position of sample yielding palaeoscolecid sclerites is indicated on its schematic stratigraphic column (Text-fig. 2). Phosphatic *Hadimopanella* sclerites were liberated using 10% acetic or formic acid. Over 300 isolated sclerites have been picked from the residues of just one productive sample. Stereoscan micrographs were taken using the scanning electron microscope Philips LX-20 at the SEM Laboratory of the Instytut Paleobiologii. The studied collection of sclerites is housed in the Instytut Paleobiologii, Polska Akademia Nauk, Warszawa, labelled ZPAL V. XXVIII.

DESCRIPTIONS

Class Palaeoscolecida CONWAY MORRIS & ROBISON, 1986

REMARKS: Members of this class were round worms with a papillate epidermis, the papillae (tubercles) being typically arranged in repeated transverse, commonly double, rows. The annular belts (rows) may bifurcate on the ventral side of the body and thus this arrangement of papillae does not reflect any internal segmentation. The now-phosphatized epidermis consisted of more or less complex, lightly sclerotized cuticular structures – dermal sclerites – arranged in an armour surrounding the entire body of the animal. The anterior part of the body is often missing because of poor preservation. Jaw apparatus identified only in the holotype of *Palaeoscolex piscatorum* WHITTARD, 1953 (pl. 5, figs 3, 4) was not confirmed in its re-examination (CONWAY MORRIS 1997). The posterior end of the body is more common, usually preserved in a coiled trunk. The alimentary canal is more or less linear along entire body with a terminal anus

More recent finds with three-dimensional preservation (MÜLLER & HINZ-SCHALLREUTER 1993, ZHANG

& PRATT 1996) and articulated arrays of sclerites in compressed specimens (KRAFT & MERGL 1989, HOU & BERGSTRÖM 1994), including the redescribed type species of *Palaeoscolex*, *P. piscatorum* WHITTARD, 1953 (CONWAY MORRIS 1997), show characteristic features (especially the proboscis with rows of spines on the anterior end and hooks on the posterior end), which place palaeoscolecides within the aschelminthes (HOU & BERGSTRÖM 1994). This indicates a close relationship with priapulids (CONWAY MORRIS 1993, 1997; MÜLLER & HINZ-SCHALLREUTER 1993; HOU & BERGSTRÖM 1994; ZHANG & PRATT 1996) or nematomorphs (HOU & BERGSTRÖM 1994). The precise evolutionary position of the Palaeoscolecida is still not resolved (HOU & BERGSTRÖM 1994; CONWAY MORRIS 1997). The controversy arises from the differing preservation styles of specimens represented by compressed organisms versus those comprising three-dimensional fragments of phosphatized cuticle. The flattened specimens are often complete individuals, while the phosphatised fragments display some delicate diagnostic features which are not visible on the compressed films.

Families assigned to the Palaeoscolecida by KRAFT & MERGL (1989) are the Palaeoscolecidae WHITTARD, 1953 and Plasmuscolecidae KRAFT & MERGL, 1989.

Family Palaeoscolecidae WHITTARD, 1953

GENERA INCLUDED: ?*Protoscolex* ULRICH, 1878 (some species of this genus are papillate while some are smooth, the latter possibly a preservational artifact – WHITTARD, 1953); *Palaeoscolex* WHITTARD, 1953; *Gamascolex* KRAFT & MERGL, 1989 (most of the previous genera are based on specimens flattened in the plane of bedding); *Australoscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Corallioscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Euryscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Kaloscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Murrayscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Pantoioscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Rhomboscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Schistoscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Shergoldiscolex* MÜLLER & HINZ-SCHALLREUTER, 1993; *Thoracoscolex* MÜLLER & HINZ-SCHALLREUTER, 1993 (those exceptiomonally preserved are three-dimensional with articulated dermal sclerites); *Hadimopanella* GEDIK, 1977 and *Kaimenella* MARS, 1988 (known from isolated phosphatic tubercles - dermal sclerites) as well as *Milaculum* MÜLLER, 1973b and *Utahphospha* MÜLLER & MILLER, 1976 (known from complex sclerites).

REMARKS: The family comprises taxa known mainly from external moulds of phosphatized complex cuticular structures. Secondary phosphatization of some organic (collagenous) stiffening of the cuticle may have protected the complex cuticular armour from disintegration, and in some cases, the three-dimensional structure of the cuticle exosclerites is preserved. Detailed studies by KRAFT & MERGL (1989), VAN DEN BOOGAARD (1989) and HINZ & *al.* (1990) have documented the affinities of all these isolated simple and complex sclerites with the Palaeoscolecida.

Genus *Hadimopanella* GEDIK, 1977

TYPE SPECIES: *Hadimopanella oezgueli* GEDIK, 1977

SPECIES INCLUDED: *H. oezgueli* GEDIK, 1977; *H. knappologica* (BENGTSON, 1977); *H. apicata* WRONA, 1982; *H. antarctica* WRONA, 1987; *H. collaris* MÄRSS, 1988; *H. ataseveri* GEDIK, 1989; *H. inurselae* GEDIK, 1989; *H. oskayi* GEDIK, 1989; *H. saiti* GEDIK, 1989; *H. turkseni* GEDIK, 1989; *H*?. *coronata* VAN DEN BOOGAARD, 1989; *H. silurica* WANG, 1990; *H.* sp. BERG-MADSEN, 1985. All species are known from isolated single sclerites only.

Hadimopanella oezgueli GEDIK, 1977
(Pls 1-3)

SYNONYMY: See MÜLLER & HINZ-SCHALLREUTER (1993).

OCCURRENCE: Upper part of 'Member' 3, Mila Formation, Upper Cambrian, Shahmirzad section, Alborz Mountains, northern Iran.

DESCRIPTION: These small discoidal phosphatic sclerites (diameter 67-140 μm) consist of two layers (Pl. 2, Fig. 8; Pl. 3, Fig. 1). The lower layer forms an expanded base, with smooth and flat or slightly convex (Pl. 2, Fig. 6; Pl. 3, Fig. 4) to concave surface (Pl. 3, Fig. 2). The upper layer forms the crown, bearing several prominent nodes (3 to 18) arranged in a circle (Pl. 2, Fig. 2; Pl. 3, Fig. 3) or in rows (Pl. 3, Fig. 6). Three or four nodes can be concentrated at the apex (Pl. 1, Figs 2, 3, 6; Pl. 2, Figs 2, 4) or more loosely arranged (Pl. 1, Fig. 5; Pl. 2, Fig. 3). One very rare sclerites possess two nodes only (Pl. 1, Fig. 1). An unusual (aberrant) sclerite shows one small spike-like node in a marginal position. The nodes are equal in size, usually 10 μm in diameter and 15 μm high. They are generally oriented upwards but some are oblique (Pl. 1, Fig. 6; Pl. 2, Fig. 6). Some specimens (Pl. 1, Fig. 1) have fine helical corrugation on the node surfaces. The crown sometimes does not cover the base; in such cases the suture of outer and inner layers is displayed, revealing a striated basal margin (Pl. 1, Figs 2-3; Pl. 2, Figs 1, 5, 8; Pl. 3, Fig. 5) in a finer radiating patern. The elevation of the upper surface ranges from about 25 μm to more than 45 μm.

REMARKS: The specimens of *Hadimopanella* described from the Mila Formation are assigned to *H. oezgueli* GEDIK, 1977 due to their similar morphology and number of nodes, although both characters are variable. The Iranian specimens differ slightly in their generally smaller size and lower number of nodes compared to Turkish specimens from the Late (or Middle) Cambrian of Karakaya Tepe, Taurus Mountains (GEDIK, 1997) and Spanish specimens from the Middle Cambrian of the Láncara Formation (VAN DEN BOOGAARD, 1983). However, GEDIK (1989, pl. 1, fig 1), VAN DEN BOOGAARD (1983, fig. 3F) and MÄRSS (1988, pl. 1, fig. 1) also illustrate examples with few tubercles. They are more similar to Australian specimens found in two fragments of palaeoscolecid cuticle (form species I and II) from the Middle Cambrian (late Templetonian) of the Georgina Basin (MÜLLER & HINZ-SCHALLREUTER, 1993, fig. 7, D-G). The latter has nodes arranged in a ring around a central node and resemble some specimens from Iran (Pl. 3, Fig. 3) and Spain (VAN DEN BOOGAARD, 1983, fig. 4a), or *Utahphospha cassiniana* REPETSKI, 1981. In the opinion of MÜLLER & HINZ-SCHALLREUTER (1993, p. 567), *H. oezguli* is similar to the plates of *Palaeoscolex sinensis* HOU & SUN, 1988 from the Lower Cambrian of Chengjiang. Specimens of the Iranian *Hadimopanella* having 15 or more nodes may form elongate plates with nodes arranged in rows (Pl. 3, Fig. 6) and are comparable with *Milaculum* MÜLLER, 1973b plates (VAN DEN BOOGAARD, 1988; MÜLLER & HINZ-SCHALLREUTER, 1993). These large sclerites differ from the *Milaculum* type material in lacking vertical canals penetrating and capping basal layers of the plate and in having more dense basal tissue as it is in typical *Hadimopanella* sclerite, without characteristic cross pattern of the horizontal parallel canals on the basal surface (DZIK 1986). These large sized sclerites with numerous nodes probably represent *H. oezgueli* intraspecific variability as it have been for exceptionally large specimen of *H. knappologica* (BENGTSON, 1977, fig. 1K). The correlation between sclerite size and the number of nodes (BENGTSON 1977) suggests that also *Milaculum*-type sclerites may have arisen from increase the number and accretion of sclerite nodes. Some sclerites of *Hadimopanella* from Iran have two or four nodes as is common in *H. acollaris*, but they differ in lacking the diagnostic ornamentation on their marginal brim (MÄRSS 1988, pl. 2, figs 1-5.). These sclerites (with few nodes) are somewhat like rare forms of *H. apicata,* BENDIX-ALMGREEN & PEEL 1988, their fig. 3. Their ornamentation can be also compared with much smaller platelets ocurring in many articulated cuticles of several palaeoscolecid genera; see *Murrayscolex,* MÜLLER & HINZ-SCHALLREUTER, 1993, their fig. 8, B) or *Palaeoscolex piscatorum* WITTARD, 1953, recently redescribed and illustrated in its microstructural details by CONWAY MORRIS (1997, figs 7-8, 9). The distinct helical corrugations ("scratches") on some *Hadimopanella* nodes have also been illustrated by MÄRSS (1988, pl. 1, figs 1-8) and BENDIX-ALMGREEN & PEEL (1988, fig. 5). The characteristic striated basal margin (Pl. 2, Figs 5, 8; Pl. 3, Fig. 5) with a finer radiating patern may reflect radially arranged apatite crystallites

The sclerites described here differ markedly in their morphology and size from *H. apicata* WRONA, 1982 and *H. antarctica* WRONA, 1987 (WRONA 1989) or *H.*? *coronata* VAN DEN BOOGAARD, 1989.

DISCUSSION AND CONCLUSIONS

Palaeoscolecid remains are widely distributed in early Palaeozoic rocks, while *Hadimopanella oezgueli* sclerites are restricted to Middle and Late Cambrian strata. The established utility of isolated sclerites for biozonation is still rather low, although they may yet have biostratigraphic potential (MÜLLER & HINZ-SCHALLREUTER 1993). Sclerites of *Hadimopanella* from a single sample of the Late Cambrian Mila Formation in Iran display great intraspecific variability. Their assignment among the palaeoscolecid genera is difficult because different kinds of sclerites may occur on the same palaeoscolecid worms (MÜLLER & HINZ-SCHALLREUTER 1993). The palaeoscolecid worms bearing dermal sclerites were a common constituent of Cambrian benthic marine communities, often in inter-reef environments, and most were probably infaunal (ZHANG & PRATT 1996, CONWAY MORRIS 1997). *Hadimopanella* sclerites have an overall worldwide distribution, but their Cambrian palaeobiogeographic ocurrence displays a closely similar pattern to that of the co-occurring Iranian trilobite fauna (PENG & *al.* 1999). They are known outside Iran from adjacent areas including Turkey, Kirgizia and China and from the more distant continents of Australia, Antarctica, Siberia, Baltica (Sweden, Estonia) and peri-Gondwanan Europe (Spain).

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PLATE 1

Scanning electron micrographs of palaeoscolecid sclerites belonging to *Hadimopanella oezgueli* from the Mila Formation, 'Member' 3, Upper Cambrian, Alborz Mountains, northern Iran.

1 – Upside view of sclerite with two nodes, showing fine, helical striae on the apex, ZPAL V. XXVIII/101S4.
2a, b – Oblique and upside views of sclerite with three nodes, showing marginal brim, ZPAL V. XXVIII/100S2.
3a, b – Oblique and upside views of sclerite with three nodes, showing marginal brim and radial striae, ZPAL V. XXVIII/100S4.
4a, b – Upside and oblique views of sclerite with four nodes, ZPAL V. XXVIII/101S5.
5a, b – Upside and oblique views of sclerite with three nodes, showing striated marginal brim, ZPAL V. XXVIII/101S10.
6 – Oblique view of asymmetric sclerite with inclined nodes, ZPAL V. XXVIII/101S7.

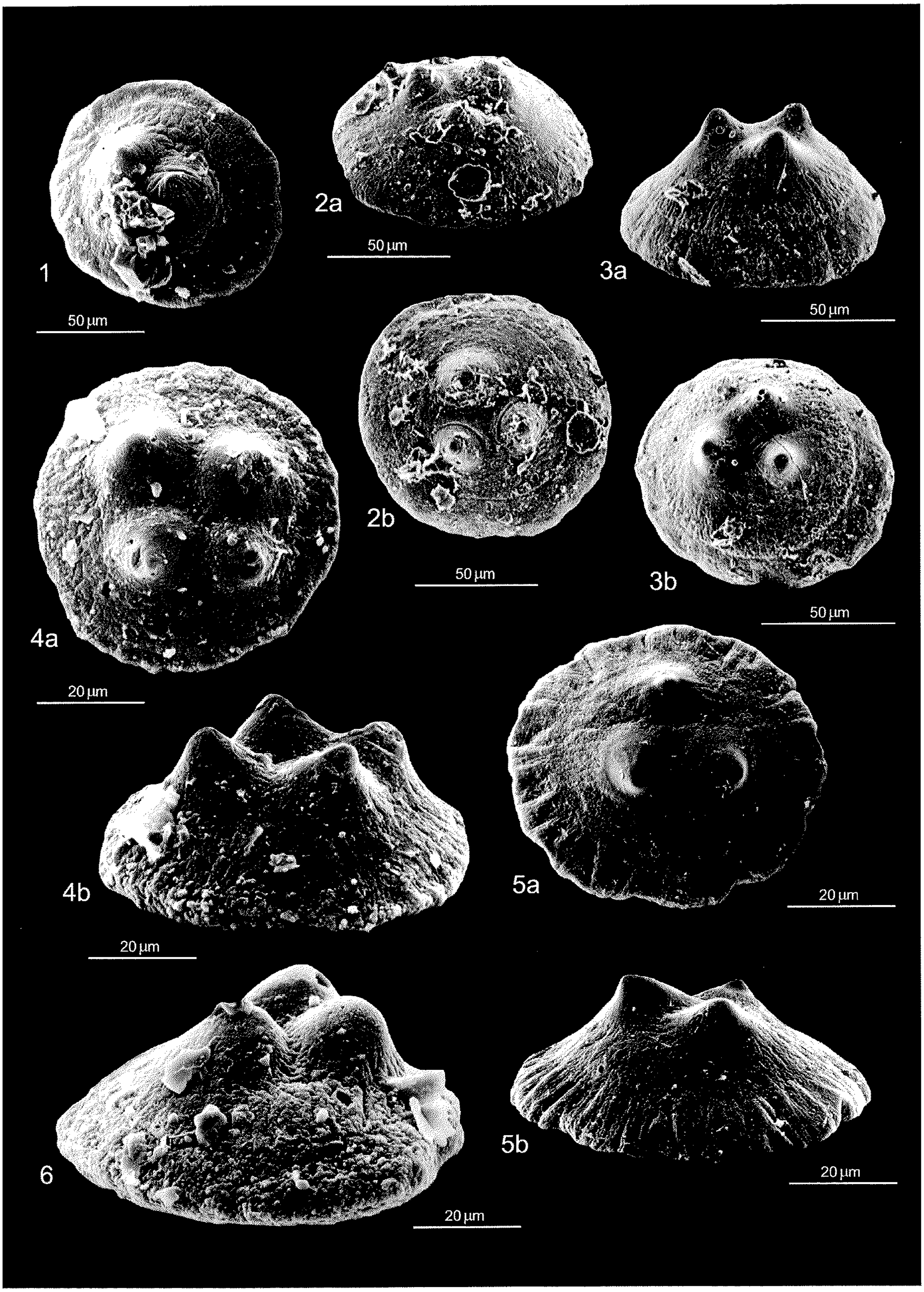
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PLATE 2

Scanning electron micrographs of palaeoscolecid sclerites belonging to *Hadimopanella oezgueli* from the Mila Formation, 'Member' 3, Upper Cambrian, Alborz Mountains, northern Iran.

1 – Upside view of sclerite with five nodes, ZPAL V. XXVIII/100S6.
2a, b – oblique and upside views of sclerite with six nodes arranged in a ring, ZPAL V. XXVIII/100S1.
3 – upside view of sclerite with four sparsely arranged nodes, ZPAL V. XXVIII/100S19.
4a, b – upside and oblique views of sclerite with five closely arranged nodes and wide marginal brim, ZPAL V. XXVIII/100S8.
5a – upside view of sclerite with five nodes and **b** - detail of striated brim, ZPAL V. XXVIII/100S7.
6 – Lateral view of asymmetric sclerite with six inclined nodes, ZPAL V. XXVIII/101S16.
7 – Oblique view of sclerite with four nodes and wide marginal brim, ZPAL V. XXVIII/100S5.
8 – Upside view of fragmentary, cracked sclerite with wide brim and fine radial striae at the basal suture on capped layer, ZPAL V. XXVIII/101S1.

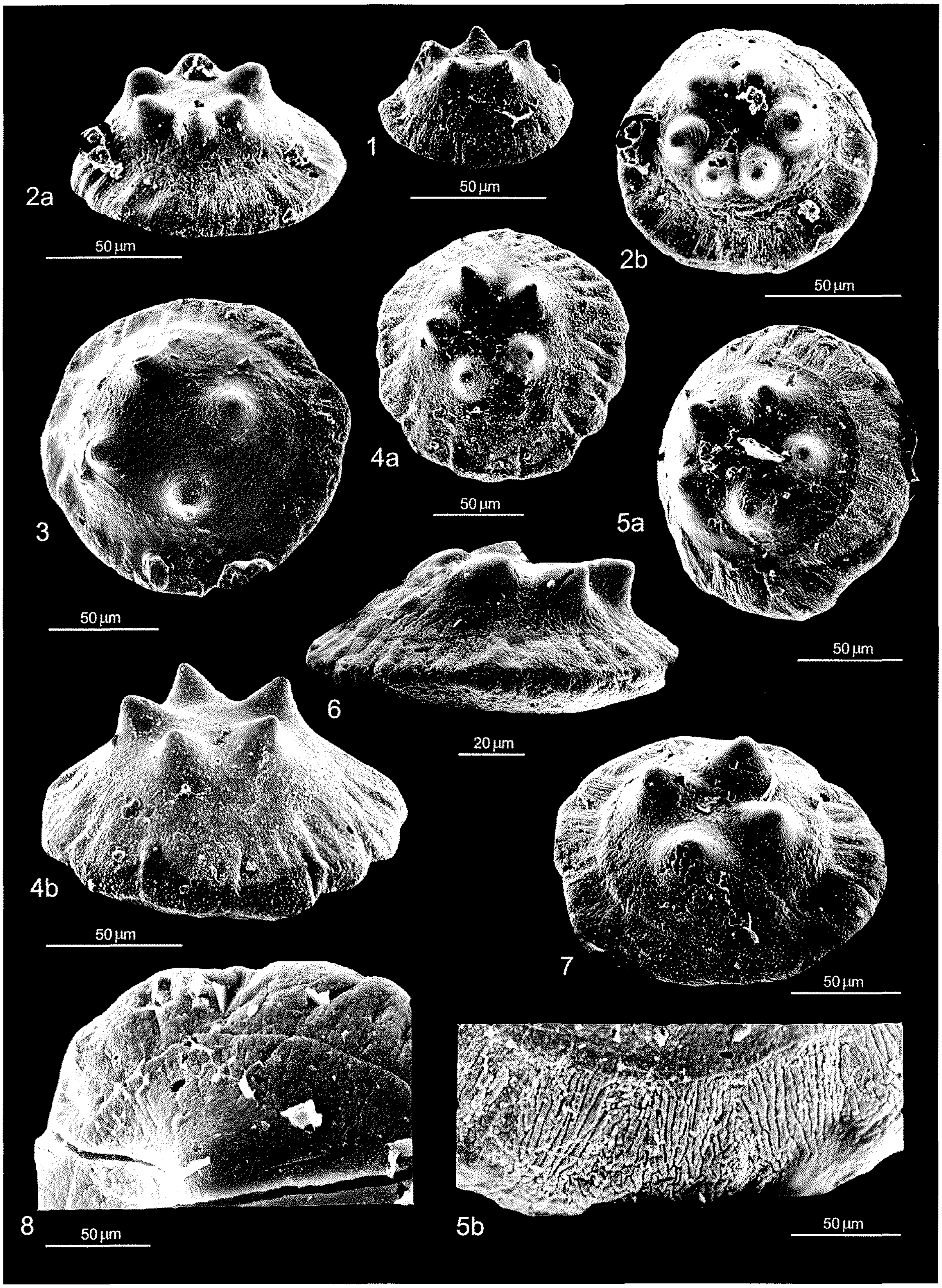
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PLATE 3

Scanning electron micrographs of palaeoscolecid sclerites belonging to *Hadimopanella oezgueli* from the Mila Formation, 'Member' 3, Upper Cambrian, Alborz Mountains, northern Iran.

1 – Upside view of sclerite with five nodes arranged in a ring around a central node, showing abraded capping layer, ZPAL V. XXVIII/100S3.

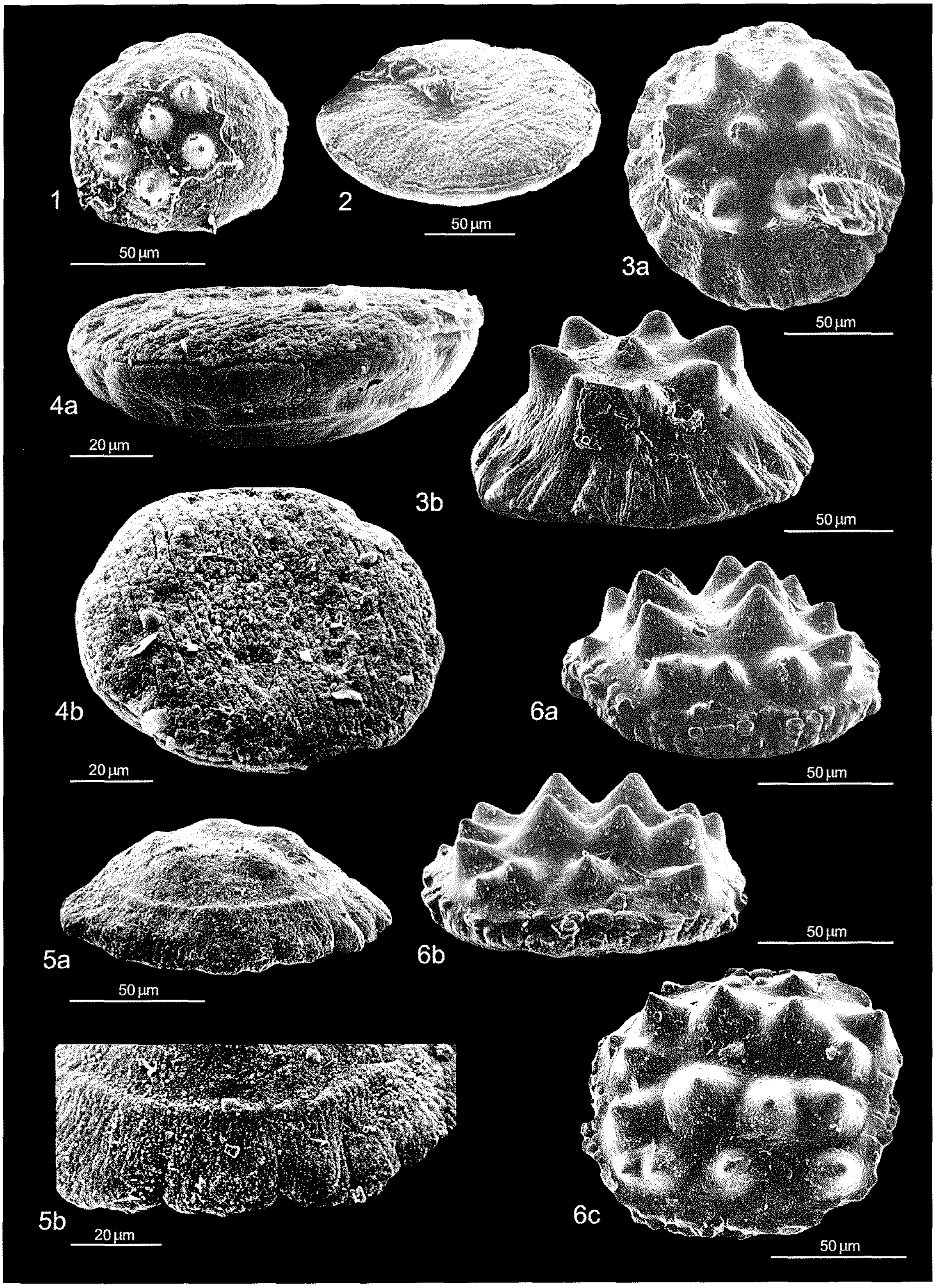
2 – Basal surface view of sclerite, showing fine striae in cross pattern, ZPAL V. XXVIII/101S10.

3a, b – upside and oblique views of sclerite with seven nodes arranged in a ring around a central node, ZPAL V. XXVIII/100S25.

4a – basal-oblique view of sclerite, showing contact of striated, inner layer and capping, ZPAL V. XXVIII/101S6; **b** - basal view of the same sclerite.

5a – lateral view of sclerite, showing partly (centrally) abraded capping layer and marginal brim, ZPAL V. XXVIII/100S27; **b** - detail of the same sclerite.

6a, b, c – *Milaculum*-type sclerite with multiple nodes in upside and oblique views, showing some polygonal platelets adhering to the sclerite margin, ZPAL V. XXVIII/100S9.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