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EARLY CAMBRIAN PHOSPHATIC MICROFOSSILS FROM SOUTHERN SPITSBERGEN (HORNSUND REGION)

WRONA, R.: Early Cambrian phosphatic microfossils from southern Spitsbergen (Hornsund region). Palaeont. Polonica, 43, 9-16.

A new phosphatic-microfossil species, *Hadimopanella apicata* sp. n., from the *Bonnia-Olenellus* Zone (upper Lower Cambrian) of southern Spitsbergen is described. The microfossils are discoidal in shape, with a cone-like elevation at the upper side. They consist of a fibrous core, with its fine structure discernible after etching, and a hyaline cover. The microfossils resemble dermal sclerites of primitive vertebrates. Their stratigraphic significance is briefly discussed.

Key words: Phosphatic microfossils, *Hadimopanella*, early vertebrates, Lower Cambrian, Spitsbergen.

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MIKROSKAMIENIAŁOŚCI FOSFORANOWE Z DOLNEGO KAMBRU SPITSBERGENU (OKOLICE HORNSUNDU)

Streszczenie. — Opisano *Hadimopanella apicata* sp. n., nowy gatunek mikroskamieniałości fosforanowych z soczewek wapiennych, występujących w łupkach, które są zaliczane do zony *Bonnia-Olenellus* (górna część dolnego kambru) z okolic Hornsundu na Spitsbergenie. Mikroskamieniałości te mają kształt okrągłych tarczek z ostrym wzgórkiem na jednej stronie, płaskich lub lekko wypukłych z drugiej strony. Zbudowane są one z dwóch warstw: szklistej i porowatej. Warstwa porowata stanowi gruby trzon, w którym po nadtrawieniu kwasem solnym widoczne są włókna zebrane w pionowe wiązki. Budowę tej warstwy porównano z budową bezkomórkowej tkanki kostnej — aspidyny i prymitywnej zębiny. Wysunięto przypuszczenie, że tkanka tworząca trzon podstawowy mogła być wyjściową dla obu wymienionych tkanek. Warstwa szklista stanowi cienką, silnie zmineralizowaną, litą pokrywę trzonu i jest porównana z warstwą emalioidalną, pokrywającą plakoidalne łuski niektórych kręgowców. Przedyskutowano podobieństwo opisanych mikroskamieniałości do sklerytów szkieletu skórnego prymitywnych kręgowców. Omówiono także znaczenie stratygraficzne tych mikroskamieniałości. Próby, zawierające mikroskamieniałości, zostały zebrane podczas wypraw Zakładu Paleobiologii Polskiej Akademii Nauk, działających na Spitsbergenie w latach 1974-1975. Praca była finansowana z problemu międzyresortowego MR-II-16 Polskiej Akademii Nauk.

INTRODUCTION

The investigated button-shaped phosphatic microfossils derive from the samples collected in the Hornsund region, Spitsbergen, during the 1974-1975 paleontological expeditions organized by the Institute of Paleobiology of the Polish Academy of Sciences. Similar microfossils

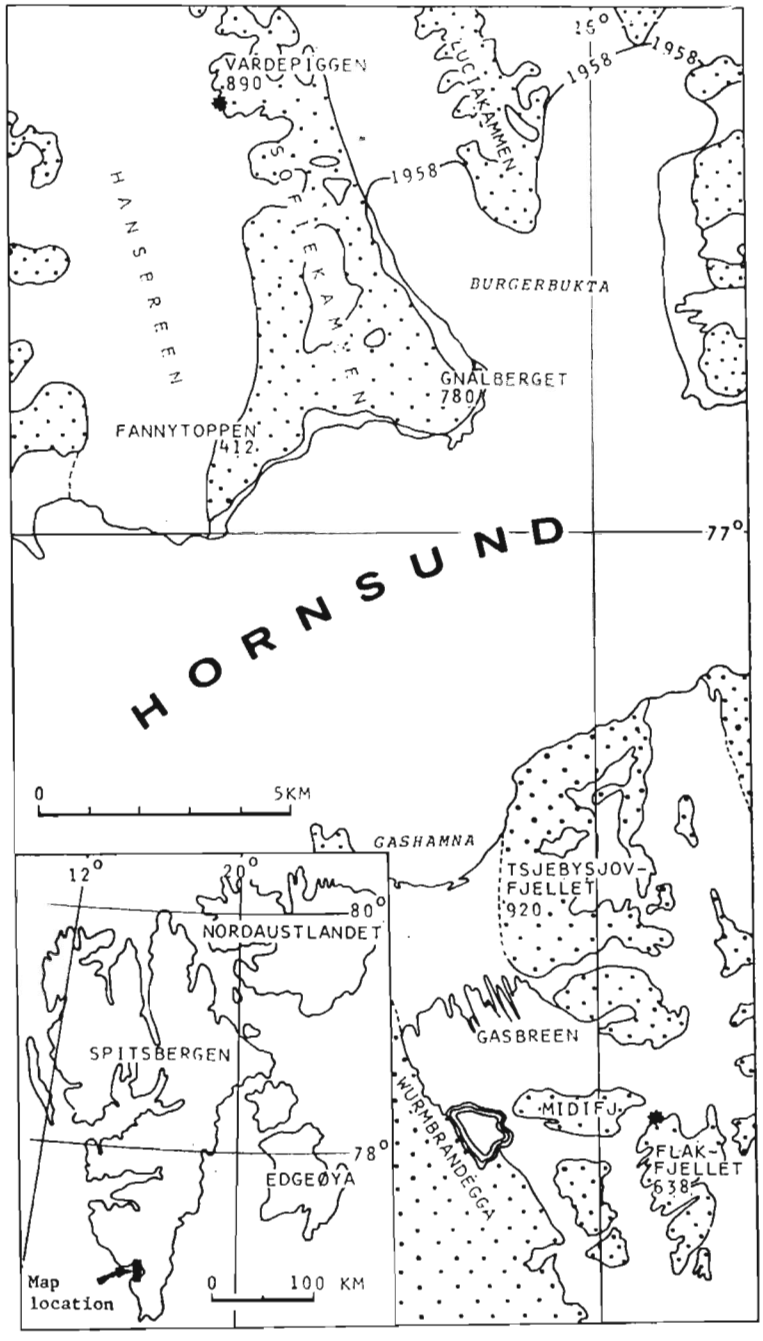


Fig. 1
Svalbard archipelago; Hornsund area, southern Spitsbergen; asterisked are sampled exposures of the Lower Cambrian limestones.

were recently described from the Cambrian of Turkey (GEDIK 1977) and Siberia (BENGTSON 1977). The microfossil-bearing samples were taken from the Lower Cambrian limestone intercalations and lenses which are exposed on the western slope of Vardepiggen and from the northwestern slope of Flakfjellet above the Russepasset (fig. 1).

The lithology and stratigraphy of the exposures are given by MAJOR and WINSNES (1955), BIRKENMAJER (1960, 1968, 1978), COWIE (1974), BIRKENMAJER and ORŁOWSKI (1977). The microfossil-bearing limestones occur as intercalations in a shaly set, rich in hyolithids, gastropods, brachiopods, and trilobites (MAJOR and WINSNES 1955). The trilobite assemblage (MAJOR

and WINSNES 1955, KIELAN 1960, BIRKENMAJER and ORŁOWSKI 1977) includes *Serrodiscus bellimarginatus*, *S.* cf. *speciosus*, *Calodiscus agnostidens*, *Pagetia* sp., *Olenellus* cf. *thompsoni*, *O. svalbardensis*, and *O. sculptilis*, and appears indicative of the upper Lower Cambrian *Bonnia-Olenellus* Zone; it permits a stratigraphic correlation with the Lower Cambrian of Atlantic and Pacific bioprovinces (FRITZ 1972, COWIE 1974, BIRKENMAJER and ORŁOWSKI 1977).

A 1000 phosphatic microfossils were isolated from about 2 kg of the rock dissolved in 10% acetic acid. A dozen thin sections were made, showing that the sclerites are disorderly and unevenly distributed up to a single specimen per 100 mm² of a section.

The microfossil morphology was studied under a scanning electron microscope (SEM). The fine structure was investigated under both polarizing and scanning electron microscopes in fractured specimens and in cross sections polished and etched with 1% hydrochloric acid for 20 to 30 seconds.

The fossils described in the present paper are housed in the Institute of Paleobiology of the Polish Academy of Sciences in Warsaw, abbreviated as ZPAL.

I am indebted to Dr. H. SZANIAWSKI (Institute of Paleobiology of the Polish Academy of Sciences) for making available the microfossils from the samples which he had investigated and for helpful discussion; to Dr. S. BENGTSON (Department of Paleobiology, Uppsala University), Dr. I. GEDIK (Karadeniz Teknik Üniversitesi, Trabzon) for making available sclerites from their collections and for comments; to Prof. T. ØRVIG (Naturhistoriska Riksmuseet, Stockholm) and to Dr. M. BORSUK-BIAŁYNICKA and Dr. J. DZIK (both of the Institute of Paleobiology of the Polish Academy of Sciences) for discussion. Dr. A. KOZŁOWSKI (Institute of Mineralogy, Geochemistry, and Petrography of the Warsaw University) is gratefully acknowledged for taking the photos in the polarized light and Mrs. M. NOWIŃSKA (Institute of Paleobiology of the Polish Academy of Sciences) for technical assistance. The SEM micrographs were taken at the Laboratory of Electron Microscopy of the Nencki's Institute of Experimental Biology, Warsaw.

DESCRIPTION

Phylum, class, order, and family — *incertae sedis*

Genus *Hadimopanella* GEDIK, 1977

Type species: Hadimopanella oezgueli GEDIK, 1977.

Remarks. — The present author considers *Lenargyrion* BENGTSON, 1977, as a junior subjective synonym of *Hadimopanella* GEDIK, 1977. This opinion follows from the morphological investigations of all thus far described sclerites. However, the author did not study in detail the structure of the sclerites described by GEDIK (1977) and BENGTSON (1977).

Hadimopanella apicata sp. n.
(pls. 1-4)

Holotype: specimen presented in pl. 2: 4; ZPAL V. VII/10S7.

Type horizon: Bonnia-Olenellus Zone, upper Lower Cambrian, Blåstertoppen Dolomite Formation, Sofiekammen Group, Hornsund Supergroup.

Type locality: northwestern slope of Flakfjellet above the Russepasset, Sørkapp Land, southern Spitsbergen.

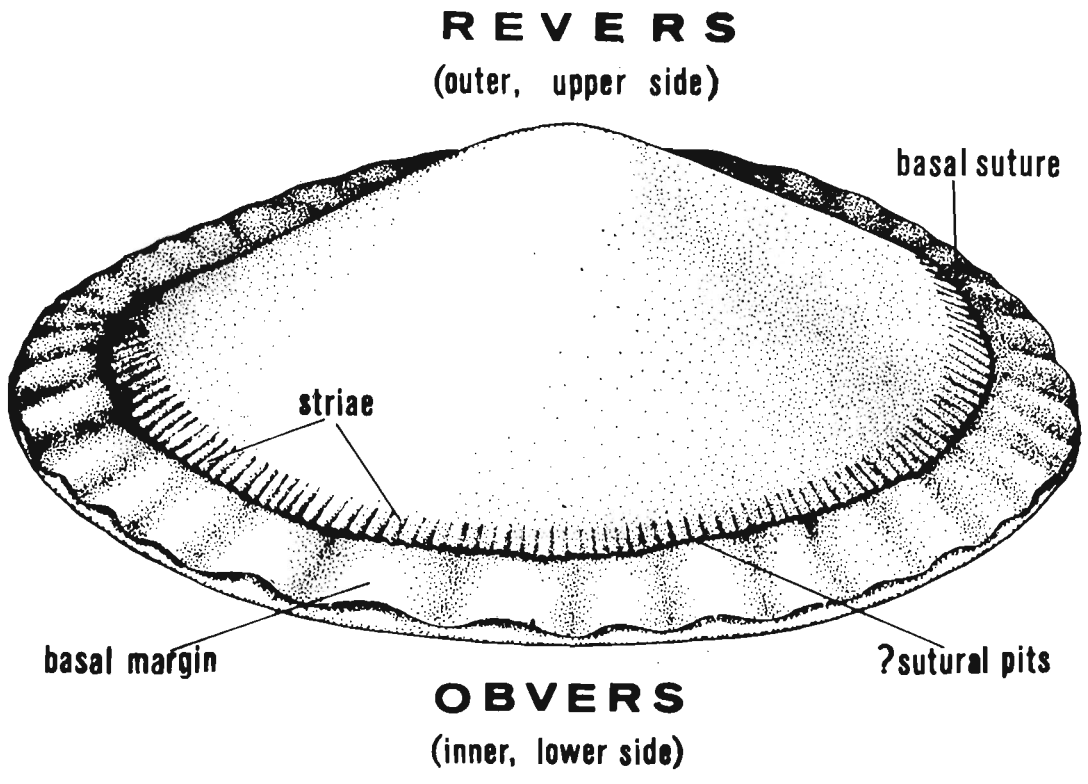
Derivation of the name: Lat. *apicatus* — capped, after the conical, apex-like shape.

Diagnosis. — Discoidal shield, smooth and flat to slightly convex at one side, considerably convex, with a pointed, centrally situated, cone-like rise at the other; bilamellar in fine structure: thick inner core covered with a thin hyaline layer.

Dimensions (in μm):		Diameter
ZPAL V. VII/10S7	Holotype	134
	Range	90-134
	Mode	100

Description. — Sclerites most commonly are circular (fig. 2A; pl. 1:1-5; pl. 2: 1-2,4), rarely oval (pl. 2:3) in outline. The cone-like apex is situated centrally or slightly deplaced eccentrically at the upper side (pl. 2:3). The sclerite diameters 3 to 5 times greater than the height. Bilamellar fine structure is discernible sometimes at the upper side due to incomplete coverage of the basal core by the outer layer thus leaving free a more or less wide basal margin (fig. 2A). This margin is smooth to slightly undulate in form of radial folds (pl. 2:4-5). The outer layer commonly shows radial striae at the margin of the upper side (pl. 2:4). In cross

A



B

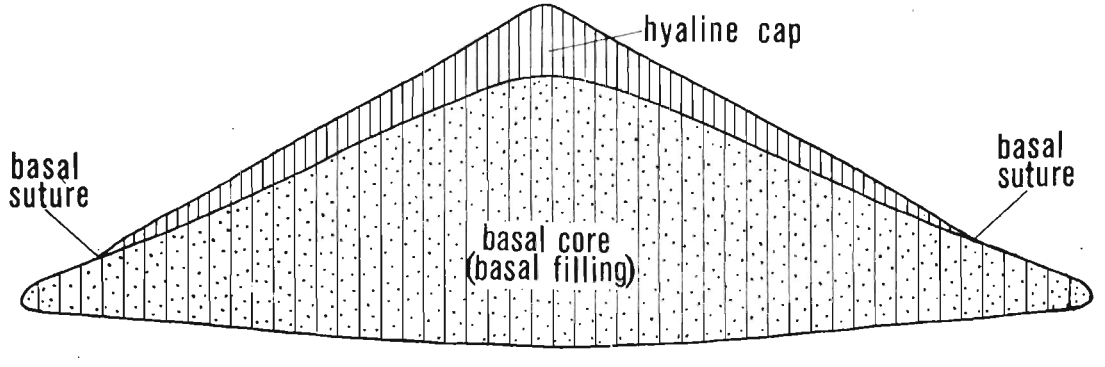


Fig. 2
A — Schematic drawing of a sclerite; *B* — Schematic cross section throught a sclerite.

section, the outer layer attains up to 5 μm in thickness at the center of a sclerite, while it gradually becomes thin outwards (fig. 2B; pl. 3:1, 4-5). It shows a considerable birefringence under a polarizing microscope (pl. 3:1). At a fresh fracture, the basal core is porous and granular, the outer layer is smooth and hyaline (pl. 3:4). In etched cross sections, the basal core is fibrous in structure (pl. 3:5; pl. 4:1-3) with the fibres ranging from 0.5 to 1 μm in diameter. The fibers are distributed in a disorderly manner, oriented most commonly along the axis of symmetry (vertically) and transversally, the latter bent acurately upwards (pl. 4:1b, c). Vertical fibers are in fan-like bunches starting at the lower (inner) surface of a sclerite (pl. 4:1).

Acid-resistant nuclei of secondary mineralization in basal cores (pl. 3:5; pl. 4:3) and secondary mineralization filling up fissures in crushed sclerites (pl.4:2) appear in cross sections. Sclerites are commonly fragmented, crushed (pl. 1:2), soiled with pyrite spherulites, crystals and minute mineral grains pressed commonly into the microfossils (pl. 1:5).

Comparative remarks. — *Hadimopanella apicata* differs in its smaller size and a single pointed apex from the Upper (or Middle) Cambrian sclerites *H. oezgueli* (50 to 400 μm in diameter) described from Karakaya Tepe, Taurus Mountains, Turkey (GEDIK 1977); and from its supposed congeners *Lenargyrion knappologicum* (50 to 460 μm in diameter) from the Lower Cambrian of Lena River, Siberia (BENGTSON 1977). The specimens from Spitsbergen and Turkey are dark-brown to almost black under reflected light, whereas those from Siberia are white. This however may be due to a difference in the preservation state.

Occurrence. — Spitsbergen (*Bonnia-Olenellus* Zone, Lower Cambrian). Sørkapp Land, Flakfjellet, Flakfjellet Member of the Blåstertoppen Dolomite Formation; Wedel-Jarlsberg Land, Vardepiggen, Vardepiggen Formation.

REMARKS ON THE FUNCTION AND ORIGIN OF SCLERITES *HADIMOPANELLA APICATA* SP. N.

The button-shaped phosphatic sclerites *Lenargyrion knappologicum* were studied in detail by BENGTSON (1977). According to this author, their morphology and fine structure indicate that these are dermal sclerites of some unknown animals. This hypothesis seems indeed plausible to the present author. The structural and morphological resemblance of *H. apicata* to the sclerites investigated by BENGTSON (1977) allows to accept this interpretation for *H. apicata* as well. This is supported by: (1) the occurrence of a thin vitrous outer layer covering a porous core; (2) the nodularity of one side and the smoothness of the other side of sclerites; (3) the broad margin in soft tissue; and (4) the evidence for abrasion of the nodular surface. One may suppose that a dermal skeleton composed of button-shaped sclerites was present in this form at the initial, hypothetical stage of dermal-skeleton development in the earliest vertebrates (ØRVIG 1968).

The investigated sclerites *H. apicata* are, however, compatible merely with the most general characteristic of the odontodes as defined precisely by ØRVIG (1977). Their structure, and especially that of the basal core, appears inconsistent with anyone of thus far known dentine or dentinous tissues.

The dimensions and arrangement of fibers recognizable in etched cross sections of the sclerites (pl. 3:5; pl. 4:1-3) may substantiate a claim that they formed the initial, organic, non-mineralized at the beginning of sclerite development, fabric of the basal core. Close to the lower, smooth surface of a basal core (fig. 2) some fibers may have never undergone complete mineralization; they could form canals like those observed by BENGTSON (1977) in the sclerites *L. knappologicum*. In *H. apicata*, canals may be entirely masked by secondary mineralization (pl. 3:5; pl. 4:2-3). Vertical fan-like bunches of fibers starting at the lower surface of a sclerite and intruding into the basal core (pl. 4:1) resemble kolageneous fibers intruding from the periodontium into the cement (BLOOM and FAWCETT 1967), or those recorded in aspidin of thelodont scales (GROSS 1967) as well as in aspidin of heterostracan armour (e. g., TARLO 1969).

The structure of the inner layer building up the basal core of the investigated sclerites may thus appear comparable to the aspidin, acellular bone tissue present exclusively in fossil early vertebrates. However, one may also suppose that the considered inner layer of the sclerites actually represents a primitive form of dentinous tissue with odontoblast canals lacking due to the small size of the sclerites. The tissue of basal core could then be a hard tissue present in vertebrate dermal skeleton prior to the appearance of both aspidin and dentinous tissue. An evolutionary increase in sclerite size could have stimulated a formation of protoplasmatic processes intruding deep into the tissue (that is dentinal tubules), resulting finally in typical odontodes (ØRVIG 1977).

The hyaline outer layer of the sclerites resembles the enameloid layer covering placoid scales in some vertebrates. Its considerable mineralization and superficial situation relative to the basal core may suggest that the hyaline layer developed at a contact with basal epidermal cells.

The structure of both the constituent layers of the sclerites and their sharp mutual contact may indicate that the basal core is of mezodermal origin, while its vitrous cover of ectodermal origin. There is no evidence for sclerite growth, lamination, or resorption. This may be due to the sclerite formation in the superficial part of the corium, under the epidermal cover; but it may also be caused by the formation and resorption of the small-sized sclerites as a whole.

The sclerites *H. apicata* show a much simpler structure than that displayed by the dermal skeleton of the oldest known vertebrates, representatives of the heterostracan genus *Anatolepis* from the Upper Cambrian Deadwood Formation, Wyoming, North America (REPETSKI 1978), and the Lower Ordovician Valhallfonna Formation, Ny Friesland, Spitsbergen (BOCKELIE and FORTEY 1976). In fact, the latter skeleton consists of minute ellipsoidal to rhomboidal scales (odontodes?) fused one with another, forming a solid armour of a composite, lamellar internal structure. Because of the poor preservation state of those early heterostracan specimens, the structure of their dermal skeleton can hardly be compared to the Early Cambrian button-shaped sclerites.

STRATIGRAPHIC SIGNIFICANCE

Significance of the button-shaped sclerites for stratigraphy and correlation is due to their exclusive occurrence in the Lower to Middle Cambrian strata of very distant areas: Siberia (BENGTSON 1977), Turkey (GEDIK 1977), and Spitsbergen. Their morphological variability and stratigraphic range suggest that they may appear as good guide-fossils in the future. Button-shaped sclerites may indeed occur in the equivalent Lower Cambrian deposits exposed elsewhere in Sørkapp Land and Wedel Jarlsberg Land (BIRKENMAJER 1968, COWIE 1974), North America, and Europe (HOLLAND 1971, 1974; FRITZ 1972: fig. 2).

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EXPLANATIONS OF THE PLATES 1-4

PLATE 1

Hadimopanella apicata sp. n.

Lower Cambrian, Blåstertoppen Dolomite Formation, Flakfjellet Member, Flakfjellet, Sørkapp Land, southern Spitsbergen

1. Soiled sclerite in oblique upside view; ZPAL V. VII/11S23, × 600.
2. Broken and slightly soiled sclerite; basal suture and basal margin hardly discernible; ZPAL V. VII/11S8, × 600.
3. Soiled sclerite in oblique upside view; hyaline layer covering entirely the porous core, no basal suture at the upper surface; ZPAL V. VII/11S7, × 600.
4. Considerably soiled sclerite in oblique upside view; ZPAL V. VII/11S20, × 600.
5. *a* sclerite in oblique upside view; central part slightly soiled, margin broken; ZPAL V. VII/13S6, × 600.
   b enlarged fragment of the same specimen; note basal margin, basal suture, and striae; mineral grains pressed into the hyaline layer (arrowed); × 2000.

PLATE 2

Hadimopanella apicata sp. n.

Lower Cambrian, Blåstertoppen Dolomite Formation, Flakfjellet Member, Flakfjellet, Sørkapp Land, southern Spitsbergen

1. Considerably soiled sclerite in oblique upside view; ZPAL V. VII/11S16, × 600.
2. Sclerite in downside view; ZPAL V. VII/11SW, × 600
3. A slightly soiled sclerite in upside view; ZPAL V. VII/11S15, × 600.
4. *a* holotype in upside view; surface slightly soiled and corroded; ZPAL V. VII/10S7, × 750.
   b enlarged fragment of the same sclerite; note basal margin, basal suture, and striae; × 3000.
5. Sclerite in lateral view; upper surface considerably corroded, lower surface soiled; ZPAL V. VII/10S9, × 750.

PLATE 3

Hadimopanella apicata sp. n.

Lower Cambrian, Blåstertoppen Dolomite Formation, Flakfjellet Member, Flakfjellet, Sørkapp Land, southern Spitsbergen

1. *a* cross section through a sclerite under a polarizing microscope with the nicols parallel; note bilamellar structure of the sclerite; ZPAL V. VII/1P, × c. 500.
   b the same thin section under a polarizing microscope with the nicols crossed; note considerable birefringency of the outer layer (light); × c. 500.
2. Sclerite in a thin section of limestone rock; ZPAL V. VII/1T1, × ç. 400.
3. Sclerite in a thin section of limestone rock; ZPAL V. VII/1T2, × c. 400.
4. *a* cross section through a sclerite; note bilamellar structure of the sclerite; ZPAL V. VII/10S16, × 750.
   b enlarged fragment of the same thin section; note considerably mineralized hyaline, outer layer and porous fracture surface of the inner layer (basal core); × 2500.
5. Etched cross section through a sclerite; note fibrous structure of the inner layer (basal core), and spheroidal nuclei of supposedly secondary mineralization (arrowed); ZPAL V. VII/13S1, × 600.

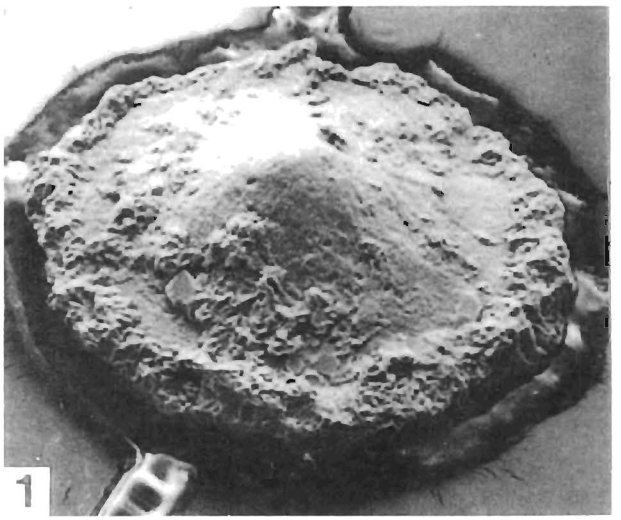
PLATE 4

Hadimopanella apicata sp. n.

Lower Cambrian, Blåstertoppen Dolomite Formation, Flakfjellet Member, Flakfjellet, Sørkapp Land, southern Spitsbergen

1. *a* etched cross section through a sclerite; note fibrous structure of the inner layer (basal core), and considerably soiled outer layer; ZPAL V. VII/13S4.
   b the same thin section more enlarged; note vertical fan-like bunches of fibers starting at the lower surface of the sclerite (arrow pointing upwards).
   c enlarged fragment of section through the basal core; note the arrangement of the fibers.
2. Etched cross section through a considerably corroded sclerite; note a secondary, mineral fill in a fissure in the broken sclerite (arrowed); ZPAL V. VII/11S5.
3. *a* etched cross section through a sclerite; note considerably etched inner layer and soiled hyaline, outer layer; spheroidal nuclei of supposedly secondary mineralization (arrowed) at the lower surface of the outer layer; ZPAL V. VII/13S3.
   b enlarged fragment of the same thin section; note a spheroidal nucleus of supposedly secondary mineralization in the basal core.

Bar scale for all the figures 10 μm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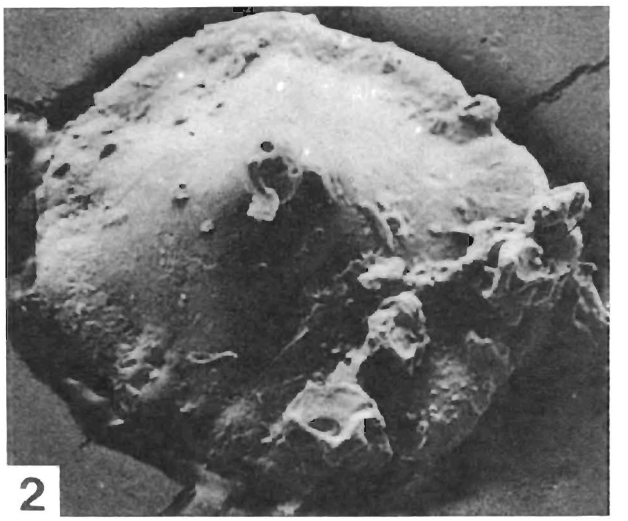
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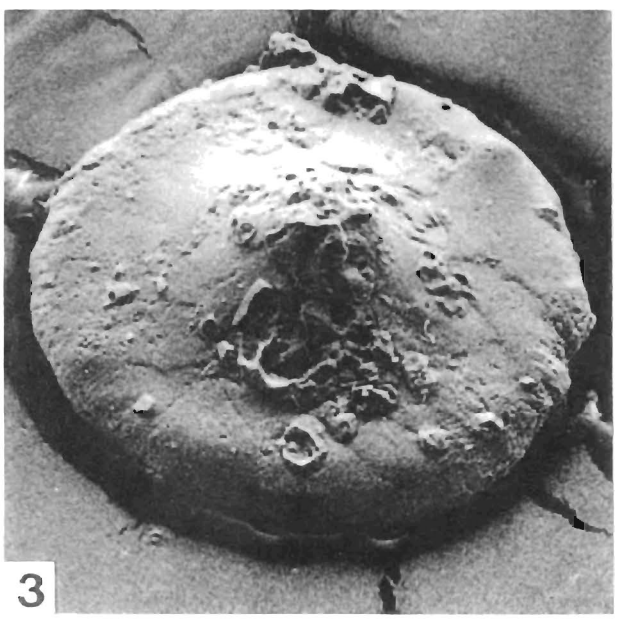
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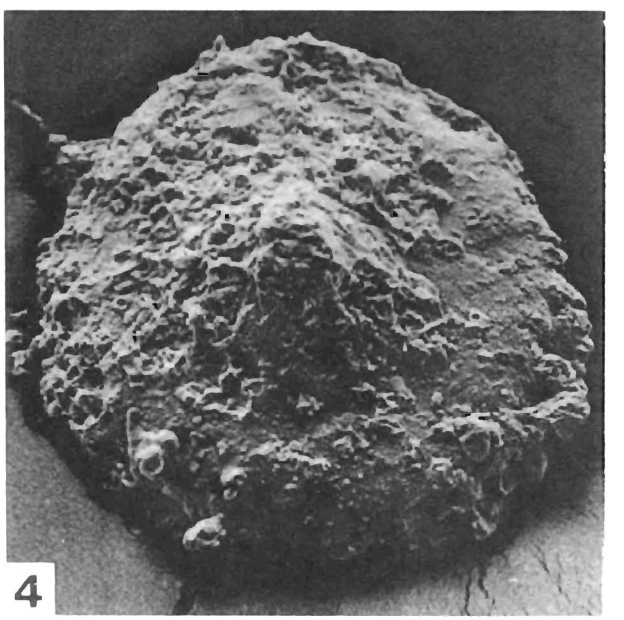
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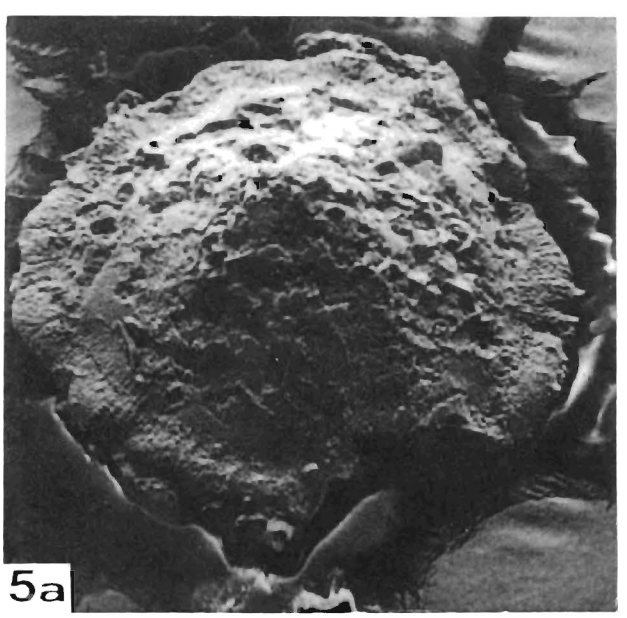
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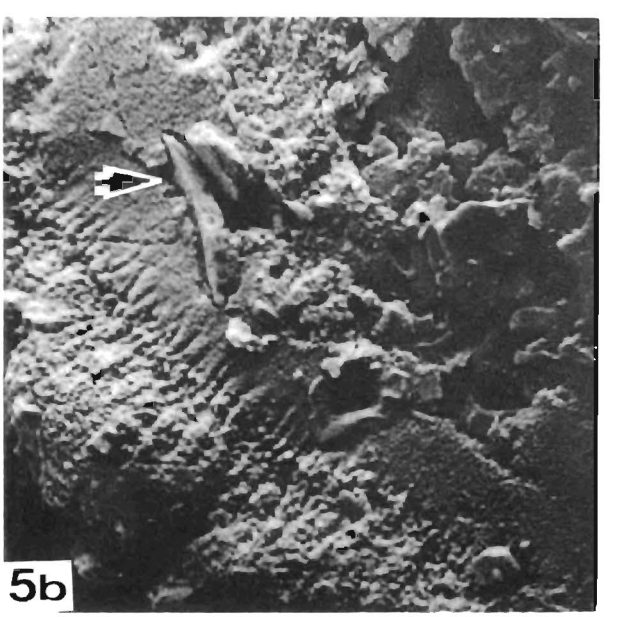
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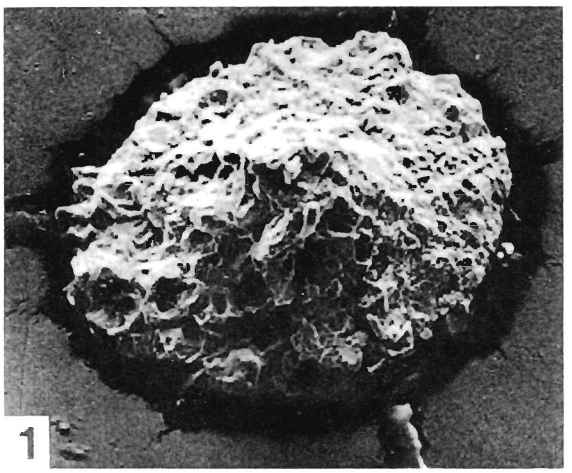
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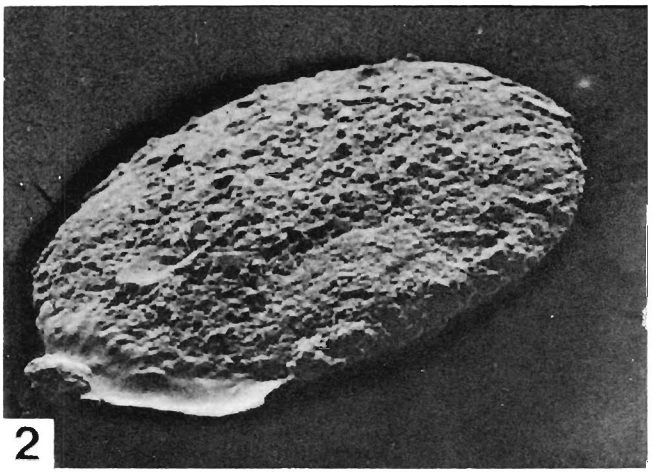
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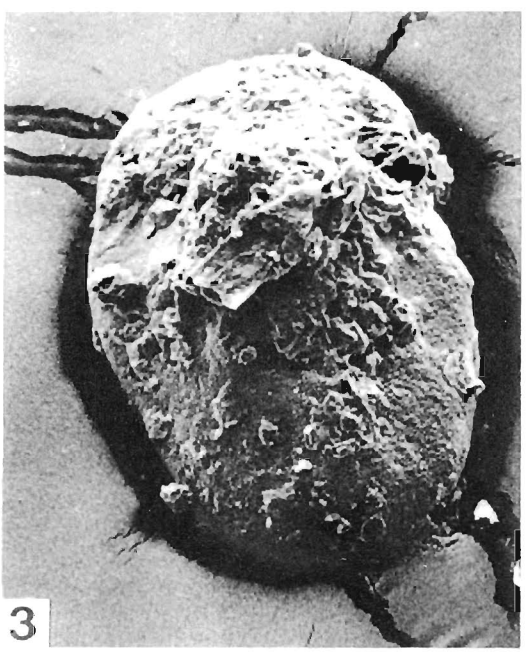
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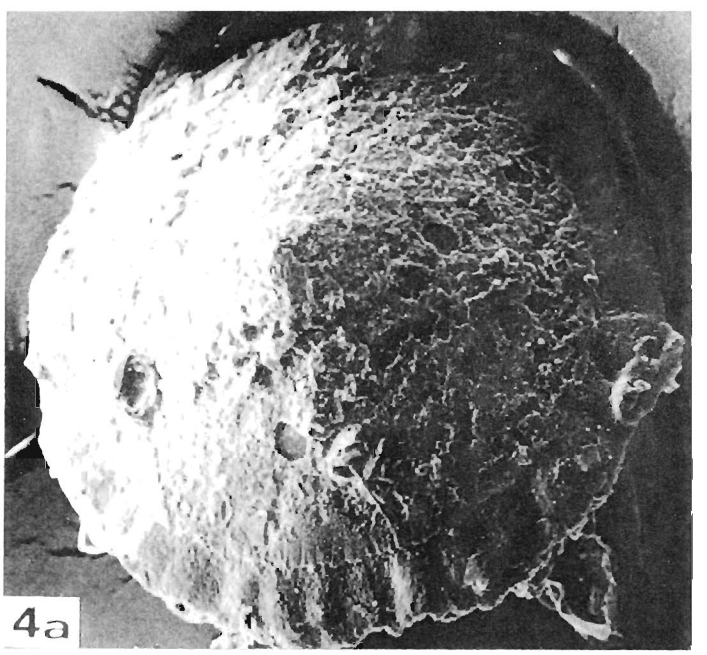
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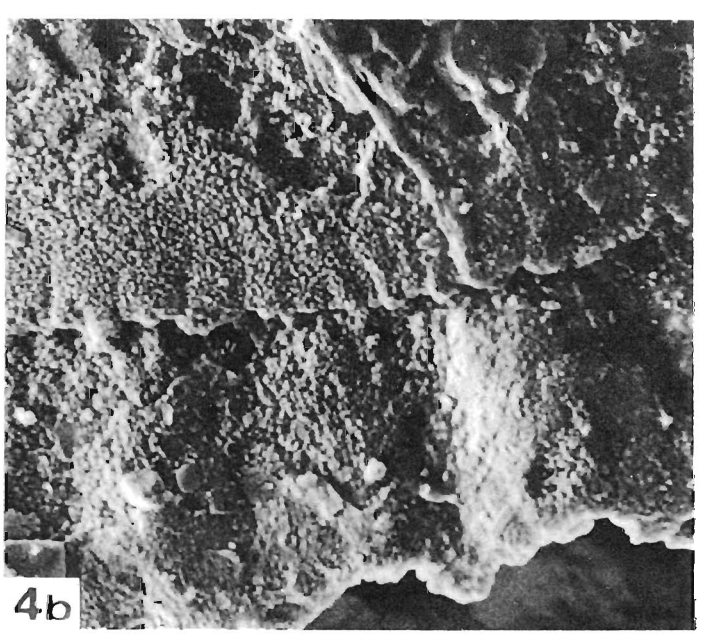
5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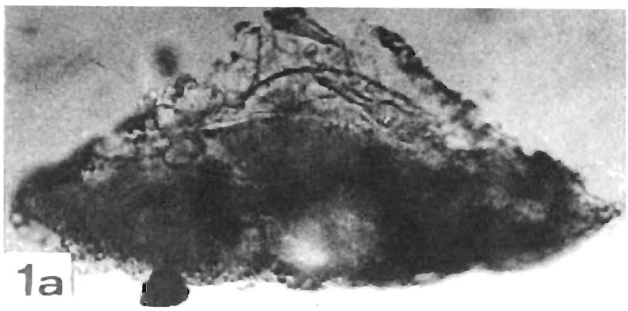
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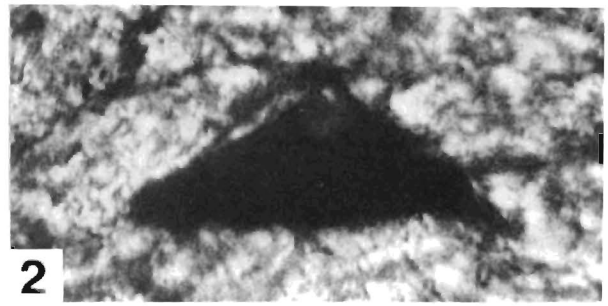
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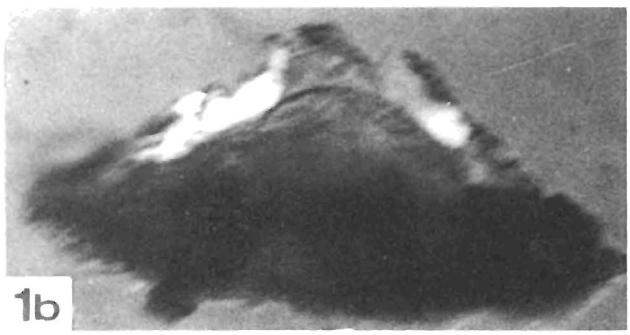
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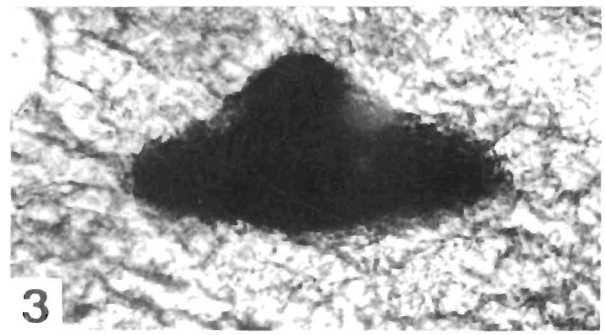
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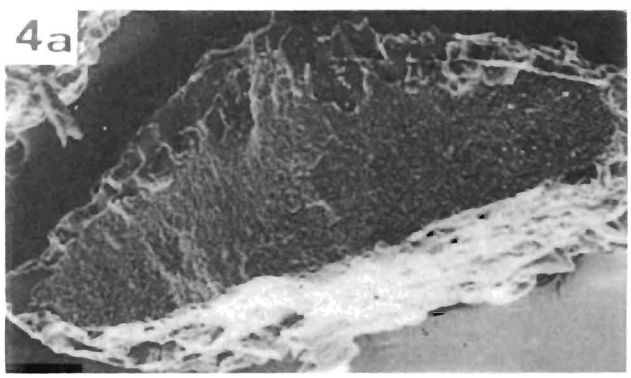
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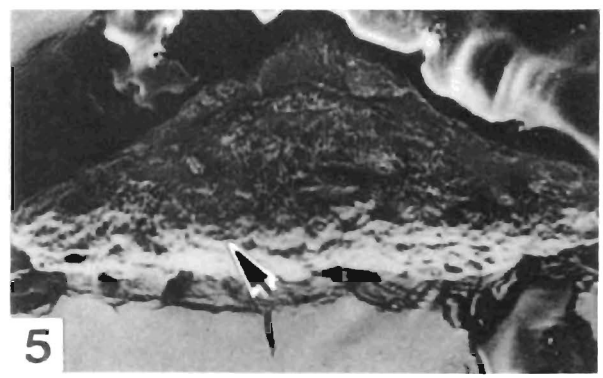
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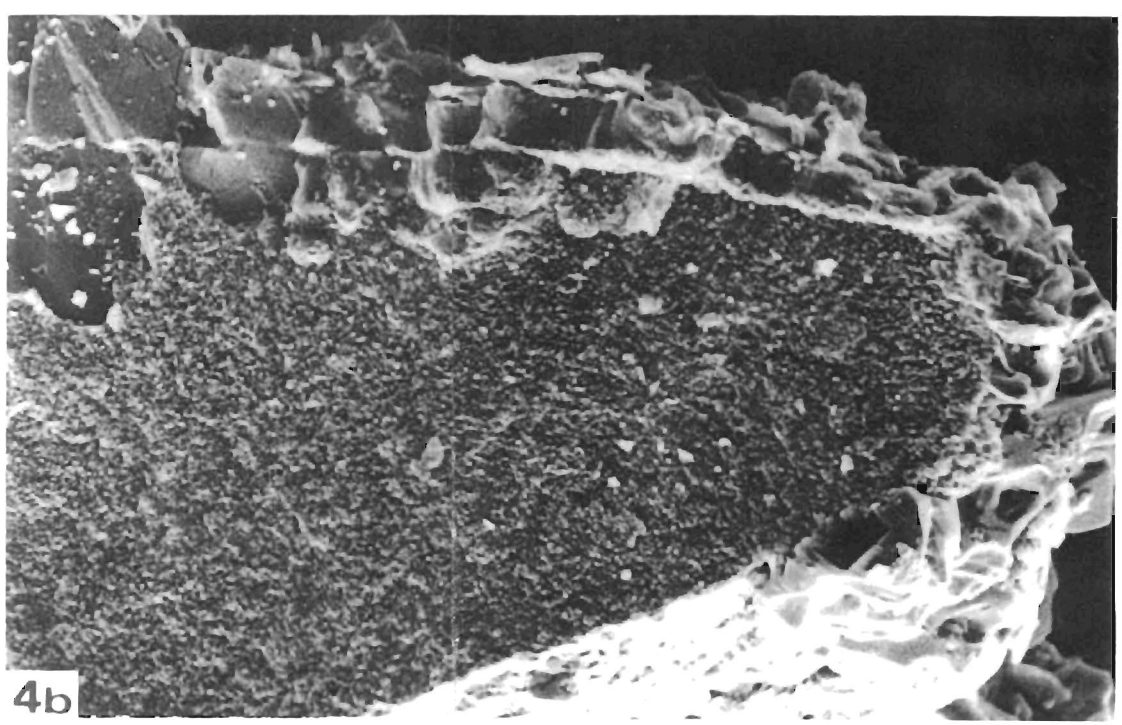
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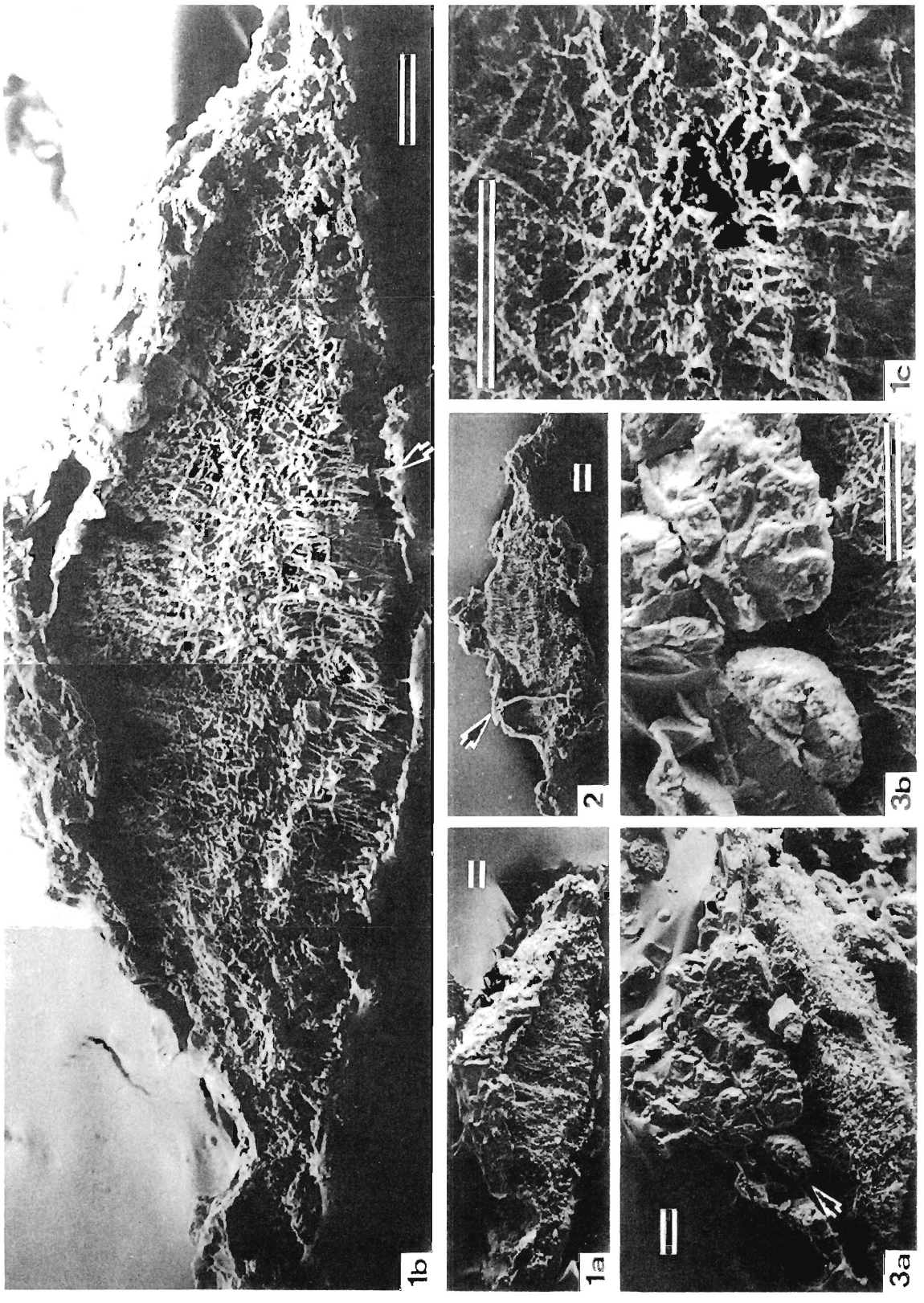
1b
1c
2
3b
1a
3a