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MORPHOLOGY AND MICROSTRUCTURE OF OLIGOLAMELLAR TEETH IN PALEOZOIC ECHINOIDS
PART 1. TEETH OF SOME EARLY LEPIDOCENTRID ECHINOIDS

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The oligolamellar, flat type of echinoid teeth in *Kongielechinus magnituberculatus* gen.n., sp.n. is described. The teeth consist of few relatively large, thick, roughly triangular lamellae. Re-interpretation of the teeth structure of the oldest known echinoids — Upper Ordovician *Aulechinus* and *Ectinechinus* is presented. It is suggested that their teeth also belong to the flat, oligolamellar type and have been hitherto wrongly assigned to the grooved type. A new lepidocentrid *Kongielechinus magnituberculatus* gen.n., sp.n. from the Givetian (Middle Devonian) of Poland is described on the basis of isolated coronal plates, spines and Aristotle lantern elements.

Key words: Devonian, echinoids, evolution, jaw apparatus, microstructure, taxonomy.

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INTRODUCTION

In spite of the great importance of the echinoid teeth morphology in the classification of echinoids, the role of fossil material in this matter has been until now insignificant. This is particularly true of the Paleozoic echinoids which generally are assigned to the "grooved" type. The "serrate" type of teeth has also been reported from the Late Paleozoic deposits (Jackson 1912, Bindemann 1938) but without entering into details and interpretation of this structure.

The very peculiar laminate echinoid teeth of the oldest known echinoids, the Upper Ordovician *Aulechinus graye* and *Ectinechinus lamonti*, described forty years ago (McBride and Spencer 1938) have not been revised. Those structures are in echinoid literature assigned to the grooved type, in spite of the fact that McBride and Spencer (*l.c.*: 96) considered them flat.

The poor knowledge of fossil echinoid teeth is certainly due to the rarity of the record of complete Aristotle lantern preserved inside the test; generally only such material is considered as having full scientific value. However, this condition is a rarity in post-Paleozoic echinoids and it is even more rare in the Paleozoic forms mainly because of their easily disassociating test. Even if jaws are found within the test most often the teeth are only fragmentarily preserved or entirely lacking as their attachment to the jaws is very weak. Also, the generally small size of the Paleozoic lantern elements in which the teeth, even in larger specimens rarely exceed 15 mm in length and 5 mm in width, has probably contributed to the poor record of that material.

During past several years an intensive search has been carried out by the author in deposits ranging in age from the Givetian (Middle Devonian) to the Miocene of several localities in Poland. The main purpose was to find and examine the samples containing echinoid skeletal elements especially those of Aristotle lantern. At the basis of this action was the conviction that many significant data may be obtained from the disassociated material. The main problem in the investigation of such material is matching of coronal plates, spines and elements of jaw apparatus which makes póssible the proper taxonomic assignment of loose assembleges of skeletal elements. This may be relatively easy (as in case of material described in this paper) when almost all echinoid skeletal parts belong to one taxonomic unit. In many other cases, where more varied material was found, much of identification work has been done by the method of comparison and elimination. In most of such instances at least family assignment was possible and very often the generic identification might be proposed. Generally, it seems that what concerns the studies aiming at elucidation of the main pattern of evolution of particular skeletal elements, the concern about the correct taxonomic assignment should not be a reason for abandoning this kind of research. The studies on echinoid material obtained by micropaleontological method are certainly difficult, risky and above all time-consuming. The results of investigations will be published in a series of papers. They are intended to include detailed studies on echinoid teeth but whenever possible also the descriptions of other skeletal elements will be presented. The present paper is the first of this series.

Several hundred of kilograms of weathered deposits has been collected in numerous localities of different ages. The samples were washed, treated with Glauber's salt or concentrated perhydrol. Skeletal elements picked up from residua were examined under binocular microscope. The microstructure was studied in thin section under polarized light and with electron scanning microscope.

The material described in the present paper was obtained from a 30 kg sample of the Givetian deposit. It was gathered in the Skały beds (Pajchlowa 1957) at Świętomarz-Śniadka profile at the locality called Błonie Valley in the Holy Cross Mts (Central Poland). Very fossiliferous, strongly weathered shales and limestones have yielded, among others, diversified echinoderm material (Piotrowski 1977). Almost all echinoid remains however belong to one taxon. Only insignificant fraction of echinoid elements namely: two interambulacral plates, one rotula, two fragmentary "serrate" teeth and a few broken spines represent some other echinoids. They differ so much in morphological details (fig. 2: *F*, fig. 4: *B*; pl. 24) from *Kongielechinus magnituberculatus* gen.n. sp.n. that their distinctness is doubtless. The matching of coronal plates was rather easy because of characteristic tuberculation. Also the bases of spines are adjusted to the unusual shape of tubercles in such a way (excentric oval acetabulum) that there is no doubt in recognizing the spines as belonging to the coronal plates.

There is no direct proof that the lantern elements are correctly assigned to the new genus. However the material contains the growth series of lantern and it is hardly imaginable that the transportation and segregation would result in accumulation of coronal plates and spines from one taxon and lantern elements from another.

As to the question why this thin-plated, easily desintegrating echinoids are found in such completeness — the only possible conclusion here admitted, would be their presumably burrowing mode of life. McBride and Spencer (1938: 134) suggested that *Aulechinus* and *Ectinechinus* might also be burrowing forms.

ACKNOWLEDGMENTS

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Most of the washing and chemical preparation has been carried out by Mrs. Joanna Skarżyńska who also revealed unusual devotion and skill in picking up whatever could be an echinoid test element. The very difficult task of preparation of minute objects as well as the thin sectioning was done by Mrs. Mirosława Nowińska who used her great inventiveness and experience when handling very fragile material.

Drawings accompanying this paper were done by Miss Magdalena Jesionek (student in Arts) and Miss Ewa Osińska (Institute of Paleobiology). SEM micrographs have been done by Mr. Jerzy Szemraj and Mr. Wojciech Skarżyński in the Nencki Institute of Experimental Biology in Warsaw. To all these persons and institutions the author wishes to express her gratitude.

The collection described in this paper is housed in the Institute of Paleobiology of Polish Academy of Sciences in Warsaw for which the abbreviation ZPAL is used.

HISTORICAL

Since the famous monograph of Jackson (1912) who summed up previous findings of Aristotle lanterns and described important new materials, no major progress in this matter has been done. The oldest echinoids, Upper Ordovician *Aulechinus* and *Ectinechinus* have been partly revised by Durham (1966), but this revision did not concern the details of their jaw apparatuses. The Silurian *Echinocystis* and *Palaeodiscus* have been thoroughly reexamined by Hawkins and Hampton (1927), but no details of Aristotle lantern structure were revealed, beyond those described by Gregory (1897), Sollas (1899) and Spencer (1904). In Silurian *Lanternarius latens* from Gotland (Regnél 1956: 173) the teeth were absent but they were found in *Aptilechinus caledonensis* Kier, 1973 from the Silurian of Scotland. According to Kier (*l.c.*: 660, pl. 83: 3) who examined this material on latex pull, the teeth of *Aptilechinus* are grooved and, in general, typical of those found in Paleozoic echinoids. Kier reports the presence of four to five longitudinal ridges on ?outer surface of teeth, but does not comment upon the meaning of this structure.

Similarly little is known on the Devonian echinoid teeth. In addition to imperfectly known teeth in *Devonocidaris jacksoni* Thomas, 1924, where deep median furrow on outer surface has been reported, Kier (1968: 1168) described in *Nortonechinus welleri* Thomas, 1924 a tooth being "concave up its lengths as viewed from the interior of the lantern".

The Carboniferous rocks are aboundant in echinoid remains, but no significant data have been added in what concerns the teeth structure. From the Lower Carboniferous deposits Bindemann (1938) described the elements of Aristotle lantern giving some very interesting details concerning teeth structure in *Meekechinus ?herbornensis*. In that echinoid the teeth are serrate on adoral end, ridged on both outer and inner surface and show the lines of growing zone at aboral end. The serrate and ridged type was previously described by Jackson (1912: 443; pl. 76: 7) in

Meekechinus elegans from the Lower Permian of Kansas, but until the Bindemann's finding it has not been reported from the Carboniferous strata. Later Kier (1957, 1965) reported similar serration in the cidaroid species from the Pennsylvanian and Mississippian deposits and also in lepidocentrid genus (Kier, 1962: 9) from Lower Carboniferous (Marbre noir de Dinant) in Belgium.

More recently Spreng and Howe (1963) examined several Mississippian and Pennsylvanian lantern elements including some fragmentary teeth. The authors assigned this material to cidaroids, lepidesthids and palechinids. Although that material represents at least two different stocks of the Paleozoic echinoids, all described teeth are reported (*l.c.*: 936—937) to be of grooved type. Aboundant material consisting of several hundred echinoid skeletal elements (including 84 fragmentary teeth) has recently been described by Hoare and Sturgeon (1976) from the Pennsylvanian in Ohio. In this paper an interesting type of tooth has been reported and illustrated (*l.c.*: 20; pl. 2: 35) for the first time in Paleozoic echinoids. Besides the description of general morphology, mention is also made of the microstructure, seen in strongly weathered specimens. However, the reference of this structure to Devanesen's illustration (1922, fig. 2) is somewhat unclear. Devanesen's figure represents the reconstruction of the inner side of Recent keeled tooth displaying at least four structurally different zones of tooth formation. As Hoare and Sturgeon do not illustrate or describe in detail the microstructure of those Pennsylvanian teeth, it is impossible to visualize what they are like.

The Permian, much reduced echinoid fauna is still very poorly known. As to the teeth, besides the serrate teeth (Jackson 1912: 443; pl. 76: 7) of *Meekechinus elegans* only cidaroid teeth were hitherto known (Kier 1958: 811; pl. 114: 5). In all external features (V-shaped cross-section i.e. grooved type) they resemble the teeth of post-Paleozoic cidaroid echinoids.

The widely disscussed Geis' (1936: pl. 60: 3) finding of keeled tooth in a Pennsylvanian deposit has remained unconfirmed since over 40 years. Unfortûnately Geis' samples were lost (Kier 1974: 5) and a revision of that material was not possible. Kier's (*l.c.*: 6) inference that Geis' material could be contaminated with the Cretaceous deposits seems to be very probable. On the other hand it is puzzling that Geis in his material has not found the grooved teeth which had to be there together with illustrated by him (*l.c.*: pl. 60) half-pyramids, epihyses and rotulae of obviously Upper Paleozoic character. One of the reasons could be the fact that weathered echinoid teeth very easily desintegrate into almost unrecognizable parts. Firstly they easily fall apart into two halves along the median line because the overlapping of the lamellae (primary plates) is in most of Paleozoic echinoids very weak. Those half-teeth may further desintegrate (especially in ridged teeth) so they are found in samples in the form of very difficult to identify calcareous rods. On the other hand some echinoderm or non echinoderm remains may imitate the external features of echinoid teeth, also that of keeled type. Many such "findings" have been encountered by the author when working on Paleozoic echinoid material but when examined in cross-section under polarized light they turned out to be of non-echinoid origin.

In order to collect abundant material concerning structure and evolution of echinoid teeth many scores of samples coming from the Middle Devonian (Givetian and Frasnian) as well as the Lower Carboniferous (Tournaisian) from several localities in Poland have been examined. In no one the keeled tooth has been found. This, however, does not preclude that in some other samples, especially from younger deposits (Upper Carboniferous or Permian), the keeled tooth may be found confirming Geis' finding.

Some important studies on Recent echinoid teeth (Davanesen 1922; Gordon 1926) contain many inferences which may be confirmed only on fossil material. The studies on microstructure of Recent echinoid teeth lead Märkel (1974, with literature) to far reaching conclusions concerning the phylogeny of echinoids. This also awaits the confrontation with the paleontological data. It is hoped that this and subsequent papers will in some way serve the purpose and contribute to the better understanding of the pattern of evolution of this beautiful apparatus called Aristotle lantern.

ATTEMPT AT NEW INTERPRETATION OF TEETH STRUCTURE IN THE OLDEST LEPIDOCENTRID ECHINOIDS

The jaw apparatus and especially the teeth of the Upper Ordovician *Aulechinus* Bather and Spencer 1934 and *Ectinechinus* McBride and Spencer 1938 have been very carefully examined, described and illustrated (McBride and Spencer 1938: 96, 119—126; fig. 10*B*; 11:*A*,*B*; 12:*B*). Although they present several unusual features, the peculiarity of their structure has been overlooked in subsequent echinoid literature. This, at least in part, was due to the rather free using by the authors the term "grooved" which in reference to teeth structure is strictly reserved to characterize the type having V-shaped appearence in cross section. McBride and Spencer (*l.c.*), however, used this term in quite another sense, namely to stress that in *Aulechinus* and *Ectinechinus* teeth, several deep grooves are present both on outer and inner surface, but otherwise the teeth are flat. In a concise description of jaw apparatuses in *Aulechinus* and *Ectinechinus* they state (*l.c.*: 96): "*Aulechinus* — Jaws of lantern very small, teeth flat with deep grooves; *Ectinechinus*: Jaws of lantern more elongate than in *Aulechinus*; teeth flat; grooves less distinct than on *Aulechinus*".

Later in the text McBride and Spencer give some more details (*l.c.*: 122) "The teeth [in *Aulechinus*] have broad edges and are laminate. Each lamina is composed of about seven ribs between which are grooves". In *Ectinechinus* (*l.c.*: 124) "the teeth are grooved, but not so deeply as in

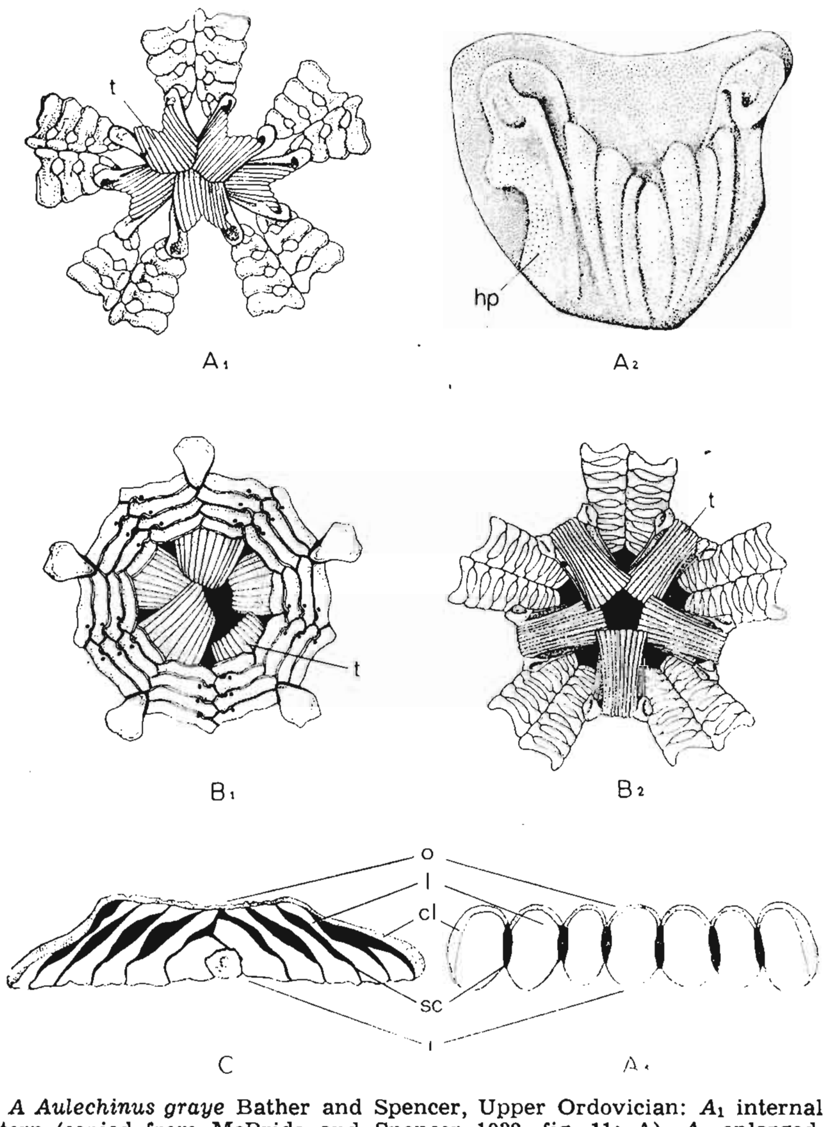

Fig. 1. *A Aulechinus graye* Bather and Spencer, Upper Ordovician: A_1 internal view of lantern (copied from McBride and Spencer 1938, fig. 11: A), A_2 enlarged tooth (copied from *l.c.* fig. 12:B), A_3 tentative cross-section of tooth from fig. A_2; *B Ectinechinus lamonti* McBride and Spencer, Upper Ordovician: B_1 external and B_2 internal views of lantern (copied from *l.c.* fig. 10—11); *C Kongielechinus magnituberculatus* gen.n.sp.n. Givetian: cross-section of tooth.
cl cortical layer, *hp* half-pyramid, *i* inner view, *l* lamella, *o* outer view, *sc* secondary calcification, *t* tooth.

Aulechinus. The grooves are much deeper on the outer side of the teeth than on the inner side". Thus in the understanding of the authors the teeth of those genera presented themselves as flat laminae (not V-shaped) showing alternation of distinct ridges and deep furrows on outer and inner surfaces. Those descriptions are accompanied by drawings, here copied (fig. 1: *A1—2, B*), presenting teeth seen from inside and outside of test.

A deeper insight into the tooth structure of *Aulechinus* is possible thanks to the detailed drawing of fragment of pyramid with tooth (here copied fig. 1: *A2*). The analysis of that drawing brings some new observations: 1. the ribs do not run parallel to the axis of the tooth (as it could be infered from certainly slightly schematic fig. 1: *A1*) but they converge towards the median plane. 2. The median elements of tooth are thicker than lateral ones. This figure shows also the considerable depth of grooves.

Looking for similar type of echinoid tooth McBride and Spencer (*l.c.*: 124) pointed out some resemblance of these Upper Ordovician teeth to those of *Meekechinus elegans* described by Jackson (1912: pl. 76: 7) from the Permian of Kansas but they note the lack of "the alternation of groove and swollen ridge so especially characteristic of *Aulechinus*" in *Meekechinus* teeth.

The studies on the teeth structure of *Kongielechinus magnituberculatus* gen.n., sp.n. (see p. 289) seem to suggest that the teeth of the new genus and those of *Aulechinus* might represent a very primitive type where this structure, so complex in modern echinoids, was still very simple. At this stage it consisted of relatively small number of lamellae (primary plates of modern echinoids) weakly connected with each other. In *K.magnituberculatus* the structure of the tooth has been studied on numerous fragments and using different methods including cross-sections (fig. 1*C*). The data on *Aulechinus* are very restricted — only inner surface of teeth has been illustrated; however, on the basis of these figures and description of outer surface given by McBride and Spencer an attempt at re-interpretation of tooth structure may be given. Unfortunately no cross-section of *Aulechinus* or *Ectinechinus* tooth has ever been made and it will not be possible to do it until new-better preserved material is found. The specimens hitherto described are leached out of calcite and all evidence on that material comes from internal and external moulds. Using these incomplete data a tentative cross-section of *Aulechinus* tooth is here presented (fig. 1: *A3*). This interpretation is based on the supposition that the ribs in *Aulechinus* (and in *Ectinechinus*) would correspond to outer and inner borders of particular lamellae (primary plates) of which the teeth of *Aulechinus*, *Ectinechinus* and *Kongielechinus* gen.n. were built. Furrows (grooves of McBride and Spencer) would be the interstices between the lamellae standing close one to other and being connected only along the relatively short median sector. In principle this model differs not very much from the teeth of *Kongielechinus*. In that genus the lamellae are relatively thinner and longer, ribs are absent. However, in the specimens where the region close to plumula zone is preserved (fig. 5: *B*; pl. 19: 2) the outer borders of lamellae in *Kongielechinus* are roundish and the shallow interstices between them are discernible. Ribs on inner side of *Kongielechinus* teeth are definitely lacking as the corresponding borders are enlarged, flattened and furnished with numerous lists (fig. 6; pl. 20: 3). This feature is here considered as an adaptation to the special feeding habit. In all these features *Kongielechinus* is more advanced than *Aulechinus*, what is in accordance with the Middle Devonian age of the former and the Upper Ordovician age of the latter genus. Dehm (1952: 91; fig. 2) described adoral ends of teeth in *Rhenechinus hopstätteri*. The material, although fragmentary, allows to infer that the teeth of this Lower Devonian species belong also to the oligolamellar type.

One of the most characteristic features of recent echinoid tooth is its paired structure. The same pattern was already present in the Middle Devonian *Kongielechinus* and most probably in *Aulechinus* — *Ectinechinus* line. Very carefull studies on *Aulechinus* tooth as represented in fig. 1: *A2* permit to suppose that here also the lamellae were deposited by pairs, the shortest median two lamellae corresponding to the "youngest" pair.

The condition of holding together of a pair of lamellae is their overlapping and the presence of secondary calcification. Nothing can be said about overlapping in *Aulechinus* and *Ectinechinus* but some kind of hard connective tissue must have been present. In more advanced *Kongielechinus* the very primitive overlapping (fig. 5: *A*; pl. 20: 1) exists and also secondary calcification on inner surface of lamellae is present (pl. 21: 1).

The horizontal position of the lantern frame in *Aulechinus* is suggested by McBride and Spencer (fig. 1: *A*, *B*) and the rotulae, epiphyses and compasses were probably absent. The vertical position of teeth (and pyramids) is here admitted for *Kongielechinus* in which typical erect half-pyramids have been found (fig. 5: *D*; pl. 21: 4). Strong rotulae are present in *Kongielechinus* but no one epiphysis or compass could be recognized. However, those lantern elements must have already eixsted. The rotula has the distinct glenoid processus for articulating with the epiphysis and a small knob (in adaxial part) by which the compass was attached is present (fig. 4: *A*; pl. 21: 2, 3).

Similar oligolamellar primitive teeth (though with some minor modification) have been found in the Givetian samples from other localities in Poland. They also are present in the Frasnian deposits. This material will be described later. Hoare and Sturgeon (1976) reported the teeth (*l.c.*: 20; pl. 2: 35) which probably belong to the same primitive type (see p. 279). If it is so it would mean that the simple type of teeth was a successful one being represented in the strata ranging in age from the Upper Ordovician to the Upper Carboniferous (Pennsylvanian).

The oligolamellar type of teeth was not the only one existing in the Givetian deposits. It was considerably outnumbered by the other very delicate multilamellar and highly complex in structure type of tooth which in some forms had adorally a peculiar serrate appearance (pl. 24: 1). The lack of appropriate Silurian materials is very unfortunate in tracing teeth evolution. Sollas' (1899; fig. 8) representation of the Silurian *Palaeodiscus ferox* Salter tooth is very vague and Spencer's (1904; fig. 6) drawing of its longitudinal section is not reconciliable with any hitherto known structure of fossil or recent echinoid teeth.

DESCRIPTION

Family **?Lepidocentridae** Lovén 1874
Genus *Kongielechinus* gen.n.

Type species: K.magnituberculatus gen.n., sp.n.

Derivation of the name: in honour of late Professor Roman Kongiel, the eminent Polish paleontologist, whose most of scientific interest was devoted to the Cretaceous echinoids of Poland.

Diagnosis. — Plates very thin and fragile. Interambulacral plates with up to four large, perforate often elongate primary tubercles situated in large areoles. Ambulacral plates with pores situated perradially in peripodia with up to two primary tubercles located close to peripodia. Spines short, fragile with excentric oval acetabulum. Half-pyramids erect, foramen magnum shallow; teeth flat, oligolamellar; rotulae thick, almost rectangular, epiphyses and compasses not found but certainly present.

Species assigned: *K.magnituberculatus* sp.n.

Geographical and stratigraphical occurrence: as for the species (see p. 290).

Remarks. — The assignment of the *Kongielechinus* gen.n. to the Lepidocentridae, whose main diagnostic is two column ambulacral area remains unconfirmed until appropriate fragment or whole test of a new genus is found. However, it should be noted that no one ambulacral plate of occluded type has been recognized in material from the Givetian of the Świętomierz-Śniadka profile. This assignment seems to be also corroborated by the similarity (see p. 289) of the jaw apparatus structure of the new genus to that of the oldest representatives of lepidocentrids — the Upper Ordovisian *Aulechinus* and *Ectinechinus* (McBride and Spencer 1938). The question whether the oligolamellar type of teeth might be the reason to establish a separate taxon (?order) remains open until more is known about the structure of teeth of other Paleozoic echinoids.

New genus is easily distinguished from other members of the family by its interambulacral plates bearing up to 4 large, perforate, mostly elongate primary tubercles situated excentrically in large areoles. However some badly weathered interambulacral plates (or fragments of plates?) of *Kongielechinus* gen.n. especially those which bear a single large tubercle (pl. 17: 2) resemble equally poorly preserved interambulacral plates of *Eocidaris* Desor 1856 from the Middle Devonian *Stringocephalus* Limestone of Vilmar. This material has been througouhly revised by Bather (1909) and considered as closely related to *Archaeocidaris* M'Coy. Mortensen's (1928:

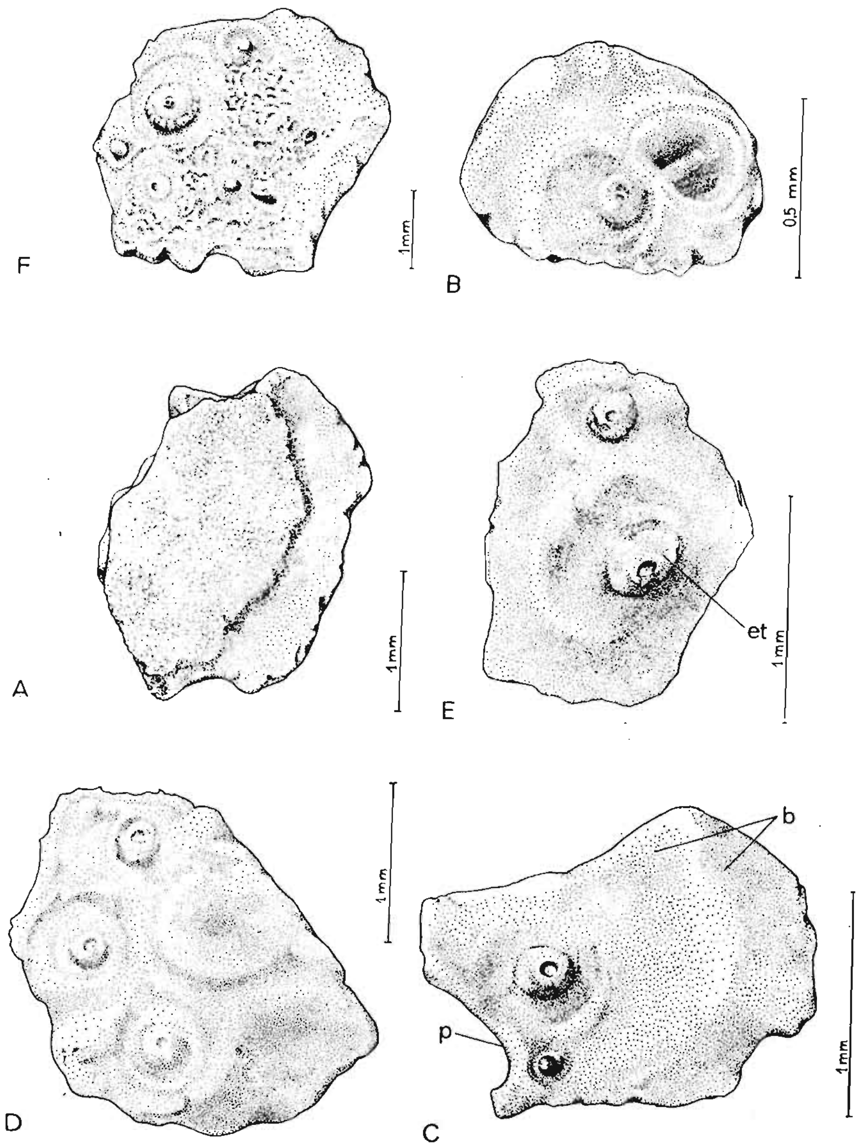

Fig. 2. *A—E Kongielechinus magnituberculatus* gen.n.sp.n. Givetian, Świętomarz-Śniadka profile: *A* madreporite, ZPAL ED 11; *B* immature ambulacral plate, ZPAL ED 21; *C* full grown ambulacral plate, peripodium region partly damaged, margins of plate beveled, paratype, ZPAL ED 22; *D* interambulacral plate, holotype ZPAL ED 31; *E* interambulacral plate with elongate tubercle, paratype, ZPAL ED 32. *F* interambulacral plate, of some other echinoid genus; surface of plate and margin of tubercle sculptured (it is not a crenulation), Świętomarz-Śniadka profile. ZPAL ED 102. *b* beveled margin, *et* elongate tubercle, *p* peripodium (fragment).

16) subsequent conclusion was to recognize *Eocidaris* as the junior synonyme of *Archaeocidaris*. In some features *Eocidaris* and *Kongielechinus* are similar, both having elongate tubercles and large areoloes, but in the new genus the smooth border of areole is in sharp contrast with the ring of scrobicular tubercles in *Eoci-*

daris. Only four interambulacral plates of *Eocidaris* all with natural margins destroyed, have been hitherto described, nothing is known about its ambulacral area and jaw apparatus structure. A fragmentary spine of *Eocidaris* is stout, densely striated being quite different from minute, fragile having few striae spines of new

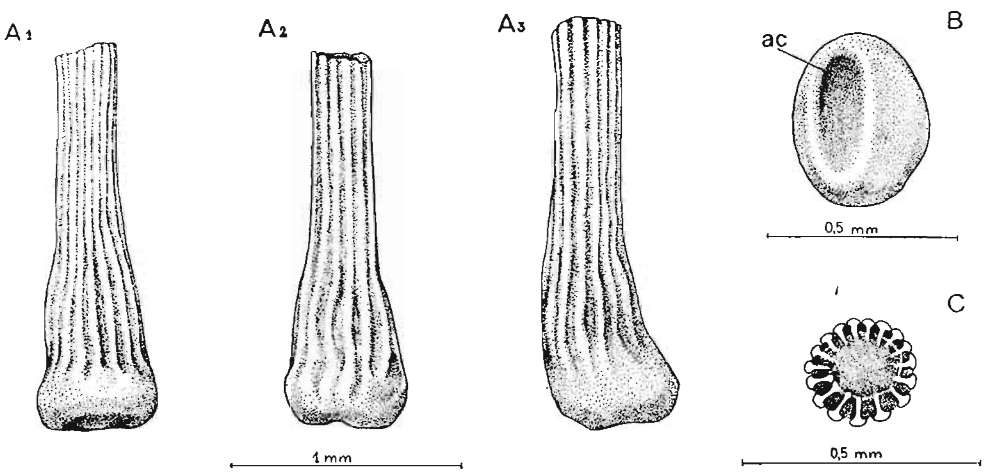

Fig. 3. *Kongielechinus magnituberculatus* gen.n.sp.n. Givetian, Świętomarz-Śniadka profile; *A* spine viewed in 3 positions: A_1 dense striae arrangment in upper part of spine, A_2 loose striae arrangment seen from bent side of spine, A_3 profile of bent side; *B* base with excentric oval acetabulum, ZPAL ED 96, C cross section showing zones of looser and denser striae, ZPAL ED 95. *ac* acetabulum.

genus. Until more material of *Eocidaris* is described, no full evaluation of the similarity of both genera is possible. New genus has certainly nothing to do with the cidaroids where only one primary tubercle per plate is present.

Kongielechinus magnituberculatus gen.n.sp.n.
(figs 1:C; 2:*A—E*; 3; 4:*A*,5;6; pls 17—23)

Holotype: ZPAL ED 31; fig. 1:*D*

Paratypes: ZPAL ED 22: fig. 1:C; ZPAL ED 32: pl. 18: 3

Type horizon: Givetian. Skały beds.

Type locality: Świętomierz-Śniadka profile, Błonie Valley, Holy Cross Mts.

Derivation of the name: Lat. *magnus* — large, having large primary tubercles.

Diagnosis. — Thin interambulacral plates with up to four large, perforate round or elongate primary tubercles, situated excentrically in large areoles. Ambulacral plates with up to two primary tubercles situated close to perradially located peripodium. Spines short, fragile with few striae (up to 18) often swollen and bent at the base; acetabulum oval, excentric.

Material. — 70 strongly weathered interambulacral plates including one with four tubercles, three with 3 tubercles, several with two tubercles; 20 ambulacral plates including one immature and one almost complete; 3 madreporite plates partly damaged; two almost entire young half-pyramids and seven fragments; 8 rotulae mostly complete; 21 fragmentary teeth and several scores of broken lamellae; around 80 fragmentary spines — a half of them with bases preserved.

Description. — Shape and size of test unknown but judging from the small size of all skeletal elements the specimens could reach no more than 30 mm in diameter.

Apical system. Only madreporite has been found. It is large (about 3 mm in diameter) thick with numerous minute pores but genital pore is absent; preserved margins strongly flattened to accomodate the adjoining interambulacral plates (pl. 17: 3; fig. 2 *A*).

Ambulacra. Only isolated plates have been found. The smallest — evidently immature plate (fig. 2:*B*) is 0.8 mm wide and 0.5 mm high, with one tubercle placed

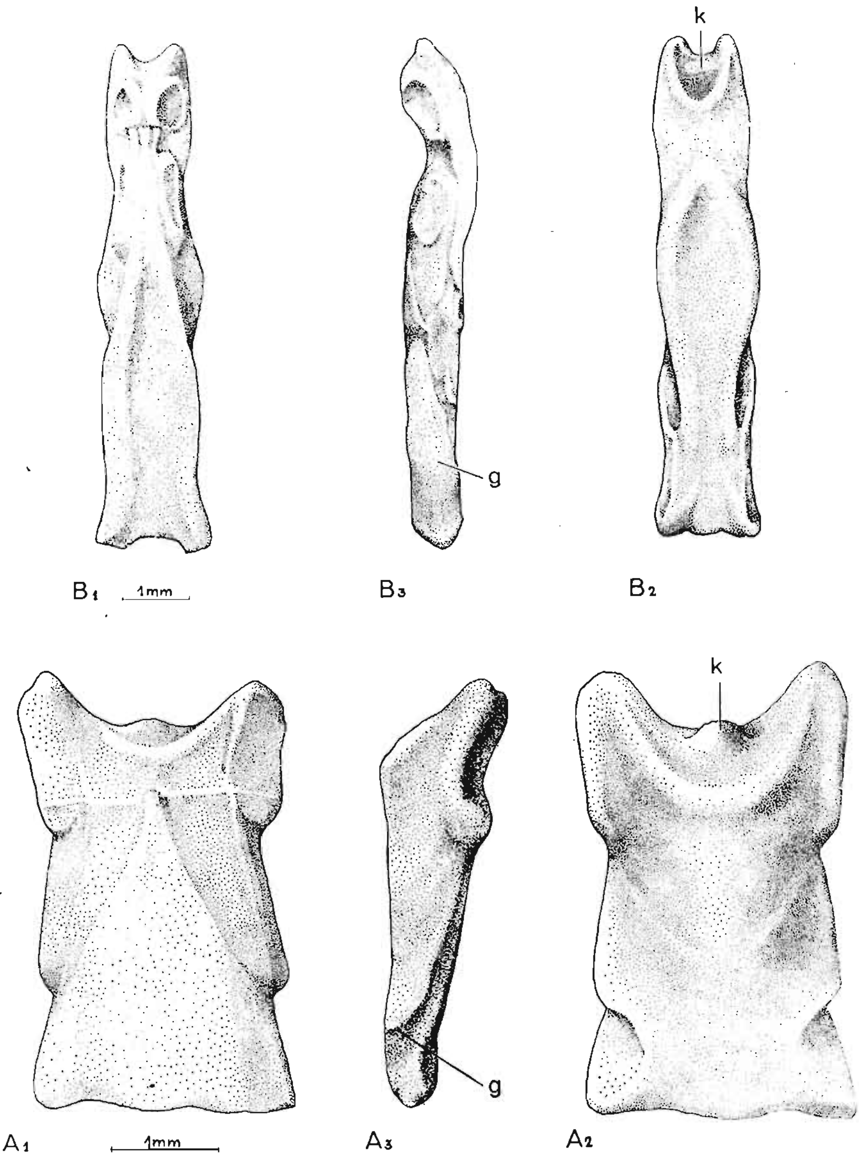

Fig. 4. Rotulae, Givetian, Świętomarz-Śniadka profile. *A Kongielechinus magnituberculatus* gen.n.sp.n. Rotula seen in 3 positions: A_1 adoral view, A_2 side view, A_3 adapical view, ZPAL ED 72; *B* rotula from other echinoid genus: B_1 adoral view, B_2 side view, B_3 adapical view, ZPAL ED 73.
g glenoid processus, *k* knob for attachment of compass.

excentrically in areole and near the perradially situated peripodium. The largest ambulacral plate (fig. 2:C) is partly broken at the region of peripodium. Adapical and adradial margins are beveled prooving that plates imbricated in common in lepidocentrids manner. Up to two perforate tubercles round or elongate in outline present on each plate. They always stand close to peripodium. On the inner side of ambulacral plates a thickening bordering the ambulacral pores from above is always present (pl. 17: 1). That thicknening has much coarser meshwork than the remaining part of plate.

Interambulacra. Thin, small, plates the largest (not complete) having 3 mm (fig. 2:D). Exact shape unknown, probably polygonal, certainly imbricating but very thin extraareolar zone is in all plates damaged. Up to 4 relatively large, perforate tu-

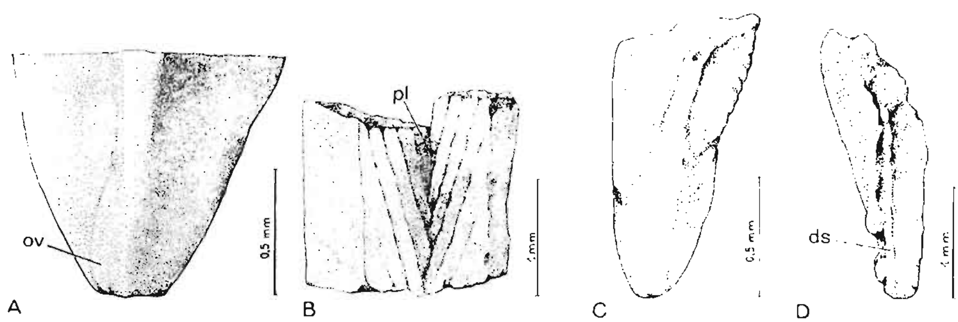

Fig. 5. *Kongielechinus magnituberculatus* gen.n.sp.n. Givetian, Świętomarz-Śniadka profile: *A* pair of lamellae overlapping in adoral part, ZPAL ED 50; *B* fragment of tooth close to plumula region (growing zone) with more loose arrangment of lamellae, ZPAL ED 51; *C* adoral part of half-pyramid with strips for attachment of inter-pyramidal muscles, ZPAL ED 86; *D* half-pyramid, inner view with dental slide, ZPAL ED 87.
ds dental slide, *ov* overlapping region, *pl* plumula (growing zone) region

bercles round or oval in outline, situated mostly excentrically in their areoles. The elongate (oval) tubercles slightly flattened on one side. Areoles large, bordered with distinct smooth rim. Very often areoles are deeper at flattened side of tubercle and rised at the other side; they often share the fragment of rim. Also interambulacral plates with 3—1 tubercles have been found (pl. 17: 2; pl. 18: 3) but as the material is strongly weathered it is not clear whether such plates are complete.

Spines. Short, slender, very fragile. The largest fragment with the preserved base is 3 mm in length. Only few spines are regular and straight (pl. 23: 2). Most are swollen and slightly bent at the base (fig. 3:*A*; pl. 23: 3). At the bent side of spine the striae are more loose and this continues along whole length (fig. 3:*A2*), what is also seen in cross section (fig. 3:C). At some distance from the base a series of whorls appears. They are arranged in 0.8 m intervals (pl. 23: 4). The distal ends of spines are broken off. The base of most spines is oval as seen from below (fig. 3:*B*; pl. 23: 1). Oval acetabulum is situated excentrically; the remaining part of base surface is flattened and beveled in accordance with shape of corresponding tubercle.

Lantern. Only half-pyramids, rotulae and teeth have been found. The erect half-pyramids (fig. 5:*D*; pl. 21: 4) are thin-walled in adaptical part but thick, strong and enlarged to form a kind of flange at adoral end (fig. 5:*C*; pl. 22: 1, 3). The linear microstructure is present in most of jaw fragments (pl. 22). Muscle scars long and deep (pl. 21: 4), dental slide only slightly pronounced (fig. 5:*D*; pl. 21: 5). Strips for attachment of interpiramidal muscles distinct (fig. 5:C). The smallest, almost complete half-pyramid is 2.5 mm high but jaws certainly could reach much larger size as it may be inferred from the several fragments of their adoral parts (pl. 21: 5; pl. 22: 1*a*, 3).

Rotulae roughly rectangular, strongly built, adaxially thickened and broadly furrowed (fig. 4:*A*, pl. 21: 2—3). They are 2.2—4.5 mm long and 1.3—2.8 mm wide. Glenoid processus distinct; small knob serving presumably as attachment point for compass is situated in adaxial furrowed bord of rotula (fig. 4:*A3*).

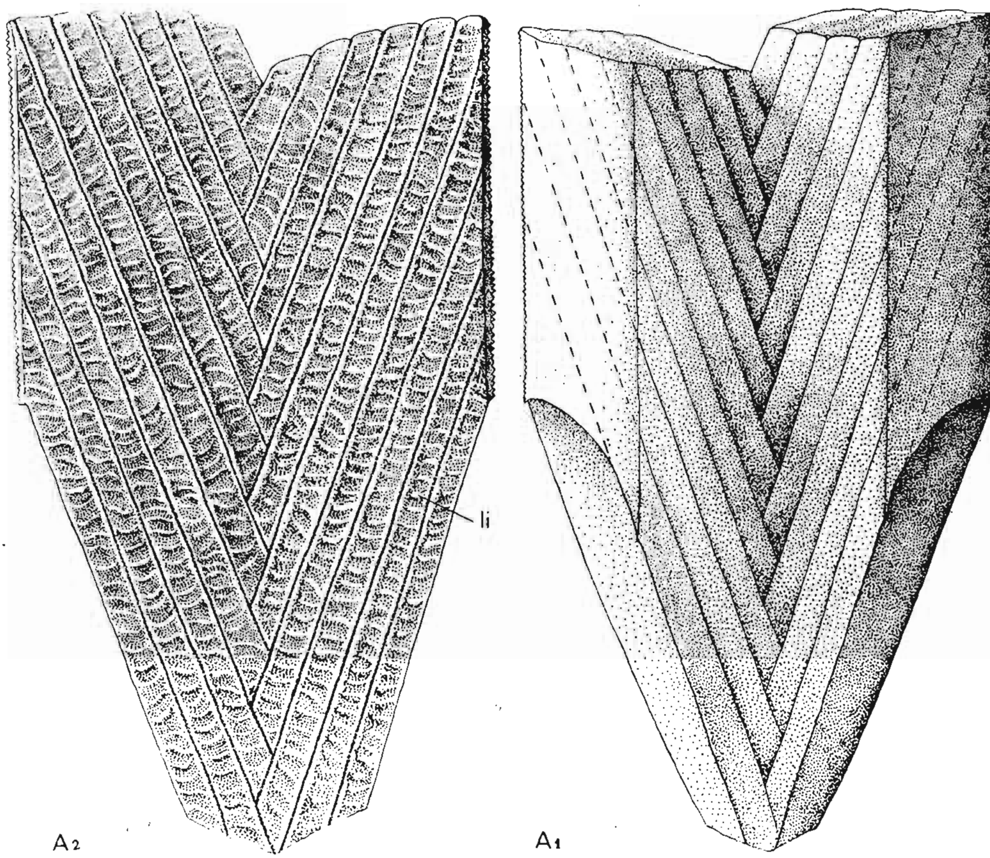

Fig. 6. Reconstruction of teeth of *Kongielechinus magnituberculatus* gen.n.sp.n.: A_1 outer view, A_2 inner view, (adoralmost lamellae not preserved). *li* lists.

Teeth. No complete tooth has been found but from several fragments the reconstruction has been made (fig. 6). The tooth is lancetlike in shape, flat on the inner side. Outer surface is divided into two sloping lateral areas and medial flat or slightly concave, especially at the adapical end area. Outer surface is covered with thin calcareous layer which is much thinner on medial area than on lateral slopes (fig. 1:C). This layer forms small denticles along the borders of teeth (fig. 6; pl. 19: 1). Inner surface shows distinct lines corresponding to the edges of lamellae of which the tooth is built. Those edges are flattened and furnished with numerous lists (fig. 6:*A2*; pl. 19: 1, 3). Up to 24 lamellae (in hitherto found material) arranged in pairs form the tooth. They are relatively thick (pl. 18: 1, 2) roughly triangular in outline and they slightly overlap themselves (fig. 5:*A*; pl. 20: 1) adorally. This overlapping is however very weak and the tooth breaks easily along the median line (pl. 20: 2). The single lamella is an elongate, roughly triangular in outline structure. The longest lamella (in collection) is 2.5 mm long, 0.6 mm wide. It is 0.1 mm thick in adoral part and 0.01 in its adapical region. On the inner side of each lamellae a layer of secondary calcification showing kind of meshwork structure (pl. 21: 1) is present. Very often this layer is weathered and the interstices between lamellae are filled with a sediment. The size of teeth (all have oral and adapical ends broken off) ranges from under one milimeter up to 4.5 mm.

Occurrence. — Poland: Holy Cross Mts (Świętomarz-Śniadka profile, Błonie Valley): Middle Devonian (Givetian), Skały beds.

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WANDA JESIONEK-SZYMAŃSKA

MORFOLOGIA I MIKROSTRUKTURA OLIGOMOLARNYCH ZĘBÓW U JEŻOWCÓW PALEOZOICZNYCH

CZĘŚĆ I. BUDOWA ZĘBÓW U WCZESNYCH PRZEDSTAWICIELI RODZINY LEPIDOCENTRIDAE LOVEN, 1874

Streszczenie

Z żywetu profilu Świętomarz-Śniadka (Góry Świętokrzyskie) opisano nowy typ zębów jeżowców, który nazwano oligolamelarnym. Składają się one z niewielkiej ilości (do 20) stosunkowo dużych i grubych blaszek (lamelli) o kształcie zbliżonym do tr:ójkąta. Przeprowadzono analizę budowy zębów u najstarszych przedstawicieli rodziny Lepidocentridae (*Aulechinus* Bather and Spencer, *Ectinechinus* McBride and Spencer) z górnego ordowiku Szkocji, dochodząc do wniosku, że ich zęby należą również do typu oligolamelarnego. Ze wstępnych badań nad materiałem z franu Polski i danych z literatury wynika, że podobny, prymitywny typ zębów przetrwał do dolnego karbonu. Temat ten będzie przedmiotem dalszych badań i' publikacji, a niniejsza praca stanowi pierwszą część tej serii. Na podstawie izolowanych płytek pancerza, kolców oraz elementów latarni Arystotelesa opisano nowego przedstawiciela rodziny Lepidocentridae — rodzaj *Kongielechinus magnituberculatus* gen.n., sp.n.

Niniejsza praca została wykonana w ramach problemu międzyresortowego PAN MR II/3.

EXPLANATION OF THE PLATES 17—24

Plates 17—23 *Kongielechinus magnituberculatus* gen.n.sp.n.
Givetian, Świętomarz-Śniadka profile, Holy Cross Mts.

Plate 17

1. Internal view of damaged ambulacral plate with thickenning above peripodium, ZPAL ED 24, SEM×50.
2. Interambulacral plate (damaged?) with elongate tubercle, ZPAL ED 34, SEM×75.
3. Madreporite plate, ZPAL ED 12, SEM×30.

Plate 18

1. Outer view of weathered tooth showing arrangement of lamellae, ZPAL ED 44, SEM×60.
2. Outer view of weathered tooth fragment close to plumula zone, ZPAL ED 45, SEM×60.
3. Interambulacral plate with two elongate tubercles, ZPAL ED 35, SEM×45.

Plate 19

1. Inner surface of tooth of young specimen, borders with denticles, ZPAL ED 46, SEM×75.
2. Fragment of tooth with region close to plumula, ZPAL ED 47, SEM×100.
3. Fragment of tooth with distinct borders of lamellae, ZPAL ED 48, SEM×75.
4. Surface of cross sectioned lamella (close to adoral end of lamellae) ZPAL ED 48, SEM×200.

Plate 20

1. Overlapping pair of lamellae, ZPAL ED 50, SEM×120.
2. Outer view of half tooth, ZPAL ED 51, SEM×75.
3. Fragment of inner surface of tooth with distinct lists, ZPAL ED 52, SEM×100.
4. Enlarged denticulate border of tooth, ZPAL ED 53, SEM×300.

Plate 21

1. Fragment of broken lamellae with meshwork of secondary calcification, ZPAL ED 54, SEM×75.
2. Rotula of young specimen — adapical view, ZPAL ED 70, SEM×45.
3. Rotula — adoral view. ZPAL ED 71, SEM×100.
4. Almost complete half-pyramid of young specimen — outer view, ZPAL ED 81, SEM×60.
5. Adoral part of half-pyramid of adult specimen with dental slide, ZPAL ED 82, SEM×45.

Plate 22

1. Adoral part of half-pyramid (*a*), enlargement to show the linear microstructure (*b*), ZPAL ED 83, SEM: 1a×20, 1b×60.
2. Fragment of half-pyramid to show thin walls, ZPAL ED 84, SEM×30.
3. Adoral part of half-pyramid with flange, ZPAL ED 85, SEM×40.

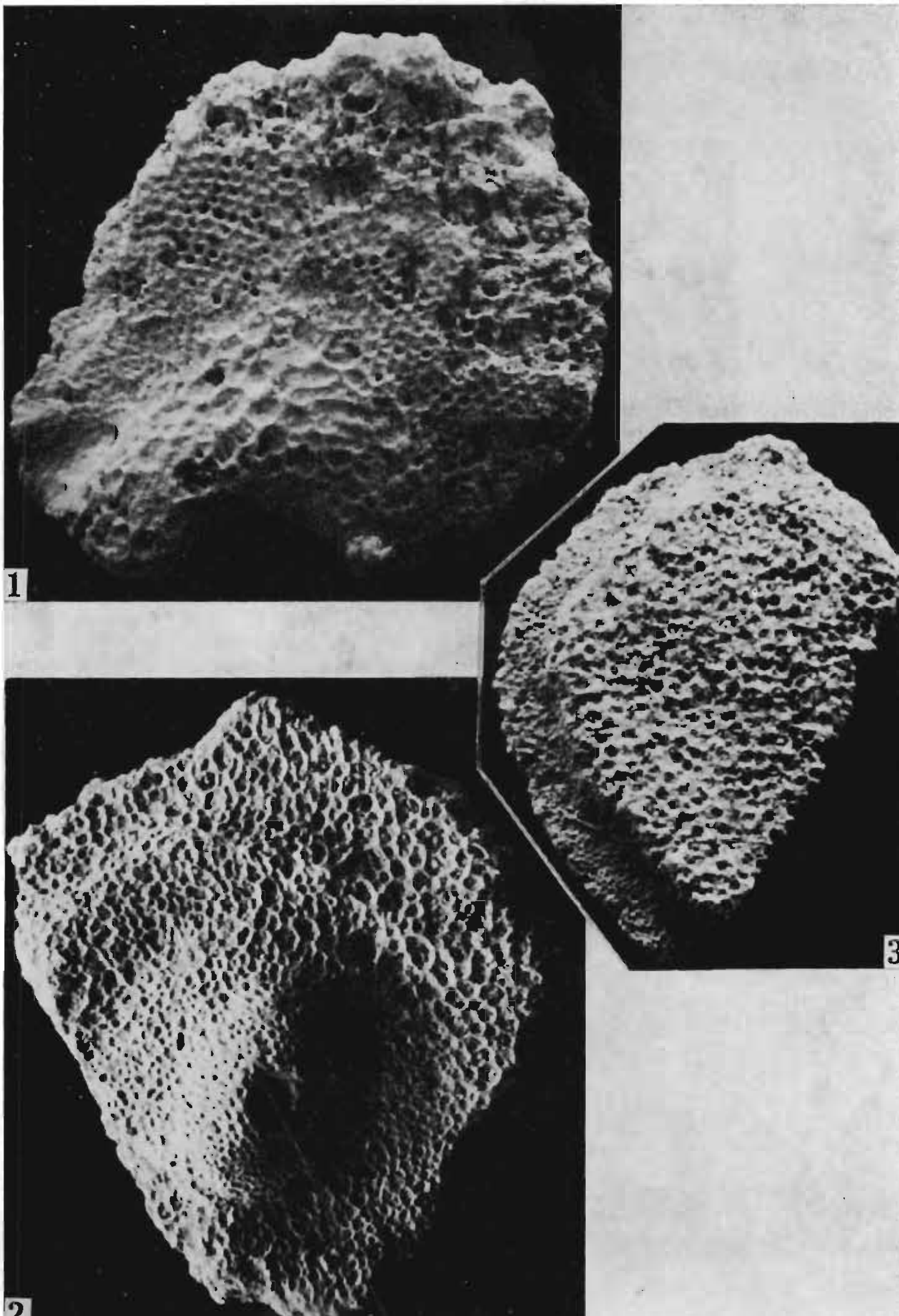
Plate 23

1. Base of spine with excentric acetabulum, ZPAL ED 91, SEM×150.
2. Side view of straight spine. ZPAL ED 92, SEM×35.
3. Fragment of spine, ZPAL ED 93, SEM×100.
4. Fragment of spine with whorl, ZPAL ED 94, SEM×200.

Plate 24

Serrate type of tooth, Givetian, Grzegorzowice-Skały profile Holy Cross Mts.

1. Oral serrate end of tooth, outer surface, ZPAL ED 101, SEM×90.
2. Plumula region of weathered specimen showing multilamellar microstructure, ZPAL ED 102, SEM×125.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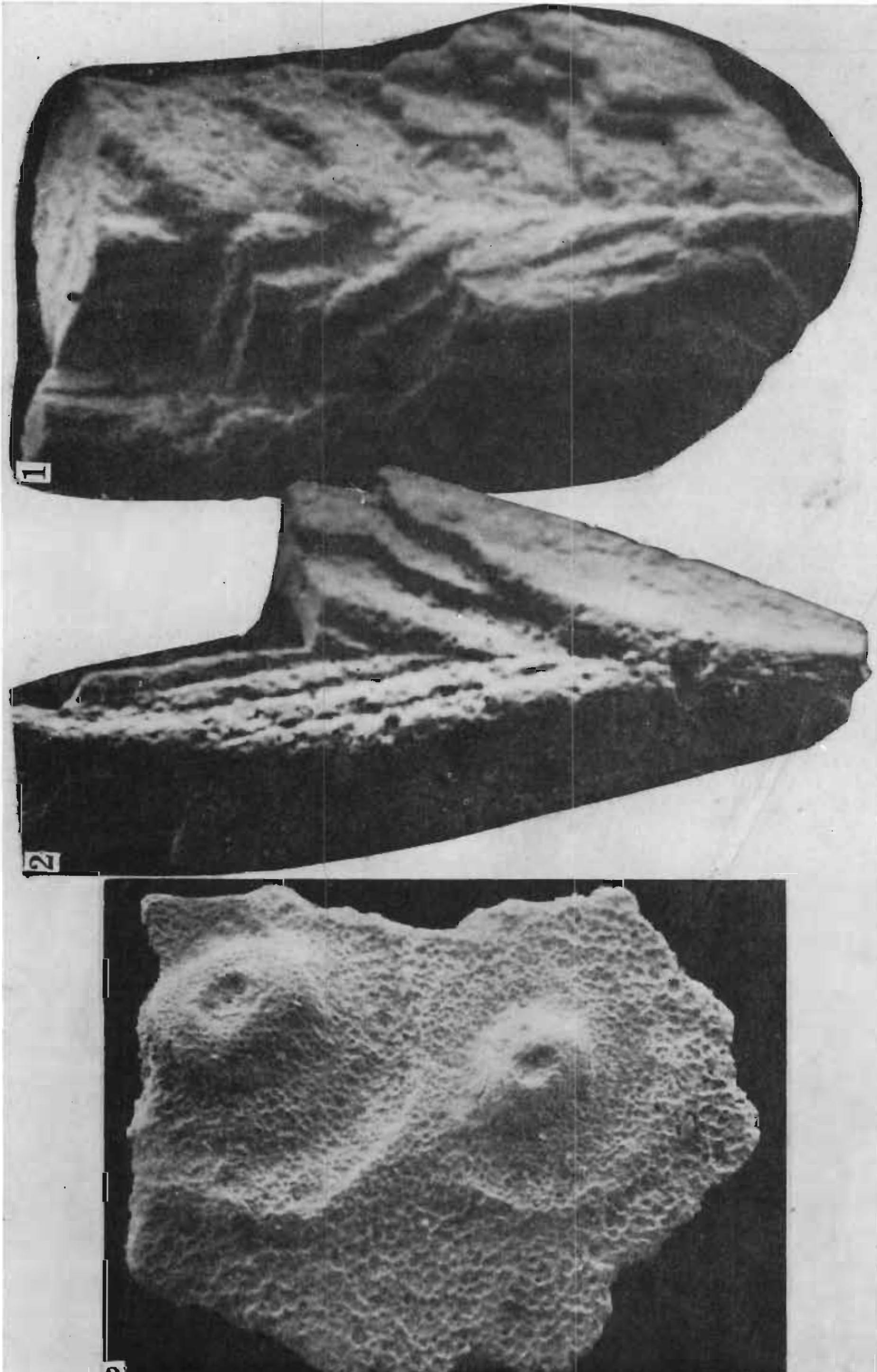
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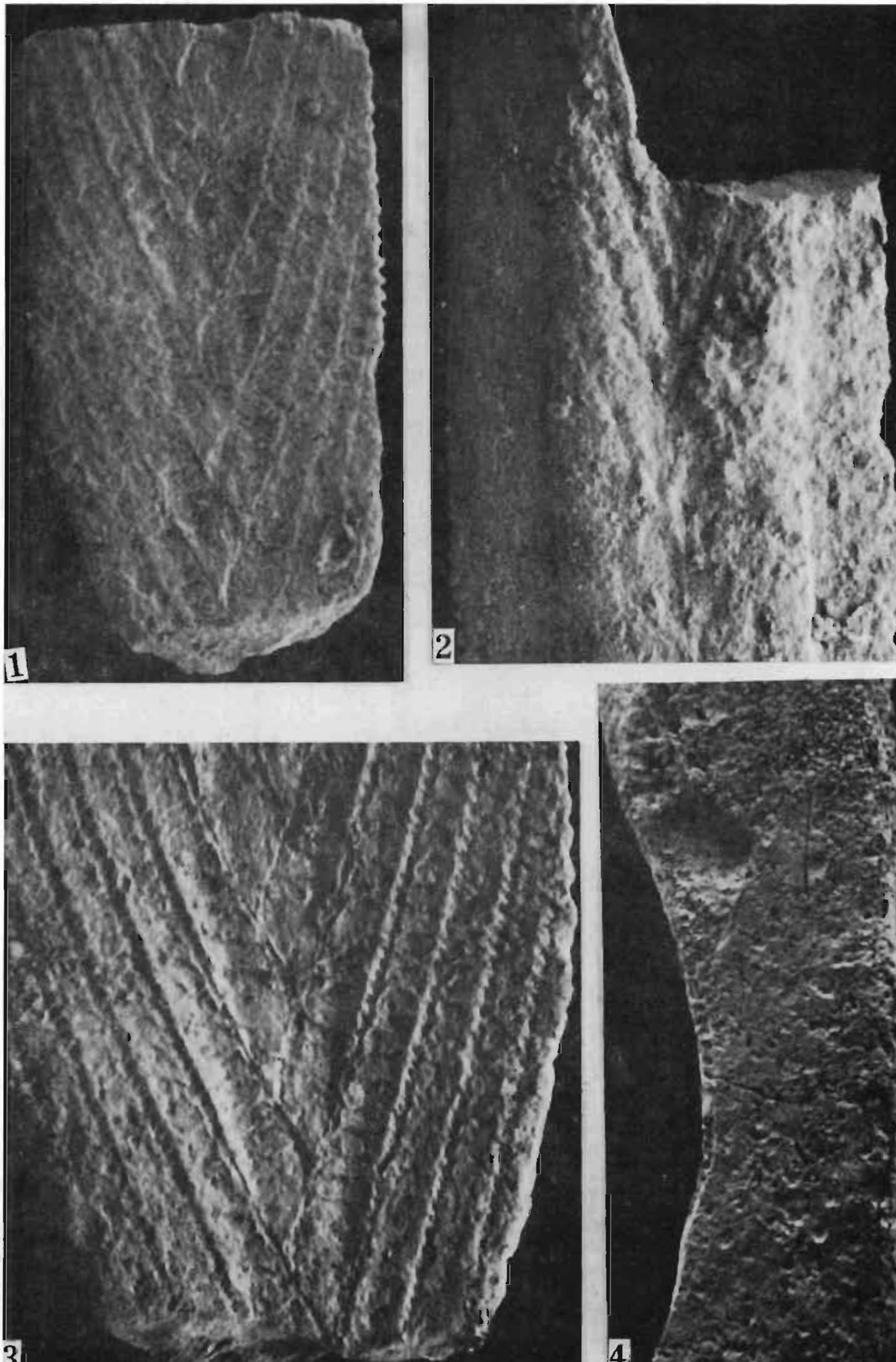
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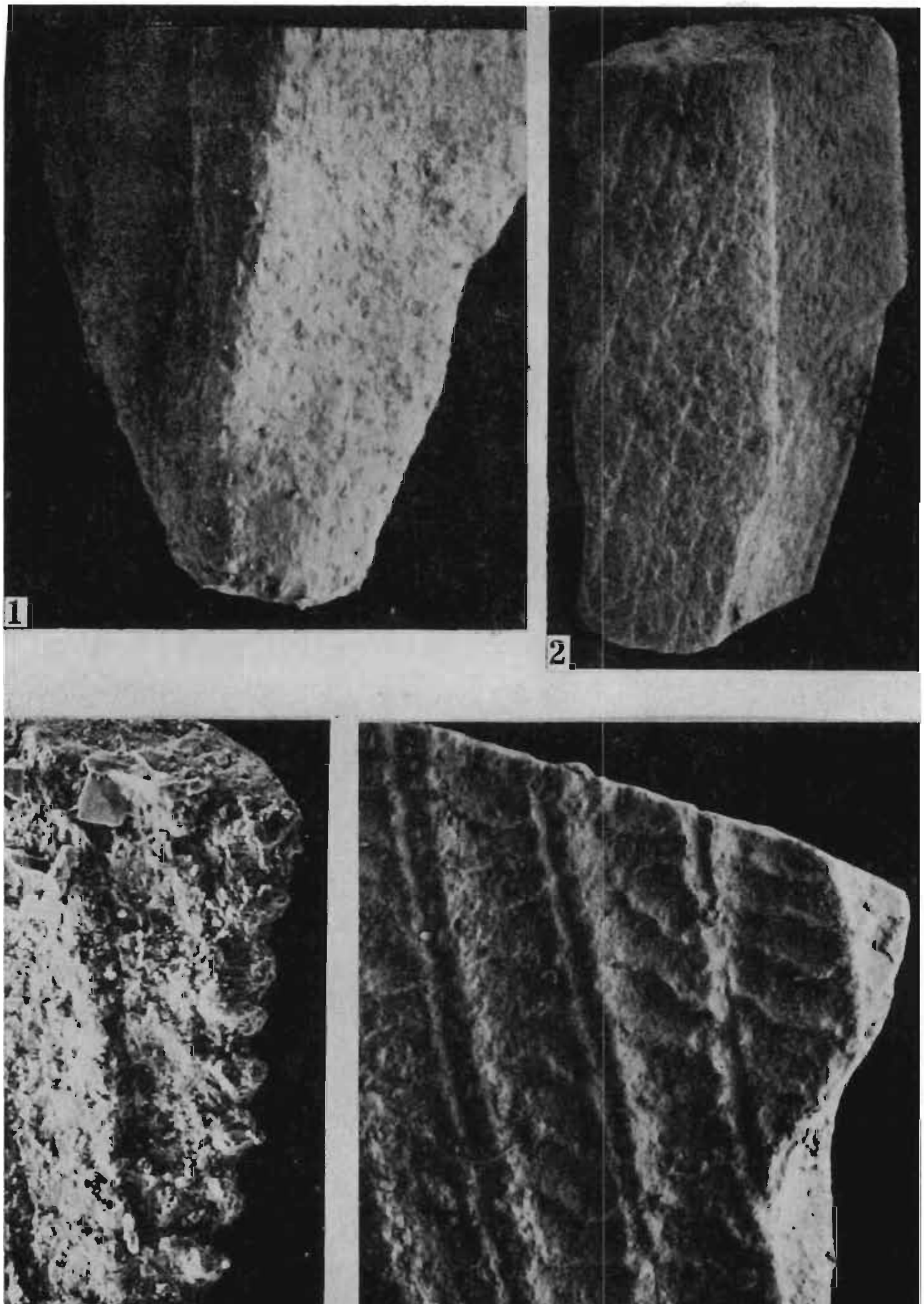
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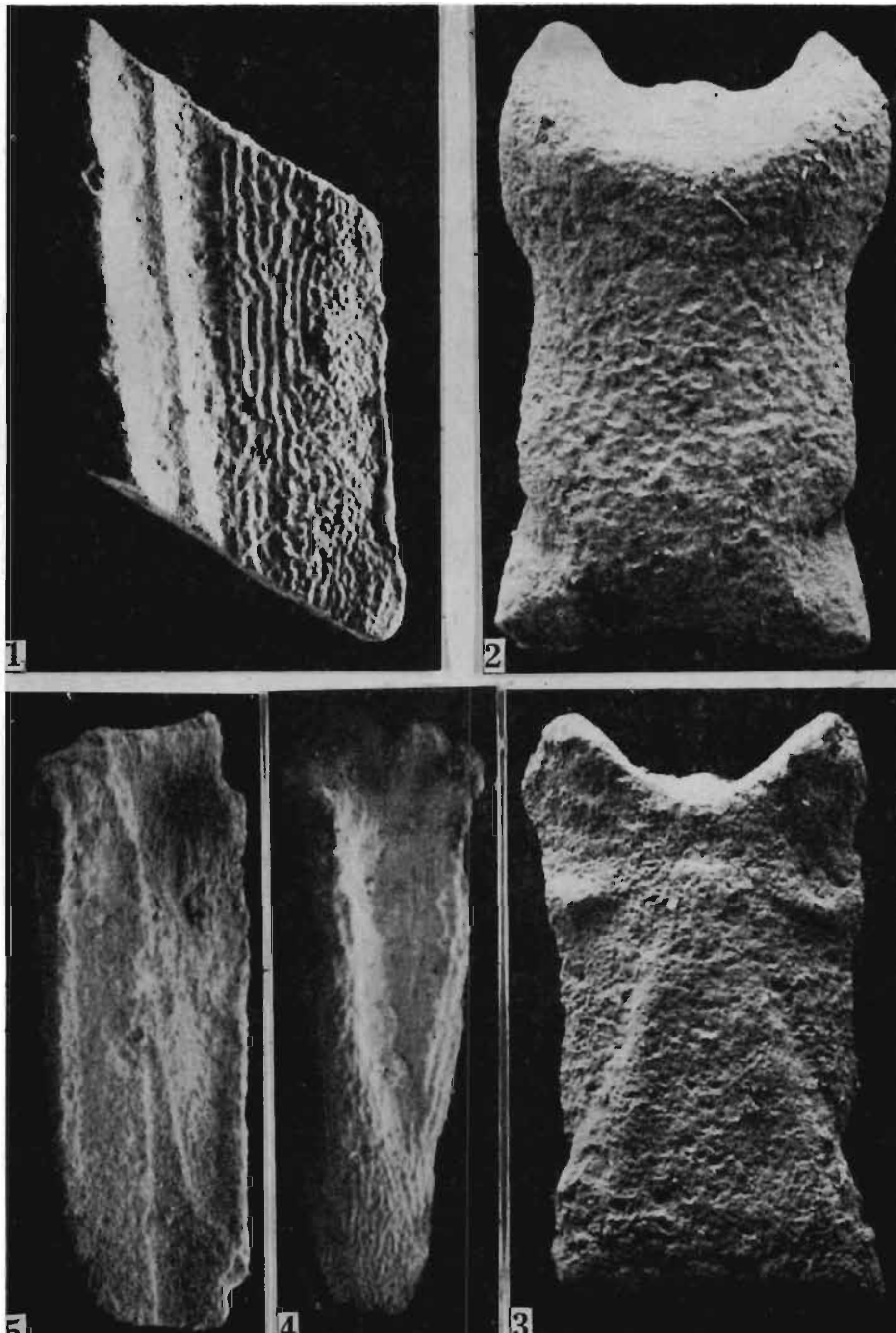
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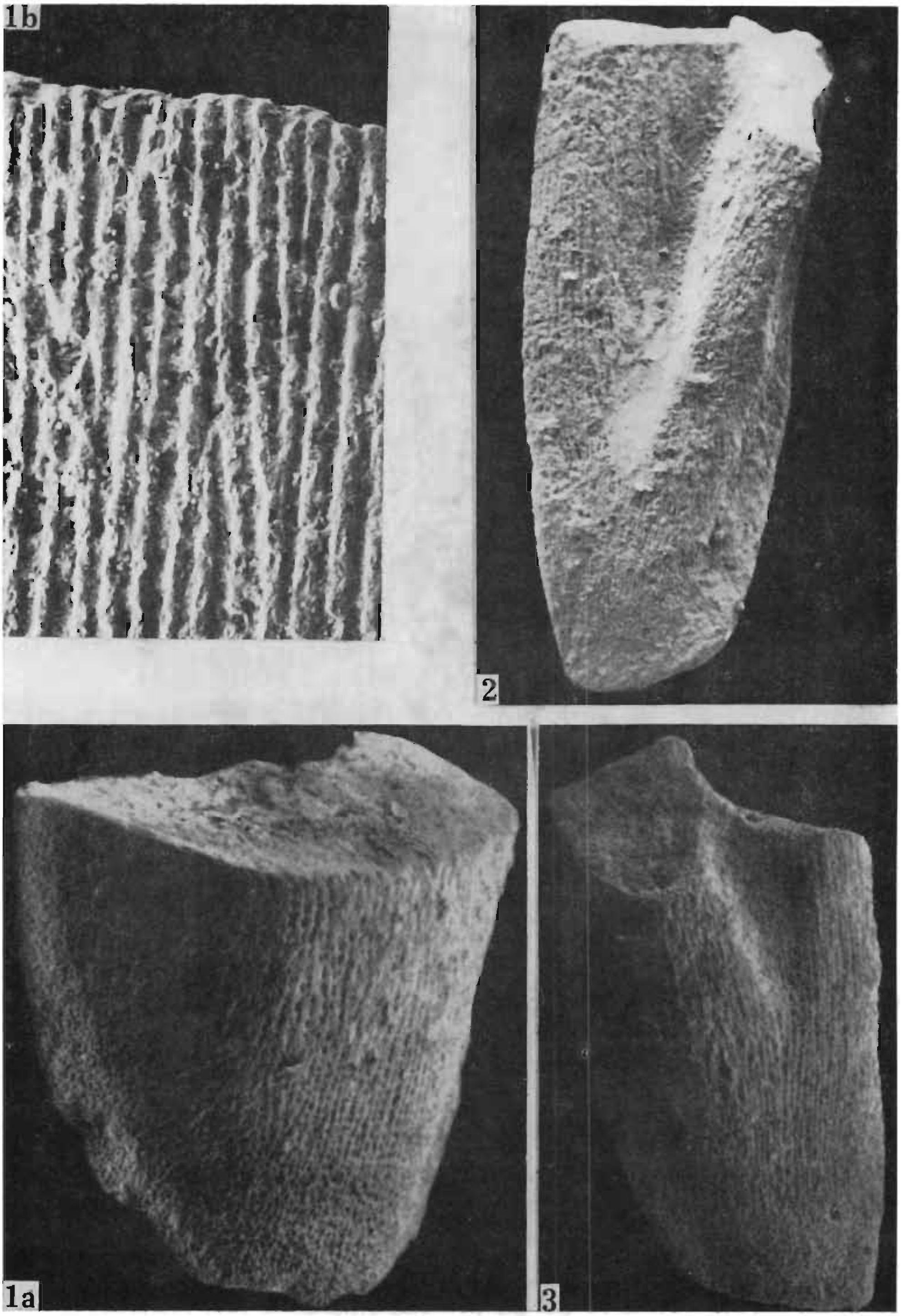
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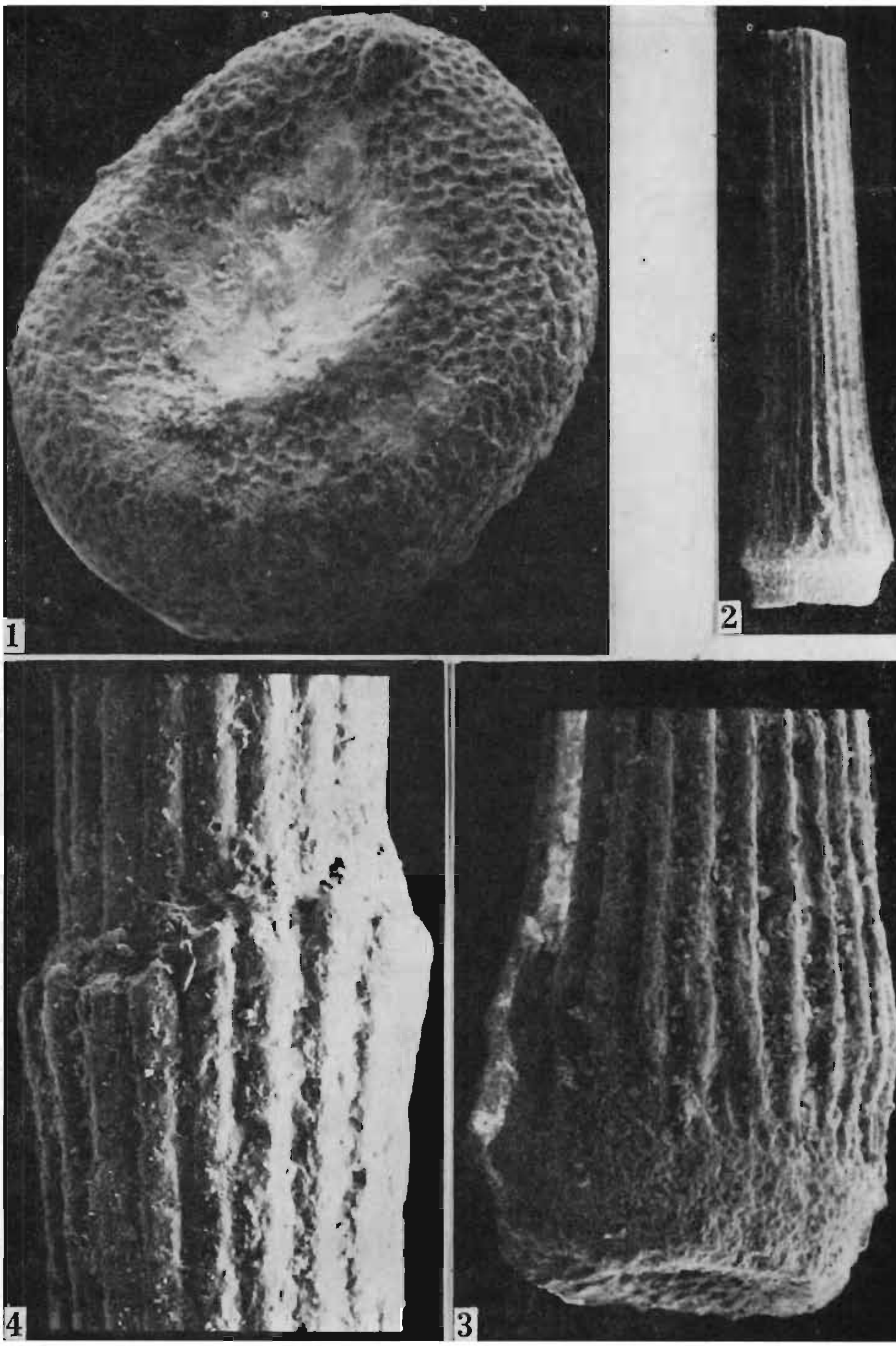
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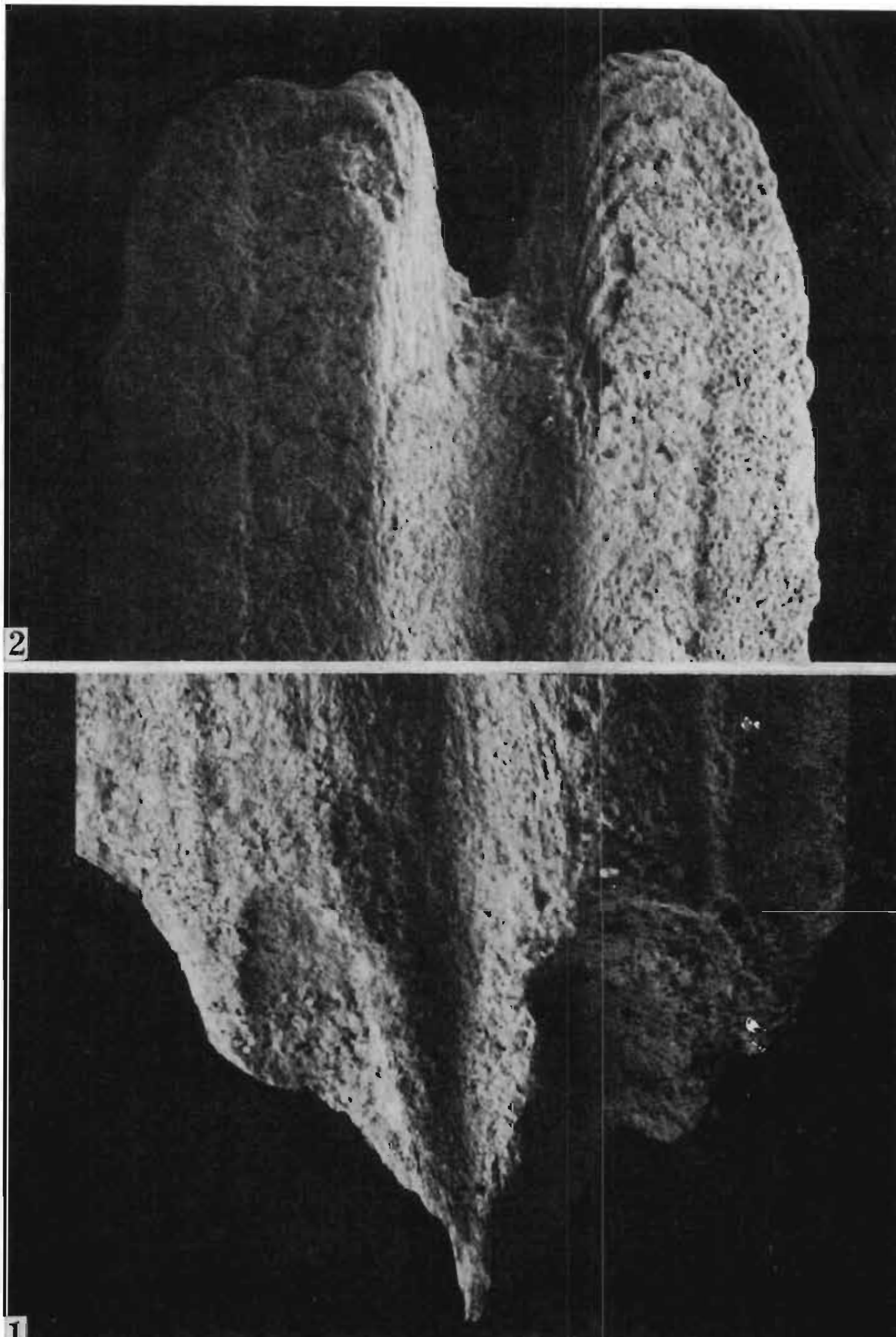
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