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CALYXDENDRUM GRAPTOLOIDES N. GEN., N. SP. — A GRAPTOLITE INTERMEDIATE BETWEEN THE DENDROIDEA AND THE GRAPTOLOIDEA

Abstract. — Specimens of the graptolite here described under the name of *Calyxdendrum graptoloïdes* n. gen., n. sp. have been etched from erratic boulders of Middle Ordovician age. This form unites certain characters of the two orders: Dendroïdea and Graptoloidea. As in the Dendroidea the rhabdosome here consists of 3 categories of thecae, with triad budding, while the sicula is the same as in the Graptoloidea, i. e. conical and provided with a nema.

INTRODUCTION

Among the numerous graptolites etched out of Ordovician erratic boulders in Poland some few specimens have been encountered referable to a form which, although having a general dendroid appearance, yet at the same time displays distinctly some graptoloid characters. In spite of the now currently accepted view that Graptoloidea descend from Dendroidea, it has not thus far been possible to accurately trace all the morphological modifications expressing this important phase of graptolite evolution. Forms intermediate between the orders of Dendroidea and Graptoloidea and which Bulman (1950) has united into the family of Anisograptidae are, so far, recorded almost exclusively from shales as more or less flattened specimens. In most cases it has been possible to study the outer morphology of these specimens only. In *Dictyonema flabelliforme* (Eichwald) and *D. canadense* Lapworth — assignable on equally valid grounds either to the Anisograptidae or the Dendrograptidae — Bulman (1949*a*, 1949*b*, 1950) has ascertained the presence of chitinized stolons and internal basal parts of thecae. The same author (Bulman, 1950) has observed pyritized stolons in several species of the genus *Anisograptus*. Thus, the here mentioned graptolites have fundamentally the same structure as the Dendroidea, differing from the typical representatives of that order in having a sicula provided with nema.

The graptolite here described under the name of *Calyxdendrum graptoloides* n. gen., n. sp. likewise realizes a stage intermediate between the Dendroidea and the Graptoloidea. A detailed morphological analysis of its rhabdosome has been possible owing to the specimens having been etched from a limestone matrix. These specimens have been recovered from six boulders between 1950 and 1960. A general description of these boulders is here given specifying the fossils they contained.

Boulders 0.26 and 0.31. Poznań-Czerwonak (province of Poznań). Organogenic coarse-grained limestone. Most of the specimens they yielded have already been described by Kozlowski (1959, p. 215) and Urbanek (1959, p. 298, 320). The following fossils have been recovered from these two boulders, probably fragments of one larger block: hydroids — *Rhabdohydra tridens* Kozl., *Epallohydra adhaerens* Kozl., *Diplohydra gonothecata* Kozl., *Palaeotuba dichotoma* Kozl., *Chitinodendron bacciferum* Eisen.; trilobites — *Pseudoasaphus* aff. *limatus* Jaan.; graptolites — *Gymnograptus retioloides* (Wiman), *Glyptograptus* cf. *teretiusculus* (Hisinger), *Calyxdendrum graptoloides* n. gen., n. sp. (a fragmentary stipe with 6 autothecae, 2 autothecae probably broken off from the preceding specimen, a young rhabdosome with preserved sicula (holotype), and a stipe branched five times).

Boulder 0.29. Stara Warka (province of Warsaw). Coarse-grained organogenic limestone. It has yielded the following organisms: hydroids — *Calyxhydra irregularis* Kozl., *Rhabdohydra tridens* Kozl., *Diplohydra solida* Kozl., *Diplohydra gonothecata* Kozl., *Kystodendron longicarpus* (Eisen.), *Chitinodendron bacciferum* Eisen.; annelids — *Polychaetaspis warkae* Kozl.; graptolites — *Dinemagraptus warkae* Kozl., Tuboidea, *Calyxdendrum graptoloides* n. gen., n. sp. (a stipe with 5 autothecae, a fragment with 2 autothecae, an autotheca with base of a triad, several detached autothecae).

Boulder 0.166. Wyszogród-Zakroczym (province of Warsaw). Grey, medium-grained limestone. It has yielded the following organisms: algae — *Glaeocapsomorpha prisca* Zalessky; hydroids — *Kystodendron longicarpus* (Eisen.), *Chitinodendron bacciferum* Eisen.; scolecodonts; graptoblastids; graptolites — *Calyxdendrum graptoloides* n. gen., n. sp. (prosicula with part of metasicula).

Boulder 0.340. Mochty (province of Warsaw). Grey, medium-grained limestone. It has yielded the following organisms: algae — *Glaeocapsomorpha prisca* Zalessky; scolecodonts; Chitinozoa; brachiopods — *Conotreta* sp.; conodonts; graptolites — *Acanthograptus* sp., *Calyxdendrum graptoloides* n. gen., n. sp. (terminal part of stipe).

Boulder 0.334. Mochty (province of Warsaw). Grey, fine-grained, dull limestone. It has yielded the following organisms: foraminifers; hydroids; Chitinozoa; scolecodonts; graptolites — *Mastigograptus* sp. (mass occurrence), *Dictyonema* sp., *Calyxdendrum graptoloides* n. gen., n. sp. (bifurcating end of stipe).

A detailed study of all the fossil organisms recovered from the just mentioned boulders will probably in the future lead to the exact determination of their age. For the present they may only be referred to the Middle Ordovician. The age of boulders 0.26 and 0.31 has more closely been established by Urbanek (1959, p. 298, 320) as corresponding to the ”*Crassicauda*” Limestone, or to the lower beds of the ”*Ludibundus*” Limestone of the Middle Ordovician of Sweden.

MATERIAL

Calyxdendrum graptoloides n. gen., n. sp. is an extremely rare graptolite in the Ordovician boulders of Poland. Among the many hundreds of dissolved boulders it has been discovered in 6 of them only. Out of these four (0.31, 0.166, 0.334 and 0.340) have yielded but one small fragment each, while three only (0.26, 0.29 and 0.31) contained several more or less fragmentary specimens. No complete rhabdosome has thus far been discovered. The largest fragment (from boulder 0.31) represents a stipe with 5 bifurcations, containing 9 preserved autothecae. Besides more or less fragmentary parts of the rhabdosome, a sicula has been found with the basal part of the metasicula, also a sicula with the stolotheca S_0, and a young rhabdosome with sicula and autothecae a_1, a_2 and a_3. Most of the specimens are not flattened and, on the whole, not much deformed. Fragments representing the terminal parts of stipes show hardly any secondary thickening of walls and after bleaching become completely transparent, thus permitting a detailed analysis of their fusellar structure and of the mutual thecal relations. Since the autothecae are very characteristically shaped the assignment of the various fragments to this species does not present any difficulties. Two detached siculae have, likewise, quite certainly been referred to this species, their shape approaching that of autothecae; moreover, they do not differ from the sicula in the specimen representing a young rhabdosome.

DESCRIPTION

Genus *Calyxdendrum* nov.
Calyxdendrum graptoloides n.sp.

(fig. 1-11)

Diagnosis. — Rhabdosome dendroid, in shape approaching *Dendrograptus*. Frequent bifurcation of stipes. Sicula conical, provided with a thick nema. Autothecae conical, non-isolated, with ventral lip bearing a short linguiform process, hyperbolic in outline. Bithecae opening into the interior of autothecae.

Holotype — fig. 3.

Remarks. — Since the genus *Calyxdendrum* is for the time being monotypic, the just given diagnosis holds for the species as well. As exclusively specific characters may probably be considered the shape of autothecae, the relation of bithecae to autothecae and the bifurcation frequency. The genus *Calyxdendrum* may formally be referred to the family Anisograptidae, by Bulman (1950) established to include genera which have a dendroid structure of stipes and carry a sicula provided with nema. In *Calyxdendrum* the sicula of a broadly conical shape differs both from the sicula of Dendroidea which is subcylindrical, and from the typical sicula of Graptoloidea which is in the shape of a narrow cone. Among the hundreds of graptoloid siculae etched from Ordovician erratic boulders, that of *Calyxdendrum* is distinguishable at first sight on its shape. *Calyxdendrum graptoloides* may not be identified with any of the so far described representative of the Dendroidea or the Graptoloidea known to the present writer.

Sicula

(fig. 1-3)

Out of the three collected specimens of the sicula, one (*A*) represents the prosicula with about two thirds of the metasicula, the second (B) represents the prosicula with nearly completely developed metasicula, but partly flattened and with damaged apertural margin, while the third specimen (C) is a sicula forming part of a young rhabdosome.

The sicula is shaped like a conical calyx, with the apical angle of 35°, length equal to about 0.5 mm and a broadly open aperture. Length of prosicula without the nema is about 0,12 mm. In the strongly bleached and transparent specimen *A* (fig. 1) we may distinguish in the distal part of the prosicula about 6 coils of the helical line, spaced approx. 8μ. The proximal portion is strongly thickened, non-transparent so that the helical line is there not discernible. The prosicula lacks the longitudinal fibers. Nema extremely thick, much thicker than is the rule in Graptoloidea. It constitutes the direct extension of the apex of prosicula. Its proximal part only is preserved in the 3 available specimens. This is a solid rod, without an axial canal and displaying a distinctly fibroid structure. In specimen *C* (fig. 3) the nema is hooked, this being probably a primary feature. In specimen *A* the boundary between the prosicula and the metasicula is very distinct since the prosicula wall viewed in transmitted light is notably darker than the wall of the metasicula. The metasicula is made up of narrow fuselli, with an average width of 10 μ. As a rule the length of fuselli is half

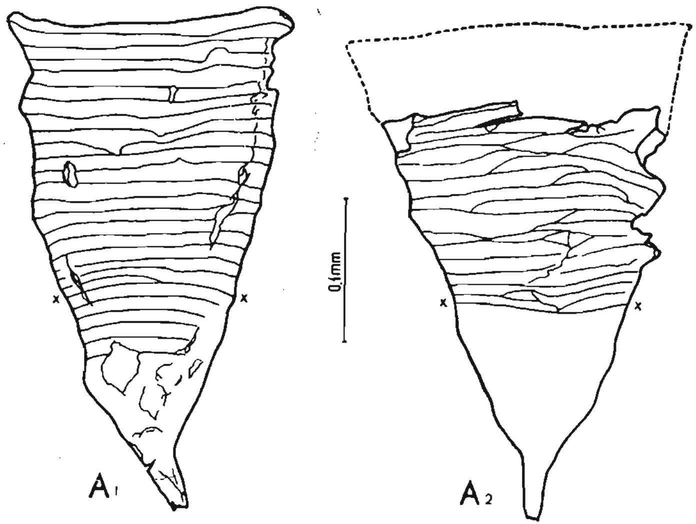

Fig. 1.— Sicula (specimen *A*) with the metasicula still incompletely developed: A_1 lateral view, A_2 ventral (dorsal?) view. Broken line indicates part destroyed after completion of the drawing A_1; *x-x* delimits the boundary of the prosicula and the metasicula (boulder 0.166).

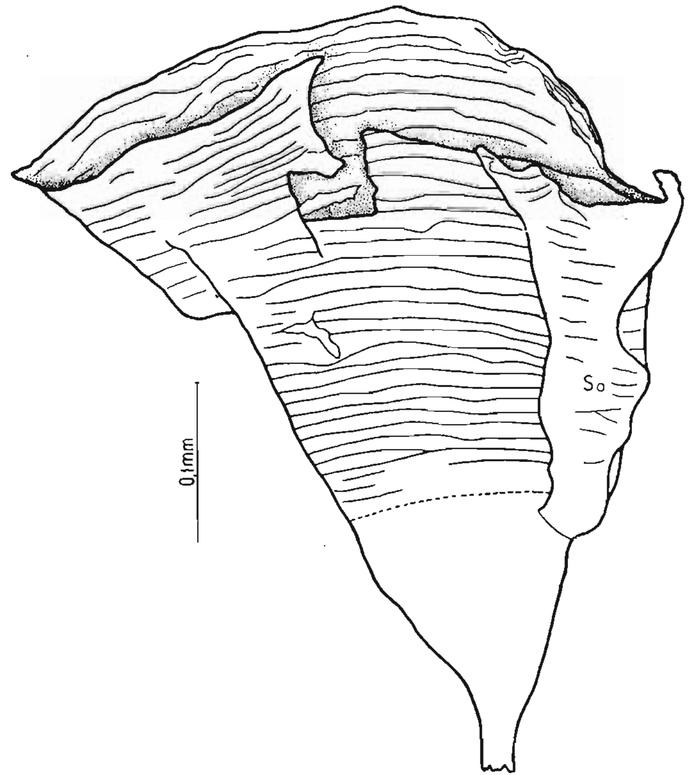

Fig. 2.— Sicula (specimen *B*) with completely developed metasicula and stolotheca S_0. Specimen strongly flattened and damaged. Broken line indicates probable boundary of prosicula and metasicula (boulder 0.29).

the circumference of the metasicula. The fuselli are interlocked by oblique sutures which are not, however, arranged in a distinctly zigzag line. Nevertheless they are fairly conspicuously grouped on the two opposite walls of the metasicula, probably representing the ventral and dorsal sides. The apertural margin of the metasicula is damaged both in specimens *B* and *C*, but did not supposedly differ from that margin in autothecae.

Mode of budding

(fig. 1-5)

The porus and stolotheca S_0 are still lacking in specimen *A* of the sicula (fig. 1) whose metasicula is but partly developed. On specimen *B* (fig. 2) stolotheca S_0 is already developed. It is badly preserved, with walls strongly corrugated. The porus seems to pierce its way through the wall of the prosicula, next to its boundary with the metasicula. The diameter of the porus is about 30 μ. Since the peristome of sicula in

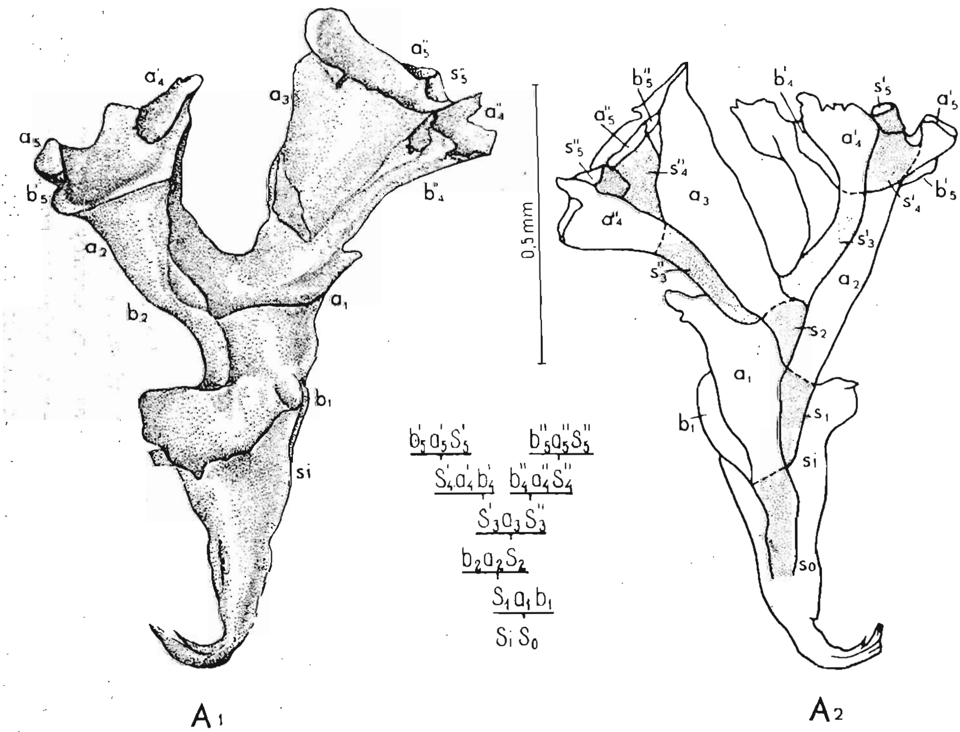

Fig. 3.— Young rhabdosome (specimen *C*) showing bifurcation and preserved sicula (*si*); holotype. A_1 apertural view, A_2 anti-apertural view, slightly schematic: stolothecae dotted (boulder 0.26).

specimen *B* is damaged, it cannot be quite surely ascertained whether the porus pierces its way on the ventral wall, as is the common rule among Dendroidea and Graptoloidea, or on the dorsal wall. In specimen *C* it occurs on the dorsal side.

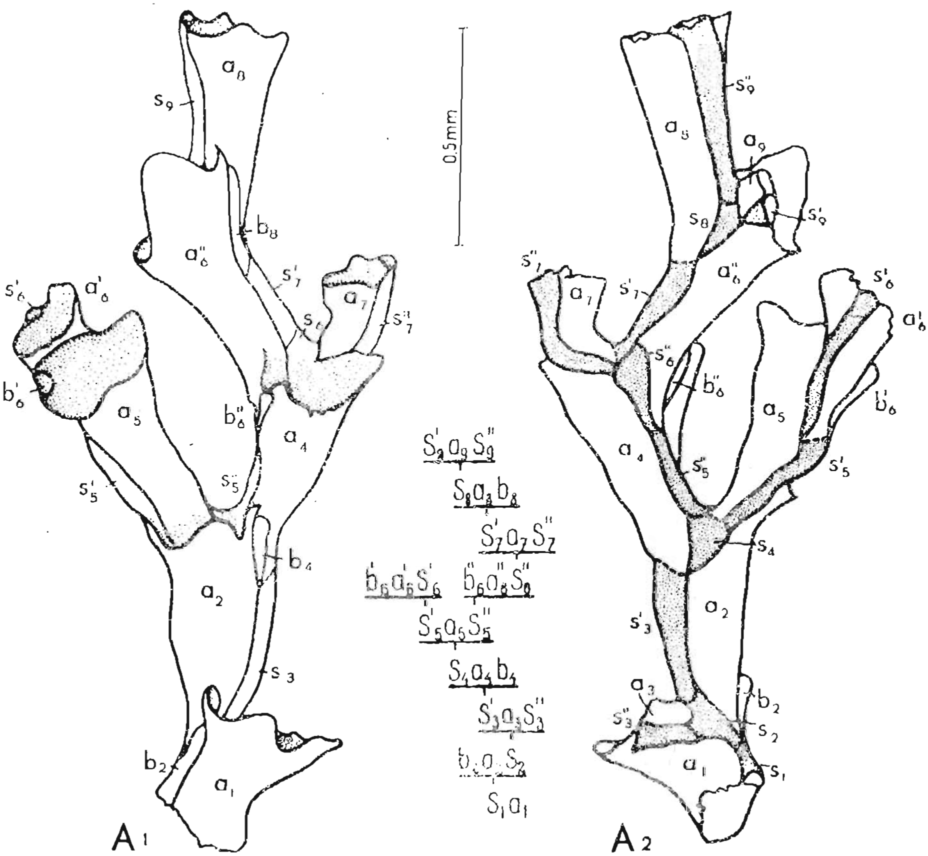

Fig. 4.— Fragment of rhabdosome showing several bifurcations: A_1 apertural view, A_2 anti-apertural view, slightly schematic; stolothecae dotted (boulder 0.26).

In specimen *B* the stolotheca S_0 creeps over the wall of the sicula, expanding considerably towards the aperture. It does not bear yet any traces of the budding triad. Neither can any traces of the internal stolotheca S_0 be discerned in the interior of the prosicula across its well transparent walls.

In specimen *C* (fig. 3) stolotheca S_0, creeping over the dorsal wall of the sicula, produces the first normal triad (s_1 a_1 b_1). Triad II likewise consists of three categories of thecae (b_2 a_2 s_2). Triad III, however, is composed of two stolothecae and an autotheca (s_3 a_3 s_3). Here i.e.

after triad III the rhabdosome initiates its first bifurcation. The subsequent budding of triads occurs normally, according to Wiman's rule (Kozłowski, 1948, p. 17). Stolothecae (fig. 4) which initiate bifurcation triads (s a s) are always shorter than those producing normal triads (s a b). The stolotheca is as a rule somewhat constricted at the point of budding of a normal triad (fig. 5).

No chitinized stolon has been ascertained in strongly bleached and well transparent stolothecae. They also lack the basal internal thecal portions characteristic of dendroid triads. It cannot, however, be quite reliably asserted that the stolon and the basal portions of thecae had not been subjected to chitinization, as is the case in Graptoloidea, or if they had been destroyed during fossilization. The latter alternative is not altogether impossible since these extremely fragile parts are not frequently preserved in typical dendroid rhabdosomes too.

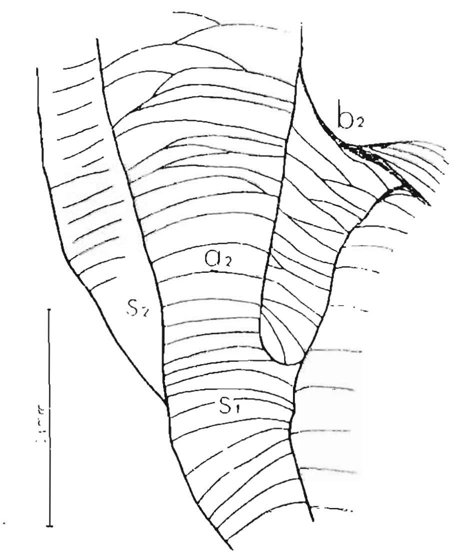

Fig. 5.— Part of a specimen showing budding of a triad from stolotheca (boulder 0,31).

Autothecae

(fig. 6)

Autothecae are very characteristically shaped like a calyx with walls diverging at an acute angle (20-25°). The aperture corresponds to the greatest diameter of theca. It is broadly ovate, ventrally narrowing (fig. 6 A_3). The ventral margin is medially provided with a broad but short linguiform process hyperbolic in outline. A more or less marked notch occurs on either side of the process. The dorsal wall of autotheca is in close contact with the stipe of the rhabdosome and the dorsal part of the peristome is usually not indicated at all. The ventral wall of theca has a normal fusellar structure with a regular zigzag suture. The passage of stolotheca into the autotheca is very gradual and they are not sharply delimited. The fuselli of the stolotheca are, however, less regular and more closely spaced than those of the autotheca. They do not produce a zigzag line which will be formed gradually during the passage of the stolotheca into the autotheca, i.e. not before thecae *s* and *b* have been budded.

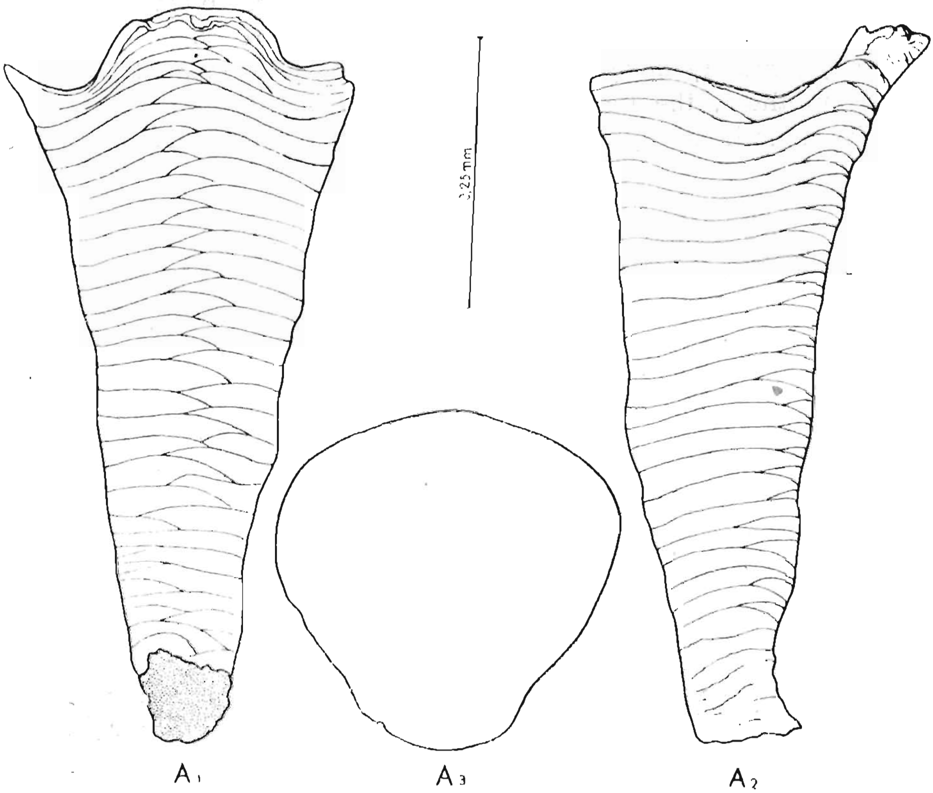

Fig. 6.— Autotheca: A_1 ventral view, A_2 lateral view, A_3 outline of aperture (boulder 0.29).

Bithecae and stolothecae

(fig. 7-11)

Bithecal apertures are not discernible exteriorly since, as a rule, they open into the interior of autothecae. Nearer to the end of the rhabdosome stipes it is possible to observe that the bitheca first opens outwards, later bends so that its aperture is directed towards the interior of the autotheca (fig. 7). Subsequently the fuselli produced along the apertural margin of the autotheca are superposed higher and higher above the bithecal aperture. Moreover, a sort of „visor" is formed above the bithecal aperture consisting of very closely spaced and irregular fusellar bands (fig. 8). On the preserved terminal stipe ends, bithecae and stolothecae are seen to open outwards. In this stage it is not always possible to distinguish the bithecae from the stolothecae. Bitheca b_1, accompanying the sicula in specimen *C* (fig. 3), opens outwards. Exceptionally the aperture of some next bithecae remains definitely opened outwards. The resulting structure suggests that, in this case, owing to delayed growth of bitheca as compared with that of the autotheca, the former might possibly not have been included into the autothecal aperture and, hence, remained underdeveloped.

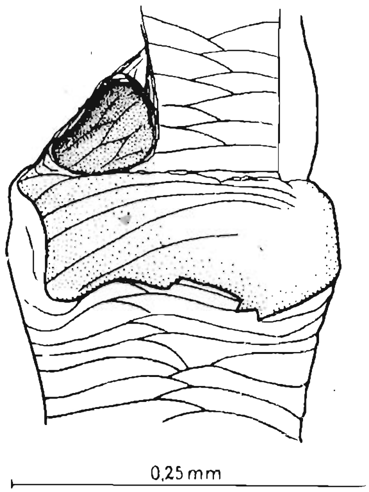

Fig. 7.— Autotheca a_2 from specimen in fig. 10 showing bithecal aperture (b_3) at early stage (boulder 0.340).

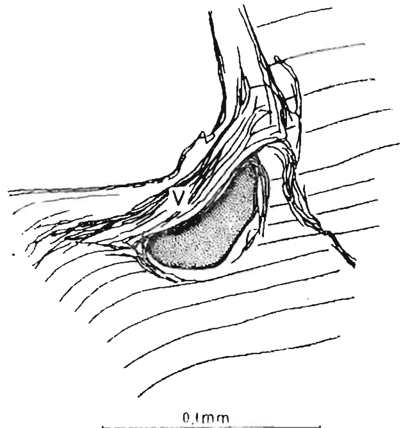

Fig. 8.— Bithecal aperture into the interior of autotheca, at an advanced stage; *v* visor-like brim of bitheca (boulder 0.29).

In one specimen, representing the bifurcated terminal end of the stipe (fig. 9) both the bitheca and stolotheca are underdeveloped. Bitheca (b_4) opens outwards much below the autothecal aperture with which it ought to have been fused, while the stolotheca (s_4) seems to be vestigial, extremely short, exceptionally thin-walled. In the same specimen the penultimate triad consists of a normally developed autotheca (a_3) and stolotheca (s_3), while the third theca is vestigial. The latter, most probably, corresponds to stolotheca (s_3'') and not to the bitheca, since the just mentioned triad is a bifurcating one. Probably, the two stipes of this bifurcated specimen were no longer capable of further growth. Another specimen (fig. 10) of the terminal part of the stipe ends up with a triad consisting of a normal autotheca (a_3) and a normal bitheca (b_3) opening into the autotheca of the preceding generation, while the stolotheca (s_3) is an unusual one. It is normally developed but does not produce a triad. A constriction is observable (x-x) where thecae s_4 and b_4 should have budded but failed to do so. Only the autotheca (a_4) developed in continuation of this stolotheca. In this case further growth of the stipe was made impossible.

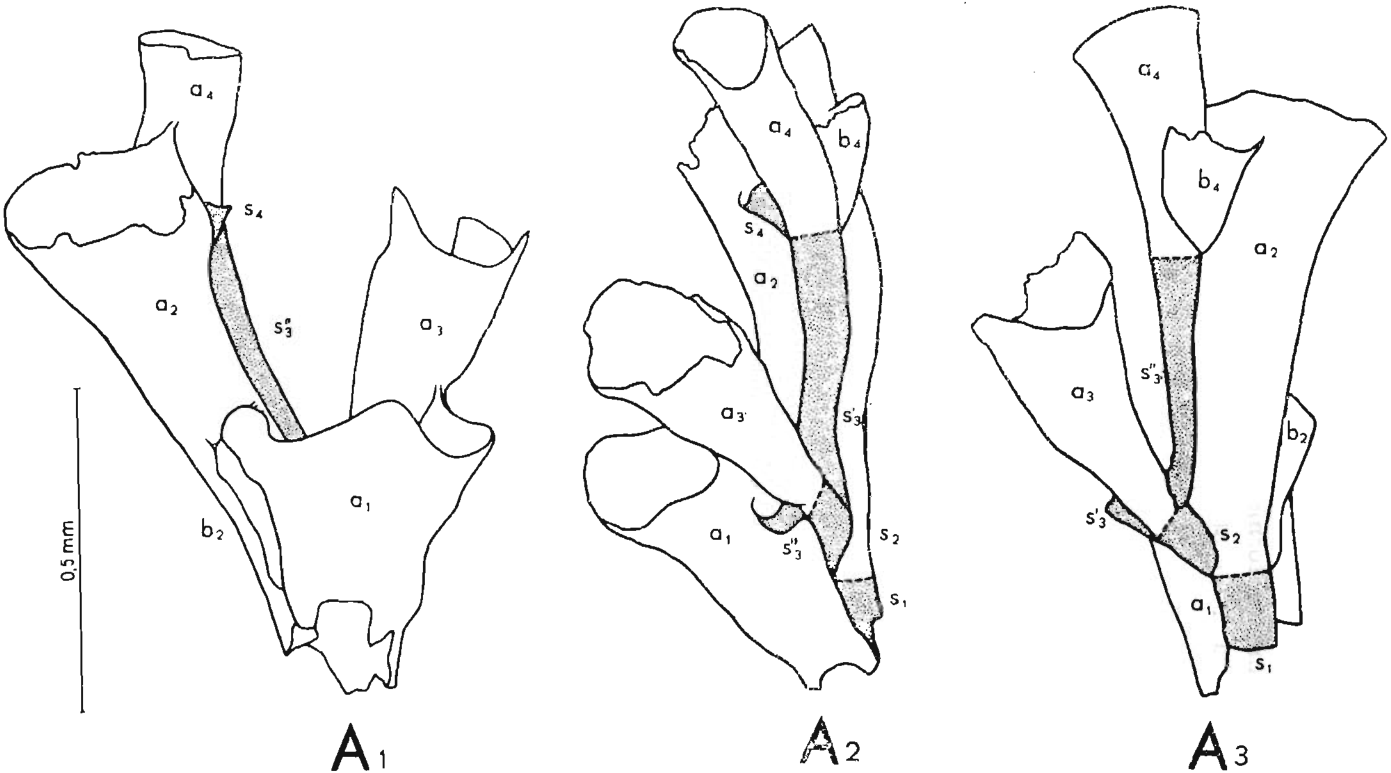

Fig. 9.— Bifurcated end of stipe shown in three positions; stolothecae dotted (boulder 0.334).

Though the size and shape of the whole rhabdosome of *Calyxdendrum* are not known, the largest available fragment (fig. 11) suggests that the rhabdosome was distinguished by frequent bifurcation of stipes. As many as 5 bifurcations have been noted on one specimen, in direct succession. The angles formed by the bifurcation of stipes vary but slightly, with the average at 55°.

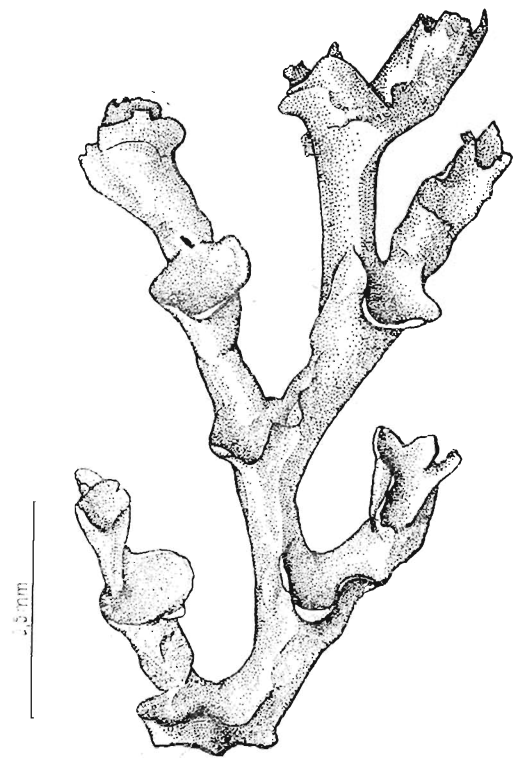

Fig. 11. — Largest collected rhabdosome fragment (boulder 0.31).

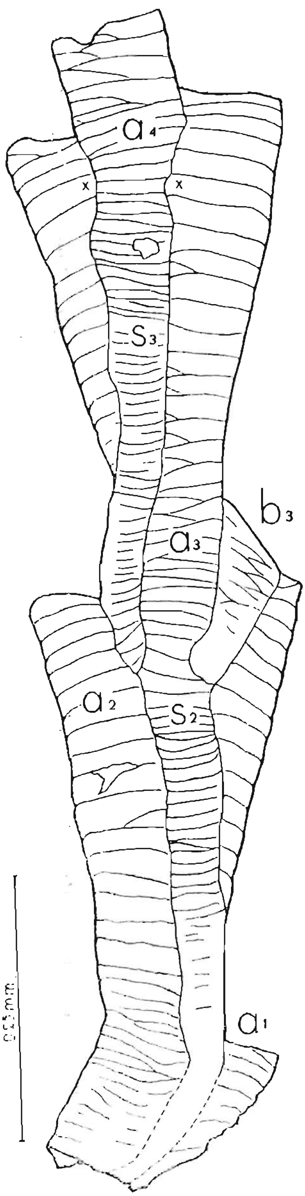

Fig. 10.— Anti-apertural view of the terminal part of a stipe. Terminal stolotheca (s_3) lacking bithecal and stolothecal buds in spite of presence of characteristic constriction (x-x) where the buds ought to have been produced (boulder 0.340).

GENERAL REMARKS

The here described graptolite is an interesting form since in it are linked some characters of two orders: Dendroidea and Graptoloidea. It throws some light on the mode of realization of the structural pattern characterizing the latter order from that common in the former. *Calyxdendrum graptoloides* n.gen., n.sp. displays the following features characteristic of dendroids: 1) triad budding according to Wiman's rule, 2) presence of bithecae, 3) presence of distinctly differentiated stolothecae, 4) uniformity of shape and size of autothecae throughout the rhabdosome length.

The graptoloid characters displayed by our form are: 1) conical sicula provided with a nema, 2) probable lack of chitinized stolons and basal parts of thecae.

The most important feature of our form in which it differs from typical dendroids is the presence of a graptoloid sicula, i.e. conical and provided with a nema. Even though this nema — at least in the preserved proximal part — is thicker than it is commonly observable in siculae of Graptoloidea, still it is an organ, fundamentally differing in its morphology and function from the basal disc in the sicula of Dendroidea. The replacement of the basal disc by the nema was probably connected with a radical change of mode of life of the graptolite colony. The morphology of the rhabdosome in Dendroidea suggests that colonies of this type were adapted to a sessile benthonic life, similarly as the dendroid colonies of bryozoans, and their thecal apertures were directed upwards. On the other hand, for rhabdosomes provided with a nema one can hardly imagine another attitude than that of being suspended on the nema and turned downwards. Indeed all the graptolitologists agree that this type of rhabdosome structure implies a planktonic mode of life. The history of graptolites indicates that the acquisition by certain dendroids of the conical sicula with a nema was a modification which had a decisive bearing upon their further evolution.

Our knowledge of the morphology of forms intergrading from Dendroidea to Graptoloidea is not sufficient to permit the clearing up of that important problem as to the mode of transition from the cylindrical dendroid sicula to the conical graptoloid type. This transformation must have taken place during the larval stage corresponding to the prosicula. Were intermediate stages realized between these two types of the sicula? Up to date observations have not provided a definite reply to that question. Rhabdosomes of intermediate forms between

Dendroidea and Graptoloidea are nearly all known from flattened specimens which are not suitable for an adequate examination of the shape and structure of sicula. It is, however, rather probable that the transition of the sicula from the dendroid to the graptoloid type occurred rapidly, inasmuch that this transformation was connected with a radical change of environment of graptolite colonies.

On the other hand, it is hardly probable that this was a unique phenomenon during the evolution of the dendroid group. The graptoloid sicula has been recorded within the genus *Dictyonema* as early as the Lower Tremadocian. The form here described is suggestive of the independent origin of a sicula of this type within the genus *Dendrograptus* too, to which *Calyxdendrum* closely approaches. The development of a graptoloid sicula within this line must have been realized much later than in the line of *Dictyonema*, since our form comes from the Middle Ordovician. The thecal morphology and the type of sicula of *Calyxdendrum* does not indicate a closer genetic relationship of that genus with Tremadocian representatives of the genus *Dictyonema*. The sicula provided with a nema was an adaptive improvement for the benefit not so much of the larva as of the colony. Hence this was a kind of prospective adaptation which did not affect the evolution of the whole colony until later on.

Another character, besides the sicula, in which *Calyxdendrum* differed from typical dendroids, is the probable lack in its stolothecae both of a chitinized stolon and of the basal internal parts of theca. In *Dictyonema flabelliforme* (Eichwald), *D. canadense* Lapworth and probably in most of the anisograptids the chitinized stolon and the internal bases of thecae were still present, as is the case in typical dendroids. If future studies based on more ample material than that available to the present writer would ascertain that *Calyxdendrum* lacked the chitinized stolons, it will suggest that in this respect its evolution had been more advanced towards the graptoloid type than that in the above mentioned Tremadocian graptolites with a graptoloid sicula.

The mode in which individuals producing bithecae were eliminated from a graptolite colony is another important problem that has not so far been cleared up. Stages distinctly intermediate between forms with normally developed bithecae and those lacking them completely are unknown. Thus far observations are obviously in support of Bulman's opinion (1950, p. 68) claiming that bithecae were eliminated independently in the particular lineages conducing from the Dendroidea to the Graptoloidea.

The frequently noted process of opening of the bithecal aperture in the interior of autotheca may perhaps express a tendency for the elimination of bithecae. This is observable among many species belonging to various dendroid genera and referable to various stages of the Ordovician. In *Calyxdendrum* all bithecae, the first (b_1) excepted, open normally into the interior of autothecae. A visor-like brim is formed above the bithecal aperture in older autothecae which emphasizes the tendency for the isolation of the bithecal individual from external environment and its consequent closer union with the autothecal zooid. In certain cases when the bithecal aperture retarded its union with the autotheca the bitheca remains like underdeveloped. Exceptionally, as has been observed in *Dictyonema longilingue* Kozl. (Kozłowski, 1948, p. 127, fig. 31 *E*) from the Tremadocian, two bithecae, belonging to two different generations, may open up into the interior of the same autotheca.

In what the stolothecae of Dendroidea are concerned it is quite doubtless that their equivalents in Graptoloidea are the so-called prothecae. In Dichograptidae the protheca retains some degree of independence in relation to the metatheca developing as its prolongation (Kozłowski, 1954, fig. 7 and 8 *C*). In diplograptids and monograptids, however, the boundary between these segments is not sharp.

In Dendrograptidae the stolotheca buds on the side of the preceding stolotheca, symmetrically to the bitheca. At first its position in relation to the autotheca of the same generation is asymmetric. Later on, however, it is shifted to the centre of the dorsal autothecal wall to occupy the position of the protheca in Graptoloidea. In relation to the stolotheca of Dendroidea, the protheca in Graptoloidea is very much shorter.

If specimens suitable for etching are collected, it may be hoped that investigations on the representatives of Anisograptidae will clarify the processes leading from forms provided with bithecae and typical stolothecae, to those lacking bithecae and in which stolothecae have been transformed in prothecae.

So far observations indicate that the evolution of various characters in the passage from the Dendroidea to the Graptoloidea was realized at different rates. In *Dictyonema flabelliforme* and similar species the graptoloid type of sicula occurs already in the Lower Tremadocian when the other characters of these forms, i.e. the presence of bithecae, of chitinized stolons and chitinized basal portions of thecae are still at the dendroid stage. In *Calyxdendrum*, the rhabdosome is typically dendroid, whereas the sicula is graptoloid and it is not impossible that the stolon here had already lost its chitinous sheath, as is the case in Graptoloidea.

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Warszawa, January 1960

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ROMAN KOZŁOWSKI

CALYXDENDRUM GRAPTOLOIDES N.GEN., N.SP. — GRAPTOLIT POŚREDNI MIĘDZY DENDROIDEA I GRAPTOLOIDEA

Streszczenie

Podano opis nowego graptolita, *Calyxdendrum graptoloides* n.gen., n.sp., pod pewnymi względami pośredniego między przedstawicielami rzędów Dendroidea i Graptoloidea. Okazy tej formy, dość fragmentaryczne, lecz na ogół dobrze zachowane, wypreparowano z sześciu wapiennych głazów narzutowych wieku środkowo-ordowickiego, zebranych w latach 1950-1960 w różnych miejscowościach Polski (*vide* p. 108 tekstu angielskiego).

Calyxdendrum graptoloides n.gen., n.sp. cechuje się, jak typowe Dendroidea, pączkowaniem odbywającym się triadami według reguły Wimana i normalnie wykształconymi autotekami, bitekami i stolotekami. Sikula jego natomiast jest typu graptoloidowego, tj. stożkowata i opatrzona nemą. Część prosikularna ma zaznaczoną linię helikoidalną, a część metasikularna odznacza się nieregularnym ułożeniem fuzellusów, bez wyraźnie ukształtowanych linii zygzakowatych. Porus otwiera się zapewne w ścianie prosikuli, lecz tuż przy jej granicy z metasikulą. W stolotekach nie stwierdzono obecności schitynizowanych stolonów i podstaw tek. Jeżeli brak tych części nie jest wynikiem stanu fosylizacji, należałoby przyjąć, że pod tym względem opisana forma realizuje stadium graptoloidowe. Ujścia bitek, prócz pierwszej (b_1), otwierają się do wnętrza autotek i w stadium dojrzałym odgrodzone są od zewnątrz rodzajem daszka.

Zastąpienie sikuli typu dendroidowego, tj. subcylindrycznej i opatrzonej dyskiem bazalnym, przez sikulę typu graptoloidowego, stożkowatą, zakończoną nemą, było niewątpliwie udoskonaleniem przystosowawczym przy przejściu od trybu życia bentonicznego do planktonicznego. Przeobrażenie to musiało nastąpić w stadium larwalnym, któremu odpowiada prosikula. Formy pośrednie między tymi dwoma typami sikuli nie są znane. Przejście od jednego do drugiego odbyło się zapewne w szybkim tempie, tym bardziej że było związane z radykalną zmianą trybu życia kolonii graptolitowej. Zmiana ta wywarła następnie decydujący wpływ na dalszą ewolucję graptolitów.

Sikula graptoloidowa powstała według wszelkiego prawdopodobieństwa niezależnie w kilku liniach ewolucyjnych Dendroidea i w różnych momentach okresu ordowickiego. W obrębie rodzaju *Dictyonema* miało to miejsce w tremadoku, a w obrębie rodzaju *Dendrograptus* — od którego wywodzi się przypuszczalnie *Calyxdendrum* — w ordowiku środkowym.

Nie wyjaśniony pozostaje nadal proces, drogą którego wyeliminowane zostały biteki w szczepach wiodących od Dendroidea do Graptoloidea.

OBJAŚNIENIA DO ILUSTRACJI

Fig. 1 (p. 111)

Sikula (okaz *A*) z niekompletnie jeszcze rozwiniętą metasikulą: A_1 od strony lateralnej, A_2 od strony wentralnej (dorsalnej?). Linią przerywaną zaznaczono część, która uległa zniszczeniu po wykonaniu rysunku A_1; x-x zaznacza granicę między prosikulą a metasikulą (głaz 0.166).

Fig. 2 (p. 111)

Sikula (okaz *B*) z całkowicie rozwiniętą metasikulą i ze stoloteką S_0. Okaz znacznie spłaszczony i uszkodzony. Linią przerywaną oznaczono przypuszczalną granicę prosikuli i metasikuli (głaz 0.29).

Fig. 3 (p. 112)

Młody rabdozom (okaz *C*), rozwidlony, z zachowaną sikulą (*si*); holotyp. A_1 od strony aperturalnej, A_2 od strony antyaperturalnej, nieco schematycznie; stoloteki zakropkowane (głaz 0.26).

Fig. 4 (p. 113)

Fragment rabdozomu, parokrotnie rozwidlony: A_1 od strony aperturalnej, A_2 od strony antyaperturalnej, nieco schematycznie; stoloteki zakropkowane (głaz 0.26).

Fig. 5 (p. 114)

Część okazu ilustrująca pączkowanie triady ze stoloteki (głaz 0.31).

Fig. 6 (p. 115)

Autoteka: A_1 od strony wentralnej, A_2 z profilu, A_3 zarys apertury (głaz 0,29).

Fig. 7 (p. 116)

Autoteka a_2 okazu fig. 10, z widocznym ujściem biteki b_3, w stadium mało zaawansowanym (głaz 0.340).

Fig. 8 (p. 116)

Ujście biteki do wnętrza autoteki, w stadium zaawansowanym; v daszkowaty brzeg biteki (głaz 0.29).

Fig. 9 (p. 117)

Rozwidlone zakończenie gałązki, widziane w trzech pozycjach; stoloteki zakropkowane (głaz 0.334).

Fig. 10 (p. 118)

Zakończenie gałązki od strony antyaperturalnej. Końcowa stoloteka (s_3) pozbawiona pączków biteki i stoloteki, pomimo charakterystycznego przewężenia (x-x) w miejscu, gdzie powinny się one były pojawić (głaz 0.340).

Fig. 11 (p. 118)

Największy znaleziony fragment rabdozomu (głaz 0,31).

РОМАН КОЗЛОВСКИ

CALYXDENDRUM GRAPTOLOIDES N. GEN., N. SP. — ПРОМЕЖУТОЧНЫЙ ГРАПТОЛИТ МЕЖДУ DENDROIDEA И GRAPTOLOIDEA

Резюме

В работе дано описание нового граптолита — *Calyxdendrum graptoloides* n. gen., n. sp., являющегося в некоторых отношениях промежуточной формой между представителями отрядов Dendroidea и Graptoloidea. Образцы этой формы довольно фрагментарны, но в общем хорошей сохранности, отпрепарированы из шести валунов ордовикского известняка, собранных в годах 1950—1960, в разных местностях Польши.

Calyxdendrum graptoloides n. gen., n. sp. отличается, также как и типичные Dendroidea, почкованием происходящим триадами, согласно правилу Вимана, и нормально развитыми автотеками, битеками и столотеками. Однако сикула граптолоидного типа — конусообразная и снабженная немой. На просикулярной

части видна геликоидная линия, а часть метасикулярная отличается нерегулярным расположением фузеллусов без отчетливой зигзагообразной линии. Порус открывается повидимому в стенке просикулы, но возле ее границы с метасикулой. В столотеках не найдено хитинизованных столонов и оснований тек. Если отсутствие этих частей не является следствием особенности фоссилизации, так надо полагать, что в этом отношении описанная форма осуществляет граптолоидную стадию. Устья битек, кроме первой (b_1), открываются внутрь автотек и на зрелой стадии отграничены снаружи своеобразной крышечкой.

Замещение сикулы дендроидного типа, т. е. субцилиндрической и снабженной базальным диском, сикулой граптолоидного типа, конусообразной, оконченной немой, было без сомнения приспособительным усовершенствованием при переходе от бентонного к планктонному образу жизни. Это преобразование должно было совершиться на личиночной стадии, которой соответствует просикула. Промежуточные формы между этими двумя типами сикул не известны. Переход от одного к другому произошел вероятно очень быстро, тем более, что был связан с резким изменением образа жизни колонии граптолитов. Изменение это решающе повлияло на дальнейший ход эволюции граптолитов.

Граптолоидная сикула возникла по всей вероятности независимо в нескольких эволюционных линиях дендроидей и в разных моментах ордовикского периода. В пределах рода *Dictyonema* произошло это в тремадоке, а у рода *Dendrograptus*, из которого ведет повидимому свою родословную *Calyxdendrum*, в среднем ордовике.

Не разъясненным остается процесс, который привел к исчезновению битек в линиях ведущих от Dendroïdea к Graptoloidea.