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*GRAPTOLODENDRUM MUTABILE* N.GEN., N.SP. — AN ABERRANT  
DENDROID GRAPTOLITE

*Abstract.* — A representative of the order Dendroidea, described as *Graptolodendrum mutabile* n.gen., n.sp., differs from other dendroid graptolites in its bithecae whose position is not stabilized. Mostly, they occur on one side of the stipe and, rarely, on both sides alternatively which is a rule in the Dendroidea. The fusellar structure of autothecae, mostly irregular in the distal part, is also unstabilized. The position of the pore which pierces the wall of metasicula, as in the Graptoloidea, and not of prosicula, is a fully exceptional character in the representative of the Dendroidea. The material investigated has been etched out from the Middle Ordovician erratic boulders of Poland.

## INTRODUCTION

The described graptolite is one of the most common representatives of the Dendroidea, met with in the Ordovician erratic boulders of Poland, both on the Baltic Sea coast and in Central Poland. Its presence has been stated in 30 boulders (of the number of over 500 ones dissolved). In the majority of the boulders, this graptolite was not accompanied by any index graptolite. Such species have only been found in four boulders. *Gymnograptus retioloides* (Wiman) and *Glyptograptus* cf. *teretiusculus* (Hisinger) occurred in the boulders Nos. O.26 and O.30 and *Dicellograptus geniculatus* (Bulman) — in the boulder No. O.28. On the basis of these graptolites, the three boulders may be considered Middle Ordovician, probably stages C<sub>I</sub> and C<sub>II</sub> of the Estonian sequence. With regard to many remaining boulders, on the basis of graptolites and representatives of other groups of animals they contain, we may only generally ascertain that they represent the Middle Ordovician. Lithologically, these boulders are fairly similar to each other. Mostly, these are the organodetritic limestones. After dissolving these 30 boulders in hydrochloric acid, several hundred graptolite specimens were obtained. None of them, how-

ever, represents a full rhabdosome. Mostly, these are small pieces of stipes, consisting of a few thecae and, less frequently, larger fragments with more than 10 thecae. Fragments of stipes, dichotomously bifurcated, are fairly numerous. On the other hand, terminal parts of stipes are rather rare. Over 30 prosiculae have been found, some of them with the metasiculae preserved. Basal parts of rhabdosomes which, in addition to prosicula, preserved their metasicula and the first thecal triad, are very rare. In most specimens, the periderm is wrinkled and only few of them do not display any secondary deformations. Although, generally speaking, the material investigated is very fragmentary, but, due to its abundance, affords a fairly accurate picture of the morphology of the rhabdosome and of its development.

*Diagnosis.* — Dendroid graptolite, with rhabdosome consisting of straight stipes without the anastomoses. Bithecae situated on one side of the stipe, less frequently, alternately on both sides. Autothecae sessile, without the ventral and dorsal denticle. Metasicula without zigzag lines. Pore in the wall of the metasicula.

*Type species:* *Graptolodendrum mutabile* n.sp.

*Name derivation:* A genus displaying a certain combination of characters of Dendroidea and Graptoloidea. The specific name indicates the instability of different characters.

## DESCRIPTION

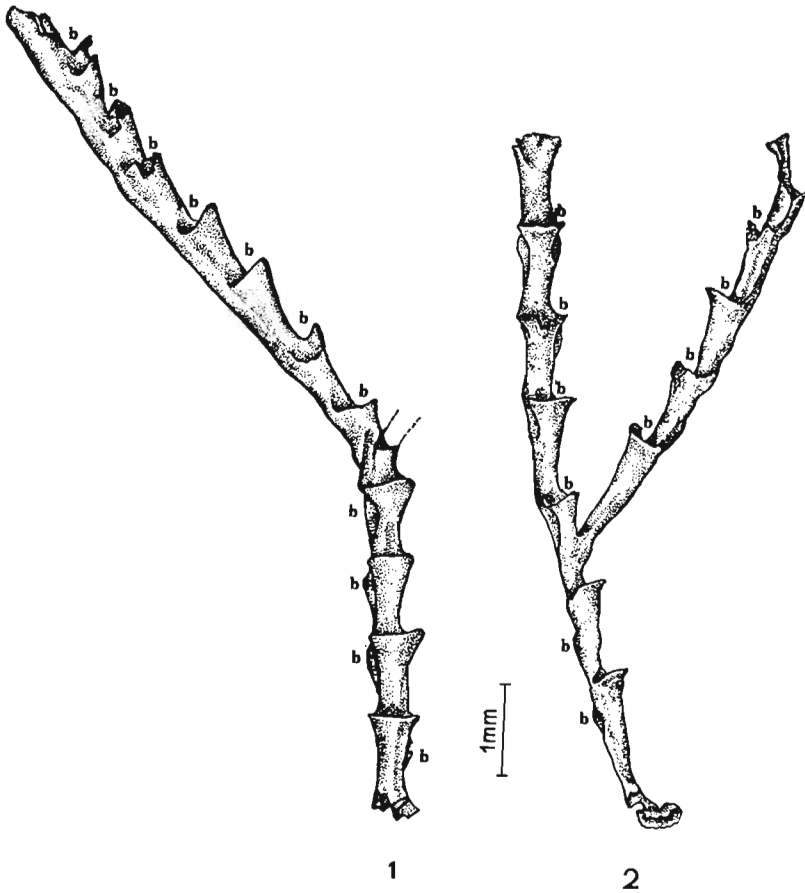
### GENERAL ASPECT OF THE RHABDOSOME

Stipes are usually straight and rigid, consisting of autothecae with non-isolated proximal part (Fig. 1), open on the ventral side of the stipe. The thickness of stipes and size of autothecae are more or less uniform over the entire length of stipes. Bifurcation took place probably at long intervals since no fragments with several bifurcations have been found. Mostly, of two stipes, forming a bifurcating specimen, one develops as a prolongation of the primary stipe and the other makes up a sort of a lateral branch (Fig. 2). The angle of the stipes divergence, although variable, is always acute and fluctuates within limits of 20 and 50°, mostly amounting to about 45°.

It may be concluded, on the basis of very many fragments, that rhabdosome is straight, rarely bifurcated and consisting of straight stipes with sessile autothecae.

### AUTOTHECAE

Autothecae have a very peculiar aspect which is different from that of autothecae of other dendroid graptolites. They are funnel-shaped,



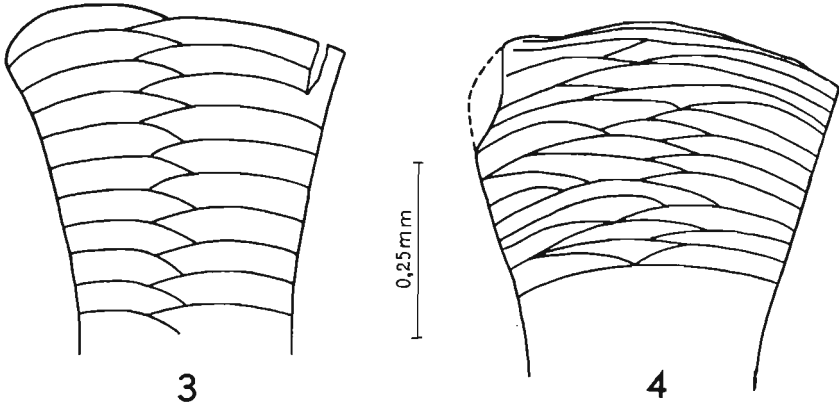
Figs. 1-2. *Graptolodendrum mutabile* n.sp.

1 Holotype. A fragment of the stipe with 11 autothecae and the same number of bithecae. A lateral branch (now, broken off) was running above the fourth theca. In the lower part, bithecae, except for the first one, are situated on the left and, in the upper part, on the right side.

2 Paratype. A fragment of a bifurcating stipe. In the lower part, bithecae are situated on the left side, in the left stipe—on the right, and in the right stipe—on the left side.

adhering, with its truncated side, to the stipe (Fig. 8D). The aperture of the theca is subcircular, its margins being arranged in a plane somewhat oblique in relation to the axis of the stipe. As a whole, the autotheca has the shape of an elongated cone. The peristomal margin does not pass ventrally into a linguliform process, as is case in typical representatives of *Dendroidea*, and does not continue on the dorsal side. It has been shown by investigating many bleached autothecae, that their fusellar structure varies from one to another theca. The autothecae with fuselli regularly arranged and with a ventral zigzag line developed in the plane of symmetry are relatively rare (Fig. 3). Mostly, fuselli are shorter than the circumference of the theca, particularly so in its distal part and,

consequently, they form wedge-like elements different in length and their oblique sutures are more or less irregularly scattered (Fig. 4). Between the type of theca with a regular zigzag line and a complete absence of such line, there are many intermediate types. It should also



Figs. 3-4. *Graptolodendrum mutabile* n.sp.

- 3 An autotheca with a regular zigzag line.  
4 An autotheca with irregularly disposed fuselli.

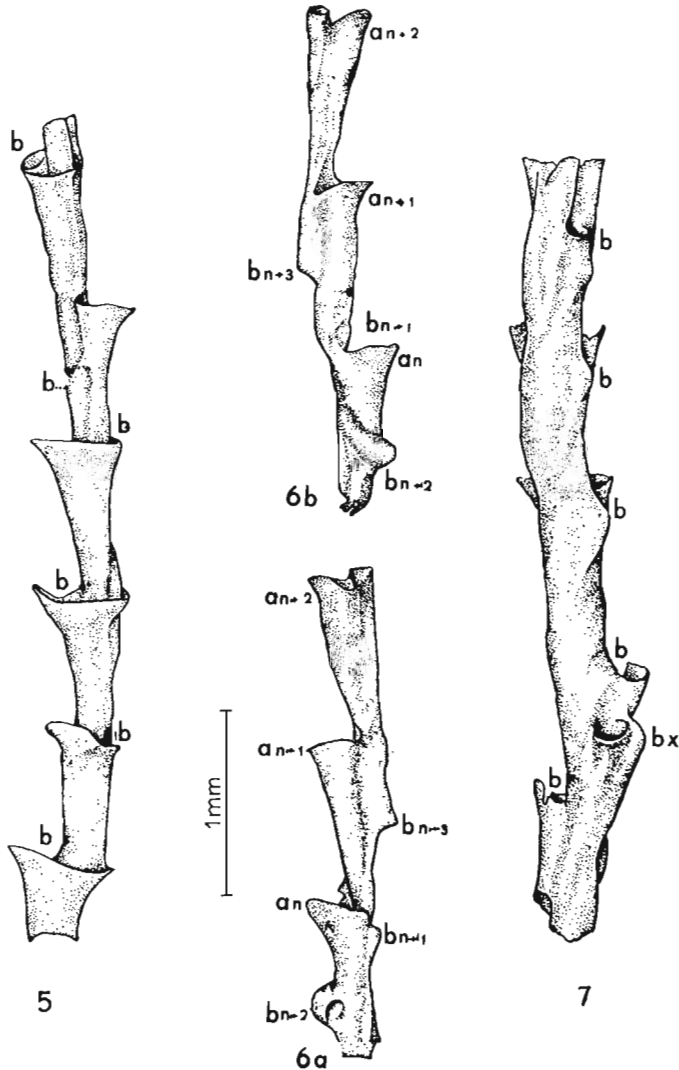
be mentioned that the irregular fusellar structure is displayed only in the distal part of the theca, while the narrow proximal part is usually regularly built with the zigzag line in the middle.

#### BITHECAE

Normally, bithecae are open inwards the autothecae and their apertures are not visible outside. An arrangement of the bithecae in relation to autothecae is very peculiar. While, usually, bithecae in Dendroidea are disposed alternately on both sides of the stipe, in the form, described here, there is no such regular arrangement. Mostly, bithecae are disposed only on one side of the stipe, on some stipes on the right and on some others—on the left side (Figs. 1 and 2). Less frequently, on a stipe having its thecae situated mostly on one side, some of them are placed on the opposite side. Finally, stipes also occur with their bithecae regularly alternate to each other, this as a rule being the case in Dendroidea (Fig. 5). When the stipe bifurcation takes place, the bithecae on each of the two derivative stipes are, in general, disposed on opposite sides (Figs. 1 and 2).

A bitheca, being considerably shorter than the autotheca of the same triad, does not open into the autotheca of this triad, but into the autotheca of the preceding triad, that is, generally speaking,  $b_n$  opens into  $a_{n-1}$ . In one case two bithecae opened towards the inside of one autotheca. Probably, one of them corresponded to  $b_{n+1}$  and other to  $b_{n+2}$ , the

latter being considerably shortened. In the specimen shown in Figs 6 a, b representing a fragment of stipe with three autothecae and three bithecae preserved, one bitheca ( $b_{n+1}$ ) opens normally into the inside of the autotheca ( $a_n$ ) accompanying it, while the remaining two ( $b_{n+2}$  and  $b_{n+3}$ ) are open outwards. These thecae are abnormally developed because both of them are directed downwards, instead of upwards, and are so long



Figs. 5-7. *Graptolodendrum mutabile* n.sp.

5 A fragment of the stipe (terminal part) with alternately situated bithecae.

6 a, b A fragment of the stipe, viewed in two aspects, with abnormally developed bithecae which open outwards.

7 A fragment of the stipe, viewed in the dorsal aspect, with bithecae situated on the left side, with one additional bitheca ( $b_x$ ) open outwards and one normal bitheca (at the top) also open outwards.

that the aperture of bitheca  $b_{n+2}$  opens near the base of autotheca  $a_n$  and the aperture of bitheca  $b_{n+3}$  — near the base of autotheca  $a_{n+1}$ . The reasons of such an abnormal development of these bithecae might perhaps be understandable if similar cases were observed in a larger number of specimens which would allow one to prepare a series of microtonic sections. A similar case of abnormal bithecae, developing in an opposite direction, was recorded in *Dictyonema wysoczkanum macrothecale* Kozł. (Kozłowski, 1949, p. 131, Pl. 9, Figs. 8 a, b).

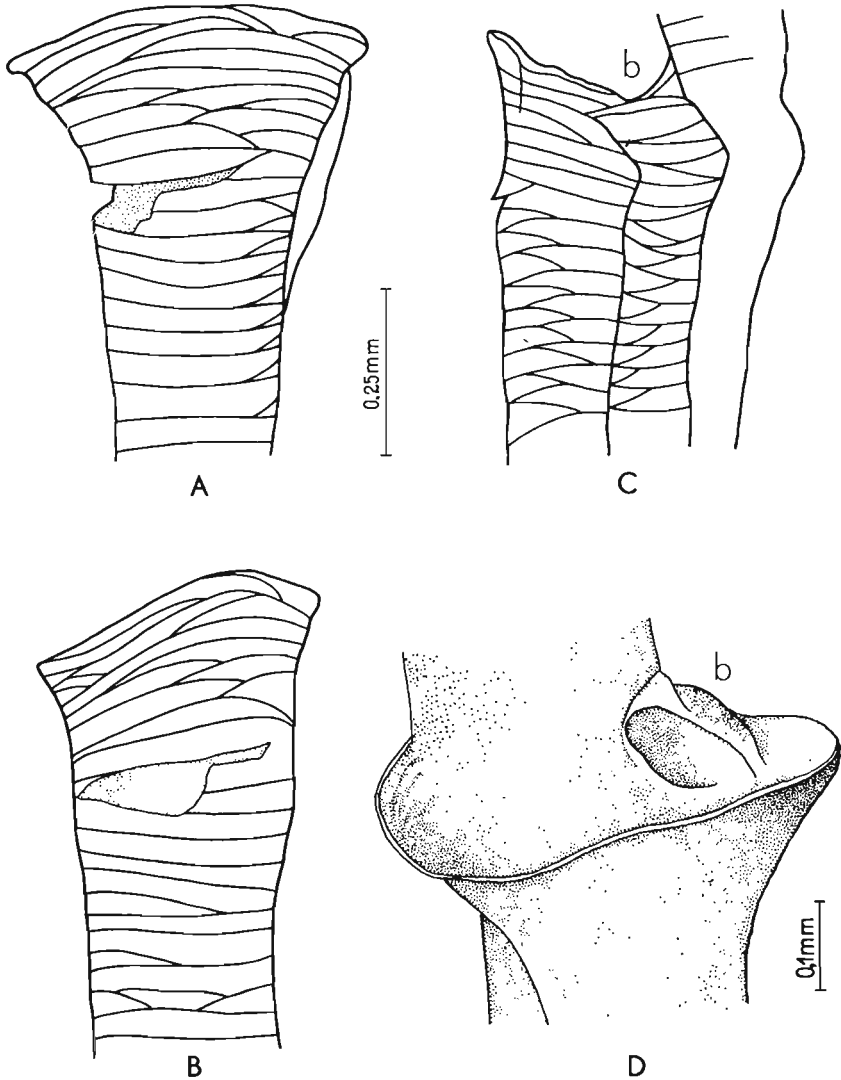


Fig. 8. *Graptolodendrum mutabile* n.sp. An autotheca, viewed in different aspects: A from the ventral side, B from the left side, C from the right side, with the adjoining bitheca, D obliquely and from above, with the aperture and visorlike lip of the bitheca visible.

## DEVELOPMENT

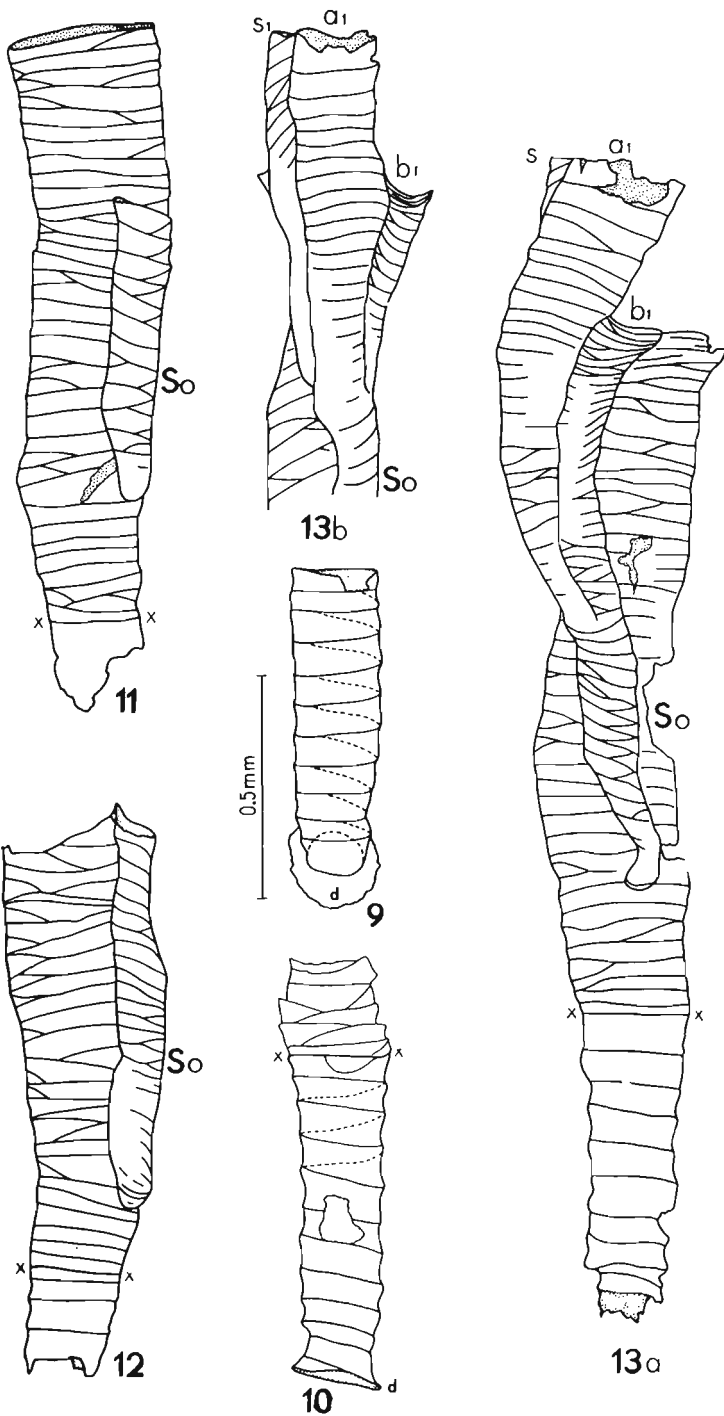
Prosicula (Figs. 9 and 10) is shaped like a cylinder, slightly extending from base to aperture, only its basal part is somewhat narrower. On the average, prosicula is 700  $\mu$  long and the diameter of its aperture amounts to 200  $\mu$ . The wall of the prosicula is provided with a characteristic spiral thread which is particularly strongly outlined and, on the outside, it appears in the form of a sharp costa. This gives the prosicula a ringed aspect. The number of coils of the spiral thread varies within limits of 10 and 12 and usually amounts to 11. The spiral may be coiled either clockwise, or counter-clockwise. It has been shown by the observation of over 30 prosiculae that both these directions are almost equally often recorded. All specimens of prosiculae with a preserved basal part are provided with a more or less developed disc of attachment which is spongy, not fusellar in structure, its lower surface is rough and the periphery — tattered. No basal discs, which certainly belong to the adult rhabdosomes of this species, have been found.

Metasicula (Figs. 10—13) develops normally in the prolongation of the prosicula. In one specimen with an almost completely preserved metasicula, its length amounts to about 1,530  $\mu$ , that is more than two times the length of the prosicula. The shape of its aperture is almost identical with that of autothecae. The walls of the metasicula are built, over their entire length, of wedge-like fuselli different in length and, therefore, their oblique sutures are irregularly scattered on the periphery of a theca and do not form zigzag lines.

*Budding.* — In five specimens which preserved their initial bud, the pore pierces the wall of the metasicula. The distance of the pore from the boundary between the prosicula and metasicula is variable. Measured on four specimens, it amounts to 113, 125, 140 and 200  $\mu$ . The diameter of the pore comes to about 45  $\mu$ .

The initial bud,  $s_0$  (Figs. 11 and 12) is built of regularly disposed semifuselli. The first triad, consisting of the bitheca ( $b_1$ ), stolothea ( $s_1$ ) and autotheca ( $a_1$ ), situated between them, takes its origin from this bud. The bitheca opens into the autotheca similarly as the bithecae of next triads (Figs. 13 a, b).

No stolons have been found in any development stage despite the fact that some specimens of siculae and a basal part of the rhabdosome became, after intensive bleaching, transparent. In the series of microtomic sections through three well-preserved specimens, the internal parts of thecae, contained within a fairly thick cortical sheath, are mostly destroyed to a different extent. It was only in a few cross sections that the stolonal triads were found within the stolothea. The lack of stolons in the specimens, corresponding to the basal part of the rhabdosome, does not perhaps prove that the stolons in this part were devoid of



Figs. 9-13. *Graptolodendrum mutabile* n.sp.

9 Proscicula.

10 Proscicula with a fragment of the metascicula.

11 Proscicula with an incompletely grown metascicula and with a young initial bud.

12 Proscicula with metascicula and a more advanced stage of the initial bud.

13 Proscicula with a fully grown metascicula and the first triad: a lateral view, b dorsal view of the triad.

d basal disc; s stolotheca; s<sub>1</sub> initial bud (sicular stolotheca); x-x boundary between proscicula and metascicula.



sclerotized sheaths, but it seems to prove that their sclerotization was very slight and consequently, there was a meagre chance of their preservation in the fossil state.

#### GENERAL CONSIDERATIONS

The graptolite, described in the present paper, departs in many respects from typical representatives of the Dendroidea, such as, for instance, *Dendrograptus* Hall. In the genera of the Dendroidea, which have so far been thoroughly investigated, the bithecae are always disposed alternately on both sides of the stipe, while in *Graptolodendrum* the position of the bithecae is not uniform. Mostly, they are distributed over the entire length of the stipe on one side only, either left or right. Sometimes, on a stipe with bithecae, arranged on one side, some of them are, as an exception, situated on the opposite side. There are also stipes with bithecae situated alternately, like in *Dendrograptus*.

The fusellar structure of the distal part of autothecae is another unstabilized character. The ventral wall of this part is usually devoid of a zigzag line in the middle. Oblique sutures of this part are mostly irregularly scattered. The structure of the metasicula and the situation of the pore deserve particular attention. In *Dendrograptus*, the metasicula in the lower part consists of irregularly disposed fuselli which are different in length. However, with the increase in the dimensions of the metasicula, the disposition of the fuselli gradually becomes more regular and two zigzag lines, situated opposite each other, are formed. On the other hand, in *Graptolodendrum* the fuselli are arranged irregularly over the entire length of the metasicula and, following this fact, the zigzag lines are not formed.

As concerns the situation of the pore, it pierces the wall of the prosicula in all the investigated Dendroidea, while in *Graptolodendrum* it is situated on the wall of the metasicula.

Some of the characters cited which distinguish *Graptolodendrum* from the typical Dendroidea may be considered primitive, some others — progressive. The unstabilized position of bithecae and the variable fusellar structure of bithecae should be considered rather primitive characters. The structure of the metasicula with irregularly arranged fuselli and the lack of the zigzag lines related with it, may undoubtedly be considered primitive characters. In this respect, the metasicula of *Graptolodendrum* is similar to the metasicula of *Dendrotubus erraticus* Kozł. (Kozłowski, 1963), the latter form being one of the most primitive representatives of graptolites.

The position of the pore on the metasicula is a rather surprising phenomenon. In this respect, *Graptolodendrum* is a long way in advance

of all Dendroidea whose sicula has been investigated. Such a position of the pore has so far been found only in the Graptoloidea, but even in this group, in more primitive forms, the pore is usually situated on the prosicula. The occurrence of this progressive character together with others, pronouncedly primitive ones, makes up an evidence of a certain independence of particular elements in the evolutionary process of Dendroidea.

The genus *Graptolodendrum*, like the genus *Calyxdendrum*, described formerly (Kozłowski, 1960), prove that, within the Dendroidea, there were different ways of evolution and a different rate of transformations of particular characters.

*Note.*— Among the Dendroidea, described so far, *Dendrograptus? balticus* Wiman, a species, described by Wiman from the Ordovician boulders of Sweden (Wiman, 1895), seems to be most similar to *Graptolodendrum mutabile* n.sp. Unfortunately, its characteristics and illustrations, presented by this author, are so superficial that they cannot be used as a basis for an accurate comparison between it and our form. Concluding from Wiman's rather sketchy illustrations (*l.c.*, Pl. 10, Figs. 10 and 11) of *Dendrograptus? balticus*, this species, like *Graptolodendrum mutabile* n.sp., is marked by conical autothecae without a distinct ventral process and with bithecae open in the autothecae. However, to compare both forms in any more accurate manner, the material, presented by Wiman, should be revised.

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GRAPTOLODENDRUM MUTABILE N.GEN., N.SP. — ABERRANTNY  
GRAPTOLIT DENDROIDOWY*Streszczenie*

Graptolit opisany pod nazwą *Graptolodendrum mutabile* n.gen., n.sp. wypreparowany został ze środkowo-ordowickich wapiennych głązów narzutowych wybrzeży Bałtyku i Polski środkowej. Jest on aberrantnym przedstawicielem rzędu Dendroidea. Różni się od typowych rodzajów tego rzędu tym, że biteki położone są na jego gałązkach nie naprzemianlegle z prawej i lewej strony, lecz przeważnie z jednej tylko strony, i to na jednych gałązkach z prawej, na innych z lewej, w obrębie tego samego rabdozomu. Zdarzają się też gałązki o naprzemianległym układzie bitek. Autoteki pozbawione są jęczyczkowatego wyrostka wentralnego i wargi dorsalnej. Biteki otwierają się do wnętrza autotek. Struktura fuzellarna distalnej części autotek jest przeważnie nieregularna, bez uformowanego środkowego szwu zygzakowatego. Prosikula odznacza się silnie zaakcentowaną linią helikoidalną w postaci żeberka. Metasikula ma niezwykle prymitywną strukturę fuzellarną, gdyż na całej rozciągłości fuzellusy ułożone są nieregularnie, nie tworząc szwów zygzakowatych. Zupełnie wyjątkowe jest położenie porusa: przebija on nie ścianę prosikuli, jak to jest regułą u Dendroidea, lecz ścianę metasikuli — jak u większości Graptoloidea. Nieustabilizowane położenie bitek, zmienną, przeważnie nieregularną strukturę fuzellarną autotek, a szczególnie nieregularną strukturę metasikuli — należy uważać za cechy prymitywne opisanego graptolita. Położenie porusa na metasikuli, tak jak u Graptoloidea, jest raczej cechą progresywną.

Rodzaj *Graptolodendrum*, monotypowy, uwidacznia, że w obrębie Dendroidea różne były drogi ewolucji i zmienne tempo przemian poszczególnych cech.

РОМАН КОЗЛОВСКИ

GRAPTOLODENDRUM MUTABILE N. GEN., N. SP. — АБЕРРАНТНЫЙ  
ДЕНДРОИДНЫЙ ГРАПТОЛИТ*Резюме*

Граптолит описанный под названием *Graptolodendrum mutabile* n. gen., n. sp. был выпрепарирован из среднеордовикских известковых эрратических валунов побережья Балтийского моря и центральной Польши. Этот aberrantный представитель ряда Dendroidea отличается от типичных родов этого ряда тем, что

битеки расположены на его ветвях не попеременно с правой и левой стороны, при чем на одних ветвях с правой, на иных с левой, в пределах этой самой рабдосомы. Бывают тоже ветви с попеременной системой битек. Автотеки лишены языкообразного вентрального выроста и дорсальной губы. Битеки открываются во внутрь автотек. Фюзеллярная структура дистальной части автотек преимущественно нерегулярная, без сформированного центрального зигзагообразного шва. Просикула отличается сильно отмеченной геликоидной линией в виде ребрышка. Метасикула имеет очень примитивную фюзеллярную структуру, так как на целом протяжении фюзеллюсы расположены нерегулярно, не образуют зигзагообразных швов. Совсем исключительное положение поруса: пробивает он не стенку просикулы, что как правило имеется у *Dendroidea*, а стенку метасикулы, как у большинства *Graptoloidea*.

Неустойчивое положение битек, изменчивую, преимущественно нерегулярную фюзеллярную структуру автотек, а особенно нерегулярную структуру метасикулы следует считать как примитивные признаки описанного граптолита. Положение поруса на метасикуле, так как у *Graptoloidea*, это признак более прогрессивный.

Род *Graptolodendrum*, монотиповый, указывает, что в пределах *Dendroidea* имели место различные пути эволюции и изменчивый темп перемен отдельных признаков.

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