

LUNDS UNIVERSITETS ÅRSSKRIFT. Band 40. Afdeln. 2. N:r 2.
KONGL. FYSIOGRAFISKA SÄLLSKAPETS HANDLINGAR. Band 15. N:r 2.

RESEARCHES
INTO THE
GRAPTOLITES OF THE LOWER ZONES OF THE SCANIAN
AND
VESTROGOTHIAN PHYLLO-TETRAGRAPTUS BEDS

BY
SV. LEONH. TÖRNQUIST

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LUND 1904
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INTRODUCTION.

The preparation of the second part of this memoir has required more time than I supposed when the first part of it was published¹⁾. The chief cause of this delay has been that, as the researches were carried on, it again and again appeared desirable to obtain more perfect materials than I had at my disposal, for the treating of those multiramose *Dichograptids* which are so characteristic of the lower zones of the *Ordovician* system. My endeavours to that end, though not quite fruitless, have, however, upon the whole fallen short of my expectations; and the description of several problematic forms must be reserved for the future. Nor are my observations on the graptolites dealt with in the following pages so comprehensive as I should have wished. Nevertheless, I hope they will, at any rate, afford some new contributions to the knowledge of our earlier graptolite fauna.

To the stratigraphical statements given in Part I, but little is to be added. My supposition that the greenish shales immediately underlying the orthoceras limestone at Flagabro might represent the *zone of Isograptus gibberulus*, has proved correct; fossils characterizing that zone having been found there by me in the summer 1902. In this locality the geological series is, accordingly, complete from the *zone of Tetragraptus phyllograptoides* up to the top of the *zone of Isograptus gibberulus*. Several portions of the exposure are, however, rather difficult of access.

To Professor J. C. MOBERG my best thanks are due for his permitting me to describe and delineate several graptolites collected by him, and now kept in the Geological Museum at Lund. All other descriptions and figures are drawn up from specimens in my private collection.

Genus *Bryograptus* LAPWORTH.

Bryograptus simplex n. sp.

Plate I, figures 1—4.

The sicula has a length of 3 mm., being apically provided with a nema of unknown extent. Its apertural edge is concave, and so obliquely placed with respect to the adjacent free portion of the sicular wall that a pointed triangle projects be-

¹⁾ Acta Univ. Lundensis, Bd. 37; Afdeln. 2, Kongl. Fysiogr. Sällskapets Handlingar, Bd. 12. 1901.

tween the two thecæ first formed. The earliest theca originates near the apex of the sicula, and gives off two stipes in much the same manner as seen in the *Didymograpti* of the Murchisoni-type. While the primordial stipe remains undivided, the first theca on the opposite side of the sicula (th. 1²) produces two stipes, one of which is usually directed more outwards than the theca from which it originates. None of the stipes seems to have exceeded 10 mm. in length, and they have all a uniform width of about 1 mm.

The thecæ number eight in the space of 10 mm. When fully developed, they are free for half their length, making an average angle of 40° with the dorsal margin of the stipe. The ventral walls of the oldest thecæ are slightly concave, but they soon become quite straight.

As already mentioned, it is, as a rule, only the complemental stipe that is ramifying, but in one specimen I think I have also observed traces of division from the first theca of the primordial stipe. On the other hand, examples with only two stipes developed occur not rarely associated with specimens of the typical form, and agreeing with them in the structure of the thecæ as well as in the easily recognizable shape of the sicula. Such specimens have, then, remained on the *Didymograptus* stage, and might even be mistaken for *Didymograpti* of the Murchisoni-type. True species of that group make their first appearance, as far as hitherto known, higher up in the series.

Bryograptus simplex resembles *Bryogr. Kjerulfi* LAPW. in the direction of the stipes of the first order, but is distinguished from this species, as well as from all other congeners, by its big sicula and simple ramification.

Horizon and locality. The species has only been found at Mossebo, where it occurs in the zone of *Tetragraptus phyllograptoides*.

Genus *Trichograptus* NICHOLSON.

Trichograptus crinitus MÖBERG MSER.

Plate I, figures 5—7.

In the Geological Museum at Lund there are two slabs, part and counterpart, the surfaces of which are so crowded with specimens of a *Trichograptus* that it is difficult to make out which branches belong to one and the same rhabdosome. In all the examples the sicula is too obscure to admit of any description, but its place is easily observable. From this point the two main stipes are bent backwards in such a way as if they were going to run parallel to each other, but, owing to their slenderness, their directions may oscillate between the limits shown in the figures 5 and 6. They attain a length of at least 50 mm., and each of them emits on its convex side three or four branches, which seem to have reached about 40 mm. in extent. The first branch on each side is given off at a distance of one millimeter from the sicula, and the following branches grow out at intervals of the same size, corresponding with the space occupied by one theca. While the earliest

branches are at right angles to the stipes, the succeeding ones make more and more acute angles with them.

Ten thecae can be counted in 10 mm.; they are inclined at angles of from 20° to 25° , and overlap two fifths of their length. In well preserved specimens their outer walls are perceptibly concave, and their apertures stand nearly normal to the general direction of the stipes.

This species is closely allied to *Trichograptus fragilis* NICH., from which it is distinguished mainly by greater size and by some slight differences in the form and overlap of the thecae. I have also been doubtful whether it should be regarded as a distinct species, or not. Only two examples of *Trichograptus fragilis* are known¹⁾. They are very small, but the possibility is not precluded that they represent young individuals, which, in mature state, might have acquired the same size as *Trichogr. crinitus*. And the differences shown in the thecae could, perhaps, be explained as due to different modes of preservation. None of these presumptions having, however, as yet, been supported by evidence, the fact that the two forms occur on such different horizons, renders their separation, at present, most advisable. It may be that *Trichograptus fragilis* will some day prove a dwarfed mutation of *Trichograptus crinitus*.

Horizon and locality. The two slabs recorded in the above were found, some years ago, by Professor MOBERG in the zone of *Didymograptus balticus* at Mossebo.

Genus *Tetraraptus* SALTER.

Tetraraptus pendens G. ELLES.

1898. *Tetraraptus pendens* G. ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 491, f. 13.
 1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 63, f. 38, Pl. VI, f. 3 a—d.

The type-species has not been observed in Sweden, but the following graptolite may be regarded as a variety of the same.

Tetraraptus pendens var. *præsagus* n. var.

Plate I, figures 8—10.

The sicula has a length of from 2,5 to 3 mm., and proceeds apically in a very delicate nema, at least 2 mm. long. At a distance of 0,3 mm. from its apex the first theca originates, and the two stipes of the first order grow out in such directions as to form, if developed, a *Didymograptus* of the Murchisoni-type. But, after the production of one theca, each stipe divides, in consequence of which two pairs of main stipes are formed. Each of these pairs reminds us again of a tuning-fork *Didymograptus*, the stipes of which show a tendency to converge distally. In my most perfect specimens they reach a length of about 18 mm. with a nearly uniform width of 0,5 mm.

¹⁾ ELLES and WOOD, Monograph of British Graptolites, Part I, p. 92.

The thecæ, which number from eight to ten in 10 mm., are five or six times as long as broad, and free for more than half their length. They are inclined at angles of from 15° to 20°, showing a marked concave curvature of their ventral walls, and the straight apertures seem to be more or less normal to the general direction of the thecæ.

From the type species this variety differs in the following points: the sicula is considerably longer, the thecæ are longer proportionally to their width, and their outer walls are more curved.

Horizon and locality. This variety occurs sparingly in the *zone of Phyllograptus densus* at Flagabro. It is, accordingly, somewhat older than the typical form, of which it may be considered as a forerunner.

Tetragraptus approximatus NICHOLSON.

Plate I, figures 11, 12.

1873. *Tetragraptus approximatus* NICHOLSON, On some fossils of the Quebec group of Point Lévis; Ann. Mag. Nat. Hist., Ser. 4, Vol. XI; p. 136, f. 2.
1885. » » HERMANN, Die Graptolithenfamilie Dichograptidæ, Lapw.; p. 75, f. 8.

Owing to the mode of embedding the sicula is obscure. The stipes of the first order form together a straight funicle, the length of which varies from 2,5 to 3,5 mm. Each of these stipes produces by dichotomy two main stipes, which, a short distance from the point of division, diverge at an angle of 180°. NICHOLSON¹⁾ has appropriately compared the general appearance of the rhabdosome with »two examples of *Didymograptus* (*Graptolithus*) *patulus* Hall united back to back by their radicles». From an initial diameter of 0,6 or 0,7 mm. the stipes expand within the first centimeter to a width of 1,5 mm. In the most perfect specimens that have come under my notice, they have a length of more than 30 mm., and the distance between two parallel stipes scarcely ever exceeds 10 mm.

The thecæ number ten in 10 mm.; their outer walls are slightly concave, inclined at 40°, and, in the mature portion of the stipes, free for a small fraction of their length. The apertural angle varies according to the effect of pressure, but is usually more or less obtuse.

One specimen in my collection, in all other details agreeing with the above description, is provided with a narrow but well defined disc, enclosing the funicle, and prolonged up the stipes for a short distance. The resemblance between this specimen and the figure given by HERMANN is complete.

Horizon and locality. The specimen delineated has been found by Professor MOBERG in the *zone of Tetragraptus phyllograptoides* at Mossebo; other specimens, though less perfect, have been collected by myself on the same horizon.

¹⁾ Op. cit. *suprà*.

The example provided with a disc was found by me at Mossebo, at a time when the zones of that locality were not yet made out.

Tetraraptus vestrogothus n. sp.

Plate I, figures 13, 14.

The stipes of the first order present the same size and direction as those of the preceding species. From each of them two main stipes spring out, which, likewise, proceed in opposite directions from their point of bifurcation. These are, however, not rectilinear, but curve outwards in such a manner that, on each side of the funicle, two stipes belonging to different primary halves of the rhabdosome, if sufficiently protracted, would cross each other at a certain distance from the sicula, thus confining an ovato-lanceolate area. They have an extent of 120 mm., or more. A square central disc, each side of which measures from 7 to 9 mm., encloses the initial parts of the graptolite.

There are nine thecæ in the space of 10 mm., but, owing to the mode of the embedding of the fossil, their true form cannot be ascertained. For the same reason I am unable to state the width of the stipes, but the dorsal side, when faintly compressed, has a width of about one millimeter throughout.

The species has several characters in common with *Tetraraptus approximatus* NICH., but is readily distinguished from it by the form of the main stipes, and by the possession of a well developed square disc.

Horizon and locality. Only a few specimens of *Tetraraptus vestrogothus* are in my collection, all seen on the same large slab produced from the zone of *Tetraraptus phyllograptoides* at Mossebo.

Tetraraptus quadribrachiatus HALL.

Plate I, figures 15, 16.

1858. *Graptolithus quadribrachiatu*s HALL, Geol. Survey of Canada, Rep. for 1847; p. 125.
1863. *Tetraraptus crucialis* SALTER, (On the Skiddaw Slate Series by R. HARKNESS with) Notes on the Graptolites by J. W. SALTER; Quart. Journ. Geol. Soc., Vol. XIX; p. 137; f. 8 b.
1865. *Graptolithus quadribrachiatu*s HALL, Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. II; p. 91, Pl. V, f. 1—5, Pl. VI, f. 5, 6.
1868. *Tetraraptus* » NICHOLSON, Graptol. of the Skiddaw Series; Quart. Journ. Geol. Soc., Vol. XXIV; p. 131.
1872. » (*Graptolithus*) *quadribrachiatu*s NICHOLSON, Monograph of the British Graptolites, p. 63, f. 32.
1875. » *quadribrachiatu*s HOPKINSON and LAPWORTH, Graptol. of the Arenig and Llandeilo Rocks of St. David's; Quart.

Journ. Geol. Soc., Vol. XXXI; p. 649, Pl. XXXIII, f. 9.

1898. *Tetraraptus quadribrachiatus* G. ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 485.
 1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 57, Pl. V, f. 1 a—d.

Though the structure of the initial parts of my specimens are commonly rather obscure, I think that, in one specimen, I have observed the fact indicated by ELLES and WOOD that each stipe of the first order produces two thecæ before dividing. Nevertheless, the funicle attains only 2 or 3 mm. in length. The rigid main stipes spread out in one plane, diverging at approximately right angles. They average 50 mm. in length, and increase in width from 0.4 mm. at their origin to a little more than one mm. in the distal portion.

The thecæ number ten in 10 mm.; their ventral walls are slightly curved, being inclined at about 30°, and free for two-fifths or half their length. The apertural margins seem, in most instances, to be normal to the thecal walls.

From *Tetraraptus serra* BRONGN., to which this species bears a decided resemblance, it is distinguished by narrower stipes, and smaller overlap of the thecæ. The examples from Victoria by R. ETHERIDGE jun.¹⁾ referred to *Tetraraptus quadribrachiatus* are, judging from the figures given, scarcely available for an exact determination.

Horizon and localities. In a paper published in 1875²⁾ I recorded *Tetraraptus quadribrachiatus?* HALL as occurring at Flagabro, and, some years later, I collected at Mossebo some *Tetrarapti*, which were by me referred to the same species. As the preservation of these examples left much to be desired, I was for a long time uncertain of the correctness of my determination. Of later years I have, however, at both the said localities come across specimens which, to my opinion, leave no doubt of their identity with *Tetraraptus quadribrachiatus*. They were found in the zone of *Didymograptus balticus*.

Tetraraptus serra (BRONGNIART) HALL.

Plate I, figures 17—21.

1828. *Fucoides serra* AD. BRONGNIART, Histoire des Végétaux fossiles, p. 71; Pl. 17, f. 7, 8.
 1865. *Graptolithus bryonoides* HALL ex p., Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. II; p. 84, Pl. IV, f. 9, 10.
 1867. » » HALL, Introduction to the study of the Graptolitidæ;

¹⁾ Observations on a few Graptolites from the Lower Silurian Rocks of Victoria, Australia; Ann. Mag. Nat. Hist. 4 Ser. Vol. XIV; p. 3, Pl. III, figs 5—8.

²⁾ Berättelse om en geologisk resa i Skånes silurtrakter år 1874; Öfvers. K. Vet.-Ak. Förhandl. 1875; p. 47.

- Twentieth Ann. Rep. of the Regents of the Univ. of
the State of New-York; Pl. 3, f. 16, 17.
1872. *Tetragraptus bryonoides* NICHOLSON ex p., Monograph of the British Graptolites; p. 105, f. 47 A.
1875. » *serra* HOPKINSON and LAPWORTH, Graptol. of the Arenig and Llandeilo Rocks of St. David's; Quart. Journ. Geol. Soc., Vol. XXXI; p. 650, Pl. XXXIII, f. 10.
1898. » » G. ELLES ex p., The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 490.
1902. » *Amii* (LAPW. mscr.) ELLES and WOOD, Monograph of British Graptolites; Part I, p. 61, Pl. V, f. 4 a—c.

From a pointed sicula, which is, however, generally concealed in the rock, the two stipes of the first order grow out in opposite directions, each being formed by one single theca. The four main stipes have a length of at least 50 mm., and include, as a rule, right angles. From an initial breadth of 0,4 mm. they suddenly expand to a width of 2 mm., which width, in the majority of our specimens, remains constant throughout the stipes. These extend all in the same plane, and the thecæ must, before their embedding, have been placed vertically to this plane. According to different directions of the lateral pressure with respect to the fossil, this has assumed different aspects. If the pressure has acted parallel to two of the main stipes, these stipes present to the observer either only the dorsal margin, or the apertures of the thecæ, while the thecæ of the two other stipes are displayed in profile; if again a similar force has acted in a direction bisecting two vertical angles formed by the main stipes, all the four thecal rows are seen in profile, turning their apertures to the same side.

The thecæ number from nine to eleven in 10 mm., and have an inclination of from 30° to 40°. Their concave ventral walls are free for, at most, two fifths their length, and, together with the apertural margins, they include acute denticles.

As regards the specific name of this *Tetragraptus*, a short discussion may here be needed, so much the more as my opinion does not agree with that advocated by such keen paleontologists as the Misses ELLES and WOOD. As far back as in 1828 BRONGNIART¹⁾ described and figured a fossil from Point Lévis under the name *Fucoïdes serra*, considering it to be an alga; and in the year 1865 JAMES HALL¹⁾ identified a Canadian graptolite, earlier called by him *Graptolithus bryonoides*, with BRONGNIART's species, and proposed that BRONGNIART's specific name should henceforth be applied to it. From that time *Tetragraptus serra* has often been recorded in the geological literature. The forms by HALL comprised under that head were later separated by LAPWORTH into two species, which in the year 1902 were described and illustrated by ELLES and WOOD¹⁾. For the one of these species which has all the four main stipes developed in one plane, the name *Tetragraptus Amii*

¹⁾ Op. cit. suprâ.

LAPW. was proposed, while *Tetragraptus serra* was characterized as having the main stipes bent backwards from the sicula. There appears to have been sufficient reason for this separation, but some doubt may be entertained as to which of the two species should justly retain the title *Tetragraptus serra* BRONGN. The species by ELLES and WOOD designated as *Tetragraptus Amii* was in the cited work by HALL represented on Pl. IV, figs. 9 and 10 (and Pl. V, fig. 4); and this author himself states expressly that it was just the specimens illustrated in these two figures that induced him to identify his *Graptolithus bryonoides* with *Furoides serra*¹⁾. To those specimens, accordingly, was the specific name *Graptolithus serra*, in the first place, assigned by him. BRONGNIART'S delineations are very indifferent, but, also in my opinion, they agree better with HALL'S figs. 9 and 10 of Pl. IV than with any other illustration of *Tetragraptus bryonoides* given by this author. Such being the case, I find it most consistent with an exact nomenclature to retain the name *Tetragraptus serra* BRONGN. for the species by ELLES and WOOD described as *Tetragraptus Amii* LAPW.

In an earlier paper of mine²⁾ a graptolite from Dalarne has been described and figured under the name *Tetragraptus serra* BRONGN. The specimens in my possession of this graptolite are too imperfect for an accurate determination; but they can hardly be referred to the species in question, as now defined.

Horizon and locality. Examples of *Tetragraptus serra* occur in great abundance in the zone of *Tetragraptus phyllograptoides* at Mossebo. It is possible that the species ranges up in the next zone, too.

Tetragraptus phyllograptoides LINNARSSON msr.

Plate I, figures 22—25; Plate II, figures 1—8.

1901. *Tetragraptus phyllograptoides* STRANDMARK, Undre Graptolitskiffer vid Fågel-sång; Geol. Fören. i Stockh. Förhandl., Bd 23; p. 552, Tafl. 17, f. 4—6.

The sicula has a length of 2 mm., and emits from its apex a short virgular nema. The stipes of the first order agree perfectly with those of *Tetragraptus Bigsbyi*, as illustrated by HOLM³⁾. All the four main stipes are bent backwards from the sicula, and those of them which belong to the same primary half, are dorsally united for a distance of from 3 to 6 mm., before separating to form a typical *Tetragraptus*. If the rhabdosome has been embedded in such a position as to display the two primary halves symmetrically placed on the both sides of the sicula

¹⁾ HALL'S words run thus: »I have little doubt that this species» (*Graptolites bryonoides* Hall) »is identical with *Furoides serra* of Brongniart (Vég. Fossiles p. 70, 1828). The locality of that species is »*Pointe Levi près Quebec*», which is the same with that of *G. bryonoides*: and the figures of Brongniart correspond with figs. 9 and 10 of plate 4 of this memoir.»

²⁾ Undersökningar öfver Siljansområdets Graptoliter; Acta Univ. Lundensis T. XXXIII (K. Fysiogr. Sällsk. i Lund Handl. XIII) p. 13, Tafl. I, figs. 3 and 4.

³⁾ Om *Didymograptus*, *Tetragraptus* och *Phyllograptus*; Geol. Fören. i Stockh. Förhandl., Bd 17, 1895; p. 331, Tafl. 11, figs. 1—3, 7—9.

(Pl. I, fig. 24), the dorsal walls of the two duplicate pairs run parallel or almost parallel to each other as far as their bifurcation, leaving between them a space measuring 1 or 2 mm. in breadth. From the points of division the four stipes generally diverge from one another, being either straight or gently curved outwards. The short stipes of the first order have a width of 1,5 mm., but the main stipes acquire as early as at the third or fourth theca a diameter of 2,5 mm., and then expand slowly to a maximum width of 3 mm. In fullgrown specimens the stipes may have reached a length of 30 mm., or somewhat more.

In the proximal region of the rhabdosome the thecæ number thirteen in the space of 10 mm., but distally there are only ten or eleven in the same length. The earlier thecæ are shorter than the following ones, and, owing to the sharp bending of the stipes, they make higher angles with the dorsal margins. In mature condition the thecæ are five times as long as wide, and curved so as to make the angle of inclination increase from 30° near the inner orifices to 70° in the apertural portion. At the distal extremity of the stipes the thecæ are again shorter and almost straight. A fine transverse striation parallel to the apertural edges is generally observable.

In a great number of specimens the thecæ show the aspect represented on Pl. II, fig. 7. They appear then free for a small fraction of their length; and the oblique apertural margins form with the ventral walls prominent denticles. In that way, too, they are described by STRANDMARK. After repeated examination of more than hundred examples, I have, however, satisfied myself that this appearance is deceptive. Specimens similar to that delineated on Pl. II, fig. 5 are by no means rare. The thecæ are there in contact throughout their entire length, and the apertures are, disregarding their slight concave curvature, parallel to the ventral margin of the stipes. Most obvious is this appearance in impressions of specimens more or less preserved in relief. Such imprints render, according to my experience, the most adequate copy of the stipes with their thecæ. But if the fossil has been subjected to a strong pressure acting obliquely with respect to the surface of the graptolite, apparent denticles may easily be effected, as shown in the thecæ marked with asterisks (*) in fig. 8 of Pl. II.

Horizon and localities. This species was first detected at Mossebo by LINNARSSON, who designed it by the museum name *Tetragraptus phyllograptoides*. At Mossebo the species occurs in great profusion; poor examples are met with at Westerby, and good specimens are not rare at Flagabro. Everywhere it is characteristic of the zone to which its name has been given.

Genus *Phyllograptus* HALL.

Phyllograptus densus TÖRNQUIST.

Plate II, figures 9—12.

1879. *Phyllograptus densus* TÖRNQUIST, Iakttagelser öfver Dalarnes graptolitskiffrar; Geol. Fören. i Stockh. Förhandl., Bd 4; p. 447.

1890. *Phyllograptus densus* TÖRNQUIST, Undersökn. öfv. Siljansomr. Graptol. I; Acta Univ. Lundensis, T. XXXVIII, (K. Fysiogr. Sällsk. i Lund Handl. XIII.); p. 19, Tafl. I, f. 15—17.

Most frequently the specimens occur embedded so as to expose to view only two of the four rows of thecæ. The rhabdosome has then an ovate or elongato-ovate form, being, however, in some cases, dilatated a little either near the initial end, or toward the distal extremity. Usually the examples have a length of from 20 to 30 mm., though individuals measuring as much as 50 mm. in extent are not very rare. Their breadth varies between 4 and 8 mm., but is commonly about 5 mm. Specimens converted into pyrites are sometimes found at Flagabro, showing the four thecal series in their original position, making right angles with each other.

The thecæ number from ten to sixteen in the length of 10 mm. Where the rhabdosome has acquired its full width, they are three or four times as long as wide; near their origin they are inclined at about 40°, but, owing to their peculiar curve, their outer third is approximately perpendicular to the axis. Though the earliest thecæ are shorter, their curvature is similar to that of the mature thecæ, but toward the distal end of the rhabdosome the thecæ become gradually less curved, and at last almost straight. A fine transverse striation is often observable.

The inner structure of *Phyllograptus* has been most minutely described by HOLM in his paper »Om Didymograptus, Tetragraptus och *Phyllograptus*»; (Geol. Fören. i Stockh. Förhandl., Bd 17, 1895).

In general habit this graptolite approaches very much to *Phyllograptus angustifolius* HALL, and in a report on geological investigations in Skåne, I have in the year 1875 recorded it under that title¹⁾. But already in the following year I spoke of it as a new species²⁾, though it was not described and denominated until 1879. TULLBERG seems to have been disposed to identify the both forms, for, having in an earlier paper³⁾ mentioned *Phyllograptus densus* TÖRNQ. as common in the lower graptolite shales of Skåne, he quotes, in his last publication⁴⁾, *Phyllograptus angustifolius* HALL as a characteristic fossil of the same beds. And HOLM regards *Phyllograptus densus* as a mutation or variety of *Phyllograptus angustifolius*⁵⁾. With a view of being able to contribute to the solution of this question, I have collected and examined a great number of specimens of *Phyllograptus densus*. In the papers cited in the list of synonyms I have separated *Phyllograptus densus* from *Phyllograptus angustifolius* HALL on account of the following characters:

1. the number of thecæ to a given unit of length is greater,

¹⁾ Berättelse om en geologisk resa i Skånes silurtrakter år 1874; Öfvers. K. Vet.-Akad. Förhandl. 1875; p. 47.

²⁾ Nyblottad geologisk profil med *Phyllograptus*skiffer i Dalarne; Geol. Fören. i Stockh. Förhandl., Bd 3; 1876; p. 244.

³⁾ Några *Didymograptus*arter i undre graptolitsk. vid Kiviks-Esperöd; Geol. Fören. i Stockh. Förhandl., Bd V, 1880; p. 41.

⁴⁾ Skånes Graptoliter, I; Sveriges Geol. Undersökn., Ser. C, N:o 50; p. 28.

⁵⁾ Op. cit. suprâ, p. 345.

2. the thecæ are in contact throughout their entire length, and their apertural margins are parallel to the general outlines of the rhabdosome.

HALL¹⁾ describes *Phyllograptus angustifolius* as having from nine to eleven thecæ in 10 mm. (twenty-six to twenty-eight to the inch), whereas in the specimens of *Phyllograptus densus* known to me in 1879 fourteen to sixteen thecæ could be counted in the same extent. According to ELLES and WOOD²⁾ English examples of the former species have from eleven to thirteen thecæ in 10 mm.; the specimens from Öland described by HOLM³⁾ agree in this respect precisely with the English ones. As indicated in the above, it results from my later investigations that in *Phyllograptus densus* the number of thecæ to a given unit varies between unusually wide limits. To convey an idea of this variation, I give in the following table an account of measurements made on twenty fullgrown specimens from each of the three richest localities known.

Number of thecæ in 10 mm.	Number of specimens from		
	Skattungbyn	Flagabro	Jerrestad
10	0	0	5
11	1	2	7
12	2	3	3
13	2	3	5
14	8	5	0
15	6	7	0
16	1	0	0
	20	20	20

From these facts it may be inferred that the great number of thecæ in a given longitudinal extent, observed in the specimens at first observed by me, furnishes, in reality, no character of specific value.

On the other hand, I have satisfied myself that my original statement concerning the structure of the thecæ holds good. It is true, as HOLM has remarked, that specimens in this respect resembling those of *Phyllograptus angustifolius* occur in Dalarn; they are associated with such as exhibit the structure described above, but it can scarcely be presumed that examples of one and the same species have originally varied in a character as this, so much the less as thecæ of both forms are often seen in the same specimen (as shown on Pl. II, figs. 11, 12). The serrated appearance, moreover, just as in the preceding species, has constantly proved to be accidental, due to the mode and amount of compression.

¹⁾ Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. II; p. 125.

²⁾ Monograph of British Graptolites, Part I; p. 100.

³⁾ Op. cit. p. 345.

As all authors who have dealt with *Phyllograptus angustifolius*, describe it as having the thecæ free for a fraction of their length, and »the apertural margins concave, with conspicuous denticles», I should not have been justified in uniting *Phyllograptus densus* with that species.

It may, however, be questioned whether the denticulated margins of the specimens from which the descriptions and illustrations of *Phyllograptus angustifolius* have been drawn up, might not possibly be interpreted as due to a pressure like that which in *Tetragraptus phyllograptoides* LINNÆ. has often brought about a similar appearance. Only in such case the name *Phyllograptus densus* must be dropped as synonymous with the older name *Phyllograptus angustifolius*. I should not have presumed to suggest this supposition but for the fact that in all other species known of *Phyllograptus* the thecæ seem to be in contact throughout their entire extent.

Horizon and localities. Specimens of *Phyllograptus densus* occur in great profusion at Neckebo, Flagabro and Martorp, being everywhere restricted to the zone characterized by this species.

Phyllograptus cfr. *Anna* HALL.

Plate II, figure 13.

- Cfr. 1865. *Phyllograptus Anna* HALL, Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. 2; p. 124, Pl. XVI, f. 11—16.
 1898. » » ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc. Vol. LIV; p. 494, f. 16.
 1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 101, f. 60 a and b, Pl. XIII, f. a—f.

In compressed condition the graptolite has the form of an ovate leaf, measuring 3.5 to 4 mm. in breadth, and, as far as my specimens are concerned, not exceeding 8 mm. in length.

The thecæ number eight in the space of 5 mm.; they are three times as long as wide, and in contact throughout. The oldest thecæ stand nearly perpendicular to the median line of the graptolite; in the middle region of the rhabdosome they are slightly arcuate, having their outer third directed straight outwards; and toward the distal extremity of the rhabdosome they become less curved, being inclined at higher and higher angles. Their apertures are faintly concave, and parallel to the outlines of the fossil.

On account of my scanty collection of this species, and considering the low horizon on which my specimens have been found, I have thought most cautious only to point out their resemblance with *Phyllograptus Anna* HALL.

Horizon and locality. The examples on which the above description has been founded, were collected by me some twenty years ago at Mossebo, probably in the zone of *Didymograptus balticus*. The point where they were found is no more accessible, and no specimens have, of later years, been obtained from that locality.

Note on the multiramose genera of *Dichograptidæ*.

In limiting and defining the more compound genera and species of the *Dichograptids*, there arise greater difficulties than in dealing with any other tribe of graptolites, and when treating them one feels as moving upon quaking ground. Owing to the common mode of embedding of the specimens, the thecæ are often concealed in the rock; and even when they are visible, they show frequently so uniform a building in different species, and also in the genera, that characters afforded by these elements prove of but secondary importance. The classification of the genera has, then, been almost exclusively founded on the different manners in which the repeated division of the stipes is accomplished. But here appear new difficulties. As the different parts of the multiramose rhabdosome spread out over an extensive area, the specimens are usually obtained in a more or less fragmentary condition, and examples exhibiting the consecutive bifurcations in a satisfactory manner are but sparingly produced. The collections made under such circumstances contain, in many instances, too poor materials for the observer to decide on the constancy of the supposed specific differences, or on the value of the accepted generic characters. If to this is added that there seems to exist in some genera of this group a remarkable capacity of variation just in the mode of division, it is not to be wondered at that the classifications of these forms advanced by different authors present noticeable discrepancies; and the same circumstances may also account for the fact that, in the following pages, questions or subjective suggestions are often met with, where positive statements would have been desired.

The disposition of the *Dichograptids* employed by ELLES and WOOD in their last publication¹⁾, exhibits a beautiful series of genera as representative of different directions and stages in the development of the branching system. I should have been inclined to adopt this classification quite unaltered but for the objection that some forms which, in my opinion, are very closely allied, are, in that classification, too far removed from one another. For these reasons, which will be further explained in the sequel, I have been induced to make a few modifications of the generic arrangement advanced by these authors. In this memoir I employ the following disposition of the genera now under consideration, accentuating, however, that I regard the same as partly provisional.

- A. Stipes of the third and higher orders produced by dichotomous division, or, at least, not by regular lateral branching.
 - a. Stipes of the second order not markedly prolonged compared with the following internodes.

Dichograptus: central disc often present; stipes of the third order simple

¹⁾ Monograph of British Graptolites, Part I.

or dividing, but all divisions confined to the disc, or to a central region in size corresponding to the disc¹⁾.

Clonograptus: division carried on beyond the central region of the rhabdosome; internodes delicate, gradually increasing in length, and decreasing in dorsal thickness with the distance from the sicula.

[*Goniograptus*].

Temnograptus: division carried on beyond the central region of the rhabdosome; internodes stout, approximately of the same dorsal thickness throughout, and not regularly increasing in length toward the distal extremities.

b. Stipes of the second order much longer than the following internodes:

Anthograptus.

B. Stipes of the third or higher orders (branches) produced by regular lateral (monopodial) division.

a. lateral branches only given off from one side, simple or rebranching:

Schizograptus

b. lateral branches given off from both sides of the main stipes.

Holograptus.

With WIMAN²⁾ and RUEDEMANN³⁾ I agree in the opinion that there can be no fundamental difference between the dichotomous and the lateral or monopodial division of stipes in the Dichograptids. This view is supported by such facts as those illustrated on Pl. IV, fig. 2, and Pl. II, figs. 23 and 24. The specimen represented in the former figure shows one of the main stipes terminating in a dichotomy instead of emitting a lateral branch; and in the two other figured specimens no kind of division can be stated as prevalent. Nevertheless, it must be admitted that the mode of division proves, in most instances, constant enough to afford characters of generic importance. Very striking is the constancy and regularity of the peculiar manner of division displayed in *Goniograptus Thureaui* M'COY, as lately described by RUEDEMANN⁴⁾. As regards the genus *Temnograptus* the dichotomy seems not to be so decidedly realized as in *Clonograptus* and *Dichograptus*, for, even disregarding the irregular forms shown on Pl. II, fig. 23 and 24, it is sometimes difficult to ascertain whether the more distal divisions should be called dichotomous or lateral.

¹⁾ Compare: FRECH, *Lethæa Geognostica*, 1897; p. 594; and HERRMANN, *Die Graptolithen-familie Dichograptidæ* LAPW., 1885; p. 80.

²⁾ Über die Graptoliten; Bull. Geol. Instit. of Upsala, Vol. II, part 2, 1895; p. 34.

³⁾ Mode of growth and development of *Goniograptus Thureaui* M'COY; New-York State Museum, Bull. 52, Paleontology 6; p. 584.

⁴⁾ Op. cit. p. 577—580, fig. 1—11.

Genus *Dichograptus* SALTER.

Dichograptus octobrachiatus HALL.

Plate II, figure 14.

1858. *Graptolithus octobrachiatus* HALL, Geol. Survey of Canada, Rep. for 1857; p. 122.
1863. *Dichograptus aranea* SALTER, (On the Skiddaw Slate Series by R. HARKNESS with) Notes on the Graptolites by J. W. SALTER; Quart. Journ. Geol. Soc., Vol. XIX; p. 137, f. 9.
1863. » (sp.) SALTER, ibidem; p. 137, f. 9.
1865. *Graptolithus octobrachiatus* HALL, Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. II; p. 96; Pl. VII, f. 1—7; Pl. VIII, f. 1—4.
1868. » (*Loganograptus*) *octobrachiatus* HALL, Introduction to the Study of the Graptolitidæ; Twentieth Ann. Rep. of the Regents of the Univ. of the State of New-York, p. 174, f. 5; Pl. 3, f. 23—27.
1868. *Dichograptus octobrachiatus* NICHOLSON, Graptol. of the Skiddaw Series, Quart. Journ. Geol. Soc., Vol. XXIV; p. 129, Pl. V, f. 1.
1872. » (*Graptolithus*) *octobrachiatus* NICHOLSON, Monograph of the British Graptolites, p. 64, f. 33.
1885. *Dichograptus octobrachiatus* HERRMANN, Die Graptolithenfamilie Dichograptidæ, Lapw.; p. 41, f. 1; p. 80.
1890. » » TÖRNQUIST, Undersökn. öfv. Siljansomr. Graptol. I; Acta Univ. Lundensis XXXIII (K. Fysiogr. Sällsk. i Lund Handl. XIII); p. 12. Tafel. I, f. 1.
1898. » » ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 483.
1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 77, Pl. IX and X, f. 1 a—e.

Each stipe of the first order is from 1 to 1,5 mm. long, and those of the second order attain the same length, each of them consisting of one single theca. The stipes of the third order, or the main stipes, again, have an extent of several centimeters, and those of the same quadrant diverge from one another at angles of from 45° to 70°. When normally developed they are eight, but, owing to failure of dichotomy, their number may be reduced as much as to only five. They are generally straight, but sometimes slightly curved near their origin. In almost all specimens examined by me the dividing portion of the rhabdosome is enclosed in a central disc, which, however, is sometimes much reduced in size, particularly if the number of stipes is incomplete.

The thecæ number seven or eight in 10 mm., but they are in all my examples

too obscure to admit of a closer description. For the same reason I am unable to state the exact width of the stipes.

Horizon and localities. On a certain level of the *zone of Didymograptus balticus* at Mossebo individuals of this species are rather common. In the year 1875 I also collected several specimens in the neighbourhood of Neckebo, no doubt, on the same horizon.

Dichograptus octobrachiatus HALL var. Kjerulfi HERMANN.

Plate II, figures 15—18.

1883. *Loganograptus Kjerulfi* HERMANN, ex parte, Vorläuf. Mitteilung über eine neue Graptolithenart; Nyt Magazin for Naturvidenskab, Bd 27; p. 343, Taf. I, f. 1—11, Taf. II, f. 12—15.
1885. *Dichograptus Kjerulfi* HERMANN, Die Graptolithenfamilie Dichograptidæ, p. 83, f. 10 (p. 84).
1898. *Loganograptus Logani* ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 476.
1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 81, Pl. XI, f. 1 a—g.

This variety differs from the typical species in possessing stipes of four orders. In the majority of specimens from Mossebo it is only the inner or neighbouring tertiary stipes of each primary half that divides, while the outer stipes of the same half remain undivided. All the quadrants being developed alike, this kind of dichotomy will result in the formation of a rhabdosome with twelve main stipes. This number of stipes is by HERMANN¹⁾ stated as the typical one for the graptolite to which he has assigned the name *Dichograptus Kjerulfi*, and he points out, too, that the bifurcating stipes of the third order are, as a rule, those most remote from the primary bisecting axis. Such a specimen would, immediately after its last dividing, agree in appearance with *Goniograptus Thureaui* M'COY, when at the same early stage²⁾. From this stage the development of *Dichograptus* deviates from that observed in *Goniograptus*, for if another dichotomy takes place, it is the exterior stipes of the primary halves that bifurcate. Examples of this kind, which typically produce sixteen main stipes, occur also at Mossebo, though they are more rarely found. Judging from the specimen illustrated in fig. 18, the division seems to have been carried out in a manner of budding which reminds us very much of that seen in *Goniograptus*. A central disc is present in all specimens examined by me.

The thecæ are nine or ten in 10 mm.; they are gently curved, widening toward the apertures, and free for about half their length.

¹⁾ Die Graptolithenfamilie Dichograptidæ Lapw., p. 82, 83.

²⁾ RUEDEMANN, Mode of growth and development of *Goniograptus Thureaui* M'COY; New-York State Museum, Bull. 52, Paleontology 6; p. 578, f. 7.

The genus *Loganograptus* was originally created by J. HALL, in the year 1868¹⁾, to include such species of multiramose²⁾ Dichograptids as are provided with a »central corneous disc»; in consequence of which he referred to that genus not only *Dichograptus Logani* HALL, but also *Dichograptus octobrachiatus* HALL³⁾. NICHOLSON⁴⁾, considering the presence or absence of a central disc to be of minor importance, characterized the genus *Loganograptus* as »composed of more than eight simple monopronidian stipes (from 18 to 25)», whereas he adduced reasons for restricting the name *Dichograptus* to those species which have no more than eight main stipes⁴⁾. In the year 1898 G. ELLES⁵⁾ advanced the principle that »the number of stipes is not an important distinction, but rather the capacity in *Loganograptus* for greater dichotomy»; and proposed, consequently, as distinctive character between the genera *Dichograptus* and *Loganograptus* that in the latter »dichotomy never takes place less than three times», while in *Dichograptus* only two successive divisions occur. These definitions have, evidently, the merit of being founded on a more essential feature than that proposed by NICHOLSON, but opinions may, nevertheless, be at variance as to whether the character even thus expressed be of generic, or even of specific, value.

HALL defined the species *Graptolithus Logani* in the following terms: »the number of stipes in this species extends from eighteen to twenty-four»⁶⁾, and has, accordingly, restricted the title to such forms as have stipes of no less than five orders. The British form by ELLES and WOOD referred to this species is stated to have typically sixteen main stipes⁷⁾. These authors have then with HALL's species united forms with stipes of only four orders; and are, in my opinion, right in doing so. My studies amongst this group of graptolites have induced me to take a step further in the same direction. The graptolite described in the above must be referred to *Loganograptus Logani*, as this species is defined by the last-named authors; but on the other hand it is, no doubt, quite as nearly related to the typical *Dichograptus octobrachiatus*. In fact, this typical *Dichograptus octobrachiatus* seems more intimately allied to *Dichograptus Kjerulfi* than even to the species next to be described. I am, for these reasons, most disposed to regard all the forms here mentioned as belonging to one single species, which might be thus subdivided:

Dichograptus octobrachiatus HALL, forma typica, has stipes of only three orders.

var. *Kjerulfi* HERRMANN has stipes of four orders.

var. *Logani* HALL has stipes of more than four orders.

¹⁾ Introduction to the study of the Graptolitidæ; Twentieth Ann. Rep. of the Regents of the University of the State of New-York; p. 237.

²⁾ Op. cit. Explanation of Pl. 3, f. 23—27.

³⁾ Monograph of the British Graptolitidæ, p. 107, 110.

⁴⁾ The above distinction does not follow immediately from NICHOLSON's definition of *Dichograptus*, but it certainly does follow from his discussion on that genus.

⁵⁾ The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 476.

⁶⁾ Graptol. of the Quebec Group; Geol. Survey of Canada, Dec. II; p. 100.

⁷⁾ Monograph of British Graptolites, Part I, p. 81.

Be this, however, as it may, to separate them into different genera appears to me an unnatural dismemberment.

Horizon and locality. This graptolite is rather common at Mossebo, where it occurs in association with the typical species.

Dichograptus regularis n. sp.

Plate II, figure 19.

Each of the four stipes of the second order is formed by three thecæ. The main stipes of each quadrant diverge at angles of about 60°; they are stout and rigide, of uniform width, and attain a length of several centimeters. No central disc has been detected.

The thecæ average ten in 10 mm. Owing to their mode of embedding, but little can be said of their form; they seem to have straight margins, and be free about half their length.

From the preceding *Dichograpti* this species is readily distinguished by the structure of the stipes of the second order, which are markedly longer than the funicle.

Horizon and locality. Occurs sparingly in the zone of *Didymograptus balticus* at Mossebo.

Genus **Clonograptus** HALL.

Clonograptus subtilis n. sp.

Plate II, figures 20 and 21.

Of this little species I possess only one example fit for description. Each of the two stipes of the first order has a length of 2,2 mm., and a width of 0,4 mm. The stipes of the second order are 2,5 mm. long, those of the third order 4,5 mm., and those of the fourth order 10 mm. All these stipes are straight, forming at the points of dichotomy angles of about 80°, and gradually decreasing in breadth with the remoteness from the sicula. The stipes of the fifth order, seen from the dorsal side, are narrow as a hair, of unknown length, and have probably undergone no further division. In each pair the two stipes are, near their origin, gently bent outwards, and then approach each other, though not sufficiently to become parallel.

Only in these stipes are thecæ clearly shown, but they are also perceptible in the stipes of the fourth and third order. There are seven thecæ in 10 mm.; they are 1,5 mm. long, very narrow, and inclined at about 10°. Their outer walls are curved, and free five-sixths their length.

The species approaches closely to *Clonograptus tenellus* LINNÆ., indeed so close that I have been doubtful whether it might not be interpreted as a mutation of this. The stipes are, however, still more attenuated towards the distal region of the rhachosome, and the thecæ are longer in proportion to their width.

Horizon and locality. The specimen described was found at Flagabro, and is labelled as probably occurring in the *zone of Didymograptus balticus*. On account of its close relationship to so old a form as *Clonograptus tenellus*, some doubt may arise as to the correctness of this statement, but on the other hand, it ought to be noticed that fragmentary stipes of a similar type have been observed as high up as in the *zone of Phyllograptus densus*, though too imperfect to allow a positive determination.

Genus *Temnograptus* NICHOLSON.

If only the generic definitions of the genera *Clonograptus* and *Temnograptus* are compared, these genera would certainly be regarded as most intimately allied, and one might perhaps feel inclined to group them in one single genus. If, again, a series of *Clonograpti* are placed side by side with some specimens of *Temnograptus*, all the species of the former genus will prove to constitute a limited natural unit, well distinguished from the examples of *Temnograptus*, which then appear as belonging to a rather isolated type. Owing to our deficient knowledge of the genus *Temnograptus*, it is difficult to decide whether the resemblance between the two genera is to be explained as indicating real affinity, or only analogy in the development of the rhabdosome. However this be, it seems, at present, most advisable to treat them as separate genera.

Temnograptus multiplex NICHOLSON.

Plate III, figures 1—4.

1868. *Dichograptus multiplex* NICHOLSON, Graptol. of the Skiddaw Series; Quart. Journ. Geol. Soc., Vol. XXIV; p. 129, Pl. VI, f. 1—3.
 1876. *Temnograptus* » NICHOLSON, Notes on the correlation of the graptolite deposits of Sweden with those of Great Britain; Ann. Mag. Nat. Hist. Dec. 2, Vol. III; p. 248, Pl. IX, f. 1.
 1898. » » ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 477, f. 6.
 1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 86, f. 48, Pl. XII, f. 1.

The stipes of the first order have a total length of from 2 to 4 mm.; those of the second order are 15 to 20 mm. long, and the following internodes average about 25 mm., though some variation exists in this respect. They have a uniform width of 1 mm., or a little more. As to the angles enclosed between the stipes, no constant rule can be stated. It does not exceed 85°, and seems never to be less than 40°. In some cases the angles of divergence diminish with the distance from the sicula; often they remain unaltered through three or four consecutive divisions; and occasionally a more distal angle is greater than those placed more proximally.

This description has been drawn from specimens collected at Mossebo. There

can scarcely be any doubt that the example from Flagabro illustrated on Pl. III, f. 3, must be referred to the same species. In some stipes of this examples the thecæ are seen in profile, numbering ten or eleven in 10 mm. They are inclined at about 25°, widen slightly towards the apertures, and are free for two fifths or half their length. The apertural margins seem to make right angles with the ventral walls.

It should here be noted that a specimen from Mossebo, now preserved in the Geological Museum at Lund, has the internodes only half as long as those of the specimens delineated, with which it, otherwise, agrees in all particulars. Probably it is a form of this species.

Horizon and localities. The species is confined to the zone of *Didymograptus balticus*. Specimens have been collected by Professor MOBERG at Mossebo, and by myself at Flagabro.

Supplementary note.

Distal parts of rhabdosomes similar to that seen on Tal. III, f. 3, are not very rare at Flagabro, but initial parts quite resembling those found at Mossebo have not been met with there. But associated with the former specimens there occur some rather anomalous forms, for which the accepted classification seems to have no place. Examples of this kind are shown on Pl. II, figs. 22—24. The original of fig. 22 might well be explained as the initial region of *Temnograptus multiplex*, but the two other specimens deviate considerably from the typical appearance of this species. One and the same rhabdosome sometimes exhibits in its different quadrants all the modes of division else characteristic of different genera. Notwithstanding this odd variation in the manner of dividing, they are all so closely connected by intermediate links that they can hardly be referred to different species. Though some of the examples, in their general habit, point in the direction of *Temnograptus multiplex*, the present evidence is insufficient to justify their being united with this species, and I have in the explanation of the figures designated them as **Undetermined irregular Dichograptidæ**¹⁾.

Genus **Anthograptus** n. g.

Anthograptus nidus n. sp.

Plate IV, figures 4 and 5.

This species is known only from examples in a fragmentary condition. And though I am of opinion that determinations and descriptions of graptolites should, as a rule, not be founded on such imperfect specimens, I, nevertheless, believe the graptolite in question to offer sufficient interest to justify me in not following the principle in this case, so much the more as the species cannot be confounded with any other graptolite known.

¹⁾ Compare: HERRMANN, Vorläufige Mittheilung über eine neue Graptolitenart; Nyt Mag. for Naturvidenskab, Bd 27 (1883); Taf. II, figs. 17, 18 (by Herrmann referred to *Dichograptus? Milesi* HALL).

There can scarcely be any doubt that the figure 4 of Pl. IV presents a quadrant of a perfect specimen. This being granted, the stipes of the second order, instead of dividing near their origin, must have remained simple for an unusually great distance before ramifying. The stipe delineated has a length of 30 mm., and has, probably, been somewhat longer. Of the two stipes of the third order the one persists simple, while the other divides again. Also at each of the two succeeding bifurcations, which are separated by very short internodes, one stipe of each pair remains undivided: and both the stipes of the fourth division, as far as they are visible, continue simple. All the terminal stipes have a length of from 15 to 20 mm.

The thecæ number nine in 10 mm., and are inclined at 25° to 30°. Their ventral walls are curved, and free for one third of their length. The thecæ widen, accordingly, toward the apertures, which form angles of about 60° with the dorsal margins of the stipes.

How many of these features are to be regarded as characters of generic or specific bearing, it is impossible to say for the present.

Horizon and locality. The specimen described was found at Mossebo in part and counterpart of a loose slab. I am unable to say whether it occurs in the zone of *Tetragraptus phyllograptoides*, or in the following zone.

Genus **Schizograptus** NICHOLSON.

Schizograptus reticulatus NICHOLSON.

Plate III, figures 5—7.

1868. *Dichograptus reticulatus* NICHOLSON, Graptol. of the Skiddaw Series; Quart. Journ. Geol. Soc., Vol. XXIV; p. 143, Pl. V, f. 4, 5.
 1876. *Schizograptus* » NICHOLSON, Notes on the correlation of the graptolite deposits of Sweden with those of Great Britain; Ann Mag. Nat. Hist. Dec. 2, Vol. III; p. 248 (4) Pl. IX, f. 3
 1898. » » ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 480.
 1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 71, Pl. VI, f. 7.

The total length of the stipes of the first order does not exceed 2 mm. From each of them two main stipes grow out, diverging from each other at approximately right angles. They are commonly quite straight, and attain a length of at least 30 mm. Each of them gives off two or three lateral branches, all turning to the same side. The first branch originates at a distance of from 3 to 7 mm. from the point of dichotomy, and no branching seems to take place beyond the fifteenth mm. from the same point. When three branches are emitted from one stipe, they are placed closer to each other than if they are only two. With the main stipes they form angles of from 50° to 80°, the higher angles being most common. They appear to have been rather short, and do not much exceed 1 mm. in width.

The thecæ number eleven or twelve in 10 mm., and are inclined at angles of about 20°, but they are in all my specimens too obscure for a more accurate description.

Though rhabdosomes showing three lateral branches originating from one or two of the main stipes, are not rare, I do not hesitate to refer this species to *Schizograptus reticulatus* NICH., since in all other particulars it agrees with that species.

Horizon and locality. All specimens known to me have been collected at Flagabro in the zone of *Didymograptus balticus*.

Schizograptus rotans n. sp.

Plate IV, figures 1—3.

Each stipe of the first order averages in length 1,5 mm., and by their dichotomous division four main stipes are produced. These are gently curved, all in the same direction, and each of them gives off, from its convex side, three, four, or five lateral branches, which are likewise arcuate, and emit branches of a second order. If the rhabdosome is embedded in the slab examined so as to turn its dorsal margin to the rock, each stipe, when directed upward, will present all its branches to the observer's left hand; and the branches of the second order are given off according to the same law. It is difficult to ascertain a general rule for the length of the interspaces between the consecutive branches. In the following table the first figure of each line indicates the distance between the origin of one of the main stipes and its first branch, while the bracketed number denotes the amount of the angle made by this branch and the next internode. The following figures indicate, in a similar manner, the successive intervals between the branches of the same stipe and their angles of inclination.

Specimen from Mossebo:

3 mm. (60°); 11 mm. (60°); 13 mm. (55°).

3 mm. (60°); 12 mm. (55°); 16 mm. (60°); 1,5 mm. (50°).

2 mm. (65°); 14 mm. (50°); 1,5 mm. (55°).

6 mm. (65°); 15 mm. (60°); 14 mm. (60°); 16 mm. (65°).

Specimen from Flagabro:

2 mm. (65°); 8 mm. (60°); 12 mm. (55°); 8 mm. (50°).

3 mm. (65°); 16 mm. (60°); 4 mm. (50°).

2 mm. (65°); 8 mm. (60°); 12 mm. (dichotomy).

7 mm. (65°); 6 mm. (55°); 13 mm. (?).

It results from this that the angles of inclination of the branches oscillate between rather narrow limits, and that the first internode of each main stipe is usually shorter than the following ones. As the main stipes in all my specimens are distally broken off, their exact extent cannot be stated, but the longest stipe observed by me has a length of 65 mm. The lateral branches of the first order have reached a length of more than 70 mm., while those of the second order seem to have been rather short; the former have an average width of 1,5 mm.

The thecæ are ten or eleven in 10 mm., and inclined at about 30°. Their ventral walls are perceptibly curved, and free one third their length. The apertures are concave, standing almost rectangular to the general direction of the thecæ.

Noticeable is the formation of one quadrant of the specimen represented in fig. 2, in which the main stipe bifurcates dichotomously at its distal end. This might, possibly, be explained as due to an accidental fracture, but the fact that the geminate stipes are straight instead of being bent, like the branches of the other stipes, seems rather to indicate an anomalous development of this quadrant.

The two species of *Schizograptus* here described are easily distinguished, so much the more as, according to the generally accepted classification, they should be referred to separate genera. *Schizograptus rotans* is closely allied to *Schizograptus (Trochograptus) diffusus* HOLM¹⁾, but differs from it by much shorter interspaces between the primary lateral branches. While the distance between the sicula and the third branch of each stipe in *Schizograptus diffusus* is about 80 mm., the same distance scarcely ever exceeds 40 mm. in *Schizograptus rotans*. The former is also described as having the convexity of the main stipes and their lateral branches turned to the right if the rhabdosome is viewed from the same side as thought in the above.

Horizon and localities. Examples of this species have been found by myself at Mossebo and Flagabro in the zone of *Didymograptus balticus*, and Mr A. H. N. WESTERGÅRD has collected specimens in the same zone at Jerrestad.

Schizograptus ambignus n. sp.

Plate III, figure 8.

By this name I designate, provisionally, the graptolite represented on Pl. III, fig. 8. In the curvature of the main stipes and of the branches it resembles *Schizograptus rotans*, but the stipes as well as the internodes are markedly shorter. The distance between the sicula and the third branch of each stipe seems not to exceed 20 m. Only one of the primary branches gives rise to a branch of the second order, all the other branches persisting simple.

The branches measure more than 50 mm. in length with a uniform width of 1,5 mm., and contain ten thecæ in the space of 10 mm. These are inclined at 30° to 35°; their ventral walls are slightly curved, free for one third their length, and form almost right angles with the apertures.

At Flagabro examples have been found which resemble that delineated in fig. 8, with the exception that all the branches are simple. The answer to the question as to whether this graptolite is to be considered as a distinct species, or as a form of one of the two preceding ones, between which it seems to stand almost midway, requires more complete material than I have at my disposal.

¹⁾ Tvenne nya slågten af familjen Dichograptidæ Lapw. Öfvers. K. Vet.-Akad. Förhandl 1881; p. 49.

Horizon and localities. The specimen figured has been found by Mr v. SCHMALENSSEE at Mossebo, probably in the zone of *Didymograptus balticus*. The examples from Flagabro mentioned in the above were collected in this zone.

Genus **Holograptus** HOLM.

Holograptus expansus HOLM.

1887. *Holograptus expansus* HOLM, Tvenne nya slägten af familjen Dichograptidæ Lapw.; Öfversigt af K. Vet.-Akad. Förhandl. 1881; p. 46, Tafel. XII, f. 1 and 2.

The only specimen of this species known is that described and figured by HOLM in the paper cited, for which reason I here confine myself to referring to the minute description of this author.

Horizon and locality. According to kind information from Professor HOLM the specimen described by him was found upon a detached slab at Hunneberg; the true horizon of the fossil can, accordingly, not be stated, but it belongs certainly to one of the two oldest zones.

Genus **Azygograptus** LAPWORTH.

Azygograptus suecicus MOBERG.

Plate IV, figures 6—11.

1892. *Azygograptus suecicus* MOBERG, Nya graptoliter från Skånes undre graptolit-skiffer; Geol. Fören. i Stockh. Förhandl. Bd 14; p. 342, Tafel. 8, f. 1, 2.
1898. » » ELLES, The Graptolite-Fauna of the Skiddaw Slates; Quart. Journ. Geol. Soc., Vol. LIV; p. 514, f. 29.
1902. » » ELLES and WOOD, Monograph of British Graptolites, Part I; p. 95, Pl. XIII, f. 3a, b.

The sicula has a length of 1,5 mm., and a width of 0,3 mm., when preserved in full relief. At the apex it is suddenly pointed, and provided with a short virgular nema. Four or five annular furrows traverse the apical portion of the sicula. At a distance of 0,2 or 0,3 mm. from its aperture the first theca springs out, forming with the sicula an angle oscillating between 130° and 150°. The single stipe is slightly arcuate, producing thecæ from its convex side. It is very narrow near its origin, but widens rapidly to a diameter of 0,5 mm.

In the distal portion of the stipe the thecæ number seven in 10 mm., being inclined at an average angle of 15°. Their ventral walls are slightly S-shaped, being in the middle portion almost parallel to the dorsal margin of the stipe, and then curving outwards so as to form, together with the apertural edge, a pointed denticle. The first theca is longer than the following ones, and free for more than four fifths its length, but the overlap increases in the succeeding thecæ to as much as one third their length.

Horizon and localities. The species is confined to the *zone of Isograptus gibberulus*, and examples are frequently met with at Killeröd, Komstad and Flagabro.

***Azygograptus validus* Moberg mscr.**

Plates IV, figures 12—14.

Under this title there lie in the Geological Museum at Lund some small graptolites, the most complete of which are represented in the figures cited. The sicula has a length of 2 mm. with a maximum width of 0,7 mm., and is apically prolonged into a nema, which may have reached a length of 1,5 mm., or more. The first theca originates near the apex of the sicula, and grows, at first, closely adpressed to it like a narrow brim until it, near the aperture of the sicula, bends outwards to produce the stipe. This makes with the sicula an angle of 130° , and is in the largest specimen only 3,3 mm. long, and 0,7 mm. wide. It contains three thecæ and the base of a fourth. These are inclined at 25° , having their outer walls straight, and free for half their length.

From *Azygograptus cælebs* LAPW., which it resembles in the formation of the first theca, this species is distinguished by shorter thecæ, and a markedly bigger sicula.

Horizon and locality. The specimens from which this description has been drawn up, were found by Professor Moberg at Mossebo, where it occurs in the *zone of Tetragraptus phyllograptoides*.



Appendix.

Table showing the vertical distribution of the graptolites described in the two parts of this memoir.

	Zone of			
	Tetragraptus phyllograptoides	Didymograptus balticus	Phyllograptus densus	Isograptus gibberulus
Didymograptus undulatus TÖRNQ.	*	—	—	—
» demissus TÖRNQ.	*	—	—	—
» geometricus TÖRNQ.	—	*	—	—
» Holmi TÖRNQ.	*	—	—	—
» suecicus TULLB.	—	*	*	—
» extensus HALL	—	—	—	*
» patulus HALL ¹⁾	—	—	—	*
» prænuntius TÖRNQ.	—	—	*	—
» constrictus HALL	*	*	—	—
» validus TÖRNQ.	—	*	—	—
» balticus TULLB.	—	*	—	—
» vacillans TULLB.	—	*	—	—
» Kurcki TÖRNQ.	—	—	—	*?
» filiformis TULLB.	—	*	—	—
» flagellifer TULLB. mscr. ²⁾	—	—	—	—
» Mobergi TÖRNQ.	—	—	—	*
Isograptus gibberulus NICH.	—	—	—	*
Mæandrograptus Schmalenseei MBG	—	—	—	*
Bryograptus simplex TÖRNQ.	*	—	—	—
Trichograptus crinitus MBG mscr.	—	*	—	—
Tetragraptus pendens ELLES var. præsagus TÖRNQ.	—	—	*	—
» approximatus NICH.	*	—	—	—
» vestrogothus TÖRNQ.	*	—	—	—
» quadribrachiatus HALL	—	*	—	—
» serra (BRONGN.) HALL	*	*?	—	—
» phyllograptoides LINES. mscr.	*	—	—	—

¹⁾ The species described under this name in Part I, p. 15, and by ELLES and WOOD referred to *Didymograptus hirundo* SALTER (British Graptolites, Part I, p. 15).

²⁾ Zone uncertain.

	Zone of			
	Tetraraptus phylograptoides	Didymograptus balticus	Phyllograptus densus	Isograptus gibberulus
Phyllograptus densus TÖRNQ.	—	—	*	—
» cfr Anna HALL	—	* ♀	—	—
Dichograptus octobrachiatus HALL	—	*	—	—
» » » var. Kjerulfi HERRM.	—	*	—	—
» regularis TÖRNQ.	—	*	—	—
Clonograptus subtilis TÖRNQ.	—	*	—	—
Temnograptus multiplex NICH.	—	*	—	—
Anthograptus nidus TÖRNQ.	—	* ♀	—	—
Schizograptus reticulatus NICH.	—	*	—	—
» rotans TÖRNQ.	—	*	—	—
» ambiguus TÖRNQ.	—	* ♀	—	—
Holograptus expansus HOLM ¹⁾	—	—	—	*
Azygograptus suecicus MBG	—	—	—	—
» validus MBG mscr.	*	—	—	—

¹⁾ Zone uncertain.

Explanation of Plate I.

Bryograptus simplex n. sp.; page 3.
Mossebo; zone of *Tetragraptus phyllograptoides*.

- Fig. 1. Reverse aspect; natural size.
› 2. Obverse aspect; natural size.
› 3. Proximal portion; reverse aspect; magn. $\frac{3}{1}$.
› 4. Proximal portion, partly preserved as imprint; obverse aspect; magn. $\frac{3}{1}$.
All the specimens compressed.

Trichograptus crinitus MOBERG mscr.; page 4.
Mossebo; zone of *Didymograptus balticus*.

- Fig. 5. Compressed specimen; natural size.
› 6. Specimen partly preserved in relief; natural size.
› 7. Portion of a branch preserved in half relief; magn. $\frac{5}{1}$.
All the specimens in the Geological Museum at Lund.

Tetragraptus pendens G. ELLES, var. **præsagus** n. sp.; page 5.
Flagabro; zone of *Phyllograptus densus*.

- Fig. 8. Imprint of a specimen; natural size.
› 9. Proximal portion of a compressed specimen; magn. $\frac{5}{1}$.
› 10. Proximal portion of a specimen for the greater part preserved as imprint; magn. $\frac{5}{1}$.

Tetragraptus approximatus NICHOLSON; page 6.
Mossebo; zone of *Tetragraptus phyllograptoides*.

- Fig. 11. Impression of a specimen preserved in flattened relief; natural size.
› 12. Portion of a stipe; magn. $\frac{3}{1}$.
The specimens in the Geological Museum at Lund.

Tetragraptus vestrogothus n. sp.; page 7.
Mossebo; zone of *Tetragraptus phyllograptoides*.

- Fig. 13. Two specimens, partly preserved in relief, partly as imprints; natural size.
› 14. Proximal portion for the most part preserved in relief; natural size.

Tetragraptus quadribrachiatus HALL; page 7.
Flagabro; zone of *Didymograptus balticus*.

- Fig. 15. Compressed specimen, partly seen as imprint; natural size.
› 16. Portion of a stipe preserved as imprint; magn. $\frac{3}{1}$.

Tetragraptus serra BRONGNIART; page 8.
Mossebo; zone of *Tetragraptus phyllograptoides*.

Fig. 17—20. Compressed specimens; natural size.

- » 21. Portion of a stipe; magn. $\frac{3}{1}$.

Tetragraptus phyllograptoides LINNARSSON mscr. page 10.
Mossebo; zone of *Tetragraptus phyllograptoides*.

Fig. 22. Young compressed specimen; natural size.

- » 23. Young compressed specimen, showing the sicula; magn. $\frac{3}{1}$.
 - » 24. Compressed specimen, showing the sicula between two main stipes of different primary halves; natural size.
 - » 25. Compressed specimen, showing two stipes of the same primary half; natural size.
-

Explanation of Plate II.

Tetragraptus phyllograptoides LINNARSSON mscr. page 10.
Mossebo; *zone of Tetragraptus phyllograptoides*.

Fig. 1—4. Specimens presenting different aspects; natural size.

- » 5. Portion of the initial region; magn. $\frac{4}{1}$.
- » 6, 7. Parts from the middle region of stipes; magn. $\frac{4}{1}$.
- » 8. Distal extremity of a stipe; magn. $\frac{4}{1}$.

Phyllograptus densus TÖRNQUIST; page 11.
Flagabro figs. 9, 10; *zone of Phyllograptus densus*.
Neckebo figs. 11, 12; *zone of Phyllograptus densus*.

Fig. 9, 10. Specimens partly preserved in relief; natural size.

- » 11. Proximal portion; magn. $\frac{4}{1}$.
- » 12. Distal portion of the same specimen; magn. $\frac{4}{1}$.

Phyllograptus cfr. **Anna** HALL; page 14.
Mossebo; probably: *zone of Didymograptus balticus*.

Fig. 13. Imprint of a specimen in half relief; natural size.

Dichograptus octobrachiatus HALL; page 17.
Mossebo; *zone of Didymograptus balticus*.

Fig. 14. Specimen partly preserved in relief; natural size.

Dichograptus octobrachiatus HALL, var. **Kjerulfi** HERRMANN; page 18.
Mossebo; *zone of Didymograptus balticus*.

Fig. 15. Specimen with ten main stipes, partly in relief; natural size.

- » 16. Specimen with thirteen main stipes, preserved as imprint; natural size.
- » 17. Portion of a stipe; magn. $\frac{3}{1}$.
- » 18. Proximal portion of a specimen preserved as imprint; magn. $\frac{4}{1}$. Geol. Mus. Lund.

Dichograptus regularis n. sp.; page 20.
Mossebo; *zone of Didymograptus balticus*.

Fig. 19. Specimen in flattened relief; natural size.

Clonograptus subtilis n. sp.; page 20.
Flagabro; probably: *zone of Didymograptus balticus*.

Fig. 20. Specimen preserved as imprint; natural size.

- » 21. Portion of a stipe of the fifth order; magn. $\frac{5}{1}$.

Undetermined irregular Dichograptidæ; page 22.

Flagabro; zone of *Didymog aptus balticus*.

Fig. 22. Specimen in faint relief; thecæ, partly visible in the original, are not rendered in the figure; natural size.

» 23, 24. Compressed specimens; natural size.



Explanation of Plate III.

Temnograptus multiplex NICHOLSON; page 21.

Mossebo figs 1 and 2; *zone of Didymograptus balticus*.

Flagabro figs 3 and 4; *zone of Didymograptus balticus*.

- Fig. 1. Specimen in flattened relief; natural size; Geol. Mus. Lund.
- » 2. Specimen partly in flattened relief; natural size; Geol. Mus. Lund.
 - » 3. Specimen partly preserved in relief, partly as imprint; natural size.
 - » 4. Portion of a stipe converted into pyrites; magn. $\frac{3}{1}$.

Schizograptus reticulatus NICHOLSON; page 23.

Flagabro; *zone of Didymograptus balticus*.

- Fig. 5. Specimen in faint relief; natural size.
- » 6. Specimen partly preserved as imprint; natural size.
 - » 7. Portion of a branch; magn. $\frac{8}{1}$.

Schizograptus ambiguus n. sp.; page 25.

Mossebo; probably: *zone of Didymograptus balticus*.

- Fig. 8. Specimen preserved in faint relief; natural size; Geol. Mus. Lund.
-

Explanation of Plate IV.

Schizograptus rotans n. sp. page 24.

Mossebo fig. 1; *zone of Didymograptus balticus*.

Flagabro figs. 2 and 3; *zone of Didymograptus balticus*.

- Fig. 1. Specimen preserved as imprint; natural size.
› 2. Specimen preserved as imprint; natural size.
› 3. Portion of a branch preserved as imprint; magn. $\frac{8}{1}$.

Anthograptus nidus n. sp.; page 22.

Mossebo; *zone uncertain*.

- Fig. 4. Specimen partly preserved in relief, partly as imprint; natural size.
› 5. Portion of a stipe preserved in faint relief; magn. $\frac{7}{2}$.

Azygograptus suecicus MOBERG; page 26.

Komstad figs. 6 and 8; *zone of Isograptus gibberulus*.

Killeröd figs. 7, 9—11; *zone of Isograptus gibberulus*.

- Fig. 6. Proximal portion of a specimen in relief; natural size.
› 7. Stipe of a specimen in flattened relief; natural size.
› 8—9. Siculæ with one theca preserved in relief; magn. $\frac{6}{1}$.
› 10. Flattened sicula with one theca; magn. $\frac{6}{1}$.
› 11. Imprint of a portion of a stipe; magn. $\frac{5}{1}$.

Azygograptus validus MOBERG mscr. page 27.

Mossebo; *zone of Tetragraptus phyllograptoides*.

- Fig. 12. Compressed specimen; natural size.
› 13, 14. Compressed specimens; magn. $\frac{4}{1}$.









