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ÅRSBOK 30 (1936) N:O 10.

UPPER DIDYMOGRAPTUS SHALE IN SCANIA

BY

GUNNAR EKSTRÖM

WITH ELEVEN PLATES

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KUNGL. BOKTRYCKERIET. P. A. NORSTEDT & SÖNER
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Preface.

This investigation was suggested by my former teacher, Professor Joh. Chr. Moberg, the late Head of the Geological-Mineralogical Institute at the University of Lund. The field-work was carried out during different periods between 1913 and 1920, under the supervision of Professor Moberg, Professor Assar Hadding — at that time docent at the University — and later on, of Professor K. A. Grönwall.

Although lacking illustrations, the main part of the paper appeared in typewritten form as early as 1920, the publishing being postponed because of other scientific investigations (soil science and hydrology). As the Geological Survey of Sweden, however, has, of late years, resumed the investigations of the rock formations in Scania in connection with the preparation of new map sheets, it seems desirable that the results of my research be published, and I have therefore kindly been given permission to complete the work as a Geologist at the Geological Survey of Sweden.

The accomplishment of the field-investigations was made possible by grants received from the Anders Jahan Retzius' Foundation of the Kungl. fysiogra-

fiska sällskapet, Lund (in 1913, 1916 and 1919) and from Lunds geologiska fältklubb (1916). In 1930 I received a grant from Konsul N. Persson's Foundation of the Kungl. fysiografiska sällskapet for photographing of the fossils and retouching.

The English text has been corrected by Dr. and Mrs. Eyolf Cullin.

To all those who have promoted the work, published herewith, or contributed to it, I beg to express my gratitude.

Stockholm, Geological Survey of Sweden, December, 1936.

Gunnar Ekström.

I. Historical Review.

This is only a brief summary including papers relating to the Upper Didymograptus shale in Scania and also, to some extent, layers adjoining these shales. Correlative deposits will not be mentioned here nor anywhere else in this treatise. They have been dealt with more or less exhaustively by, among others, Hadding (1913) and Funkquist (1919).

In 1840 Hisinger gave a short description and a reproduction of *Prionotus? geminus* and *Prionotus teretiusculus* from shales belonging to the »Transition Beds» at Fågelsång.

In »Palaeontologia Scandinavica», Angelin (1854) reported twenty-two trilobites from the Orthoceras limestone of Fågelsång.

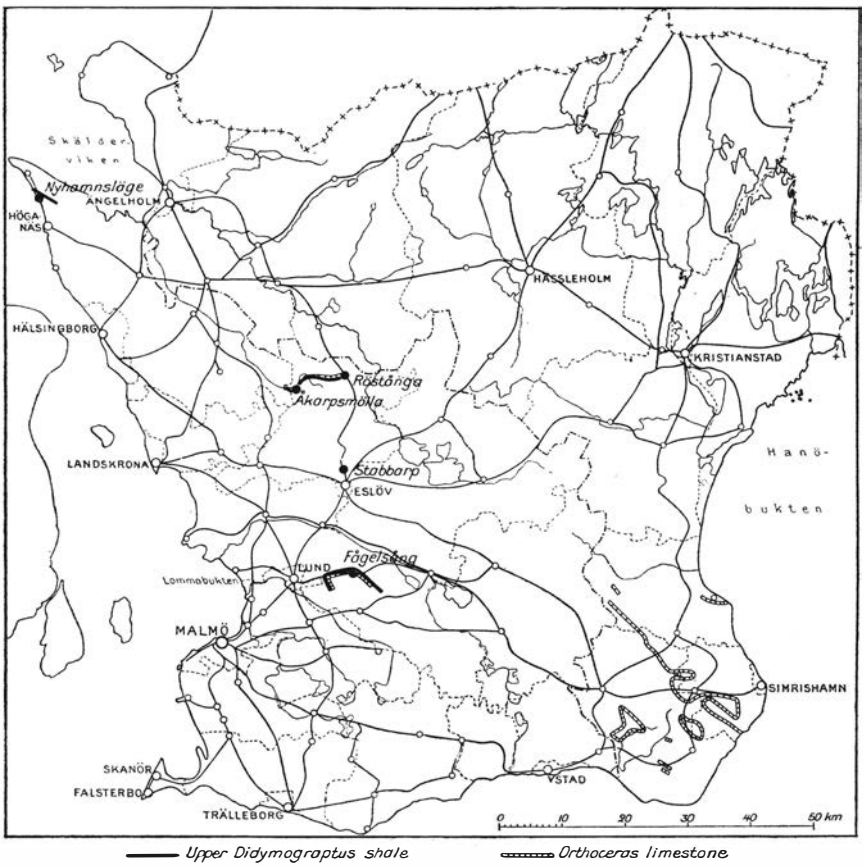
Törnquist, in 1865, referred the Orthoceras limestone and the overlying layers of shale to the Llandeilo-group (according to Murchison). An investigation was made in the localities d, f, g and k in Fågelsång,[1] the species *Diplograptus teretiusculus, Phyllograptus typus* Hall and *Didymograptus murchisoni* Beck being described and reproduced. (The latter species is *Did. bifidus;* cf. Törnquist 1911, p. 427—429.)

In 1873 (p. 698) Linnarsson introduced the denomination »Middle graptolite shale» for the series of graptolite-bearing shales lying immediately above the Orthoceras limestone (= the Middle and the Lower Dicellograptus shale as well as the Upper Didymograptus shale, according to the present terminology). The »Lower graptolite shale» (Linnarsson 1869) was thought to be underlying the Orthoceras limestone.

In the capacity of palaeontologist at the Geological Survey of Sweden, Linnarsson (1875) visited a great number of Cambro-Silurian localities in Scania, including Fågelsång. By studying several sections in this district, he at once arrived at the conclusion that there were a great number of more or less well-characterized strata of shales of different ages. The locality d of Törnquist was rather closely studied. Linnarsson considered the graptolite-fauna of this locality very remarkable and mentioned from this place »*Phyllograptus typus, Didymograptus hirundo* Salt., *Climacograptus teretiusculus,* or a closely related species, and also a multi-branched, very slender form». The stratigraphic position of the shale in the locality d could not be exactly determined

[1] A correlative table of the locality-names of Törnquist, Linnarsson and Moberg will be found at the end of this summary (p. 10).

by Linnarsson, but he did not consider this shale younger than the Orthoceras limestone but rather an interstratification in the limestone; finally, however, he included this shale in the Lower graptolite shale. Linnarsson considered *Didymograptus geminus* and *Dicellograpti* the most characteristic, though not the most common, fossils in the Middle graptolite shale.



Textfig. 1. Sketch map of Scania, showing the locations of the outcrops of the Upper Didymograptus shale, and the area within which, according to Josef Eklund, this shale and the Orthoceras limestone are to be found. (The occurrence of Orthoceras limestone at Röstånga is doubtful; rock in situ has not been found.)

In 1875 (p. 57) Törnquist proposed the denomination »Dicranograptus shale» for the Middle graptolite shale, and »Phyllograptus shale» for the Lower graptolite shale. In conformity to Linnarsson, he contended that the shale of the locality d was underlying the Orthoceras limestone and recorded from this locality *Climacograptus teretiusculus*, *Didymograptus patulus* Hall, *Didymograptus indentus* Hall, *Phyllograptus typus* and a narrow, long-celled, probably branched graptolite. In the locality g he found (p. 53) *Climacograptus teretiusculus*, *Didymograptus bifidus*, *Phyllograptus typus* and the narrow, long-

celled graptolite. The similarity of the fauna at d and g was pointed out, the Phyllograptus shale thus lying partly above and partly below the Orthoceras limestone, and the latter forming a layer in the Phyllograptus shale.

In 1876 Linnarsson enumerated the following genera as characteristic of the Lower graptolite shale: *Dichograptus, Phyllograptus, Tetragraptus* and *Didymograptus;* of the Orthoceras limestone: *Phyllograptus;* and of the Middle graptolite shale: *Didymograptus, Dicellograptus, Dicranograptus, Climacograptus* and *Diplograptus.*

In the summer of 1878 Linnarsson made his second journey to the Cambro-Silurian districts of Scania (Linnarsson 1879). He now came to the conclusion that the Middle graptolite shale ought to be divided into several subdivisions. The whole group was further characterized as embracing the graptolite-bearing shales lying between the Orthoceras limestone and the nearest overlying trilobite-bearing stratum. From the lower part of the locality o (= the locality d of Törnquist) Linnarsson (p. 9—10) mentioned the following fossils: *Phyllograptus typus,* several *Didymograpti,* both tuning-fork and with horizontal stipes, *Diplograptus* n. sp. (nearly related to *D. hopkinsoni* Nich.), *Climacograptus* n. sp. (closely related to *Clim. confertus* Lapw. and *Clim. perexcavatus* Lapw.) and *Climacograptus scharenbergi* Lapw., indicating this horizon in the Middle graptolite shale by α. In the upper part of the locality o, *Didymograptus geminus* was found among others, and this horizon was indicated by β. In the locality g, Linnarsson again found the same fossils as in the bottom of the locality o, and from this he rightly inferred the strata of the last-mentioned locality to be younger than the Orthoceras limestone. The denominations Phyllograptus shale and Dicranograptus shale suggested by Törnquist were found unsuitable. With regard to the palaeontology, he considered that the series of strata α ought to be brought together with the overlying shales under a common denomination (= the Middle graptolite shale), and the localities 1—3 were referred to the division β. Linnarsson did not find any other outcrops of this zone in Scania; von Schmalensee, however, had brought home several fossils from Nyhamnsläge, which were examined by Linnarsson and referred by him to the division β. The shales in the hillocks, localities 4—7, were assumed to be solid rock. Finally, Linnarsson decided for the following lithological sequence at Fågelsång (descending order):

γ) Zone of *Glossograptus hincksi.*
β) » » *Didymograptus geminus.*
α) » » *Phyllograptus typus.*
k) Orthoceras limestone.

In 1880 Tullberg (1880: 2) described two new genera and species of graptolites from Fågelsång, viz. *Lonchograptus ovatus* and *Janograptus laxatus,* the former found in the zone of *Didymograptus geminus* in Linnarsson's localities o and 1 (one specimen in each locality), the latter in the shale in the locality 7 (the western hillock).

In his paper 1882: 1 (p. 16—19), Tullberg described and reproduced *Didymogr. murchisoni* var. *geminus* and *Diplograptus teretiusculus.*

The new genus *Pterograptus*, together with its species *P. elegans*, were described by Holm in 1881 from the Ordovician (the shale above the Orthoceras limestone) in the neighbourhood of Oslo, in Norway.

In Tullberg's table of 1882, completed 1883, we find the first attempt at giving a total view of the Cambro-Silurian of Scania. Tullberg divided the Ordovician of Scania into the following three divisions:

D) Upper Stage
E) Middle » (= The Middle graptolite shale)
F) Lower » .

At the bottom of the Middle Stage, we find the zone of *Didymogr. geminus* (o), below the zone of *Glossogr.* cf. *hincksi* (n). The Lower Stage, F, was divided into the following subdivisions:

a) Zone of *Phyllogr.* cf. *typus*
b) Orthoceras limestone
c) Zone of *Tetragraptus*
d) Ceratopyge limestone.

The zone of *Didymogr. geminus*, which was supposed to correspond to the Llandeilo in England, was divided into the three following subzones.

α) Subzone of *Glossograptus* sp., *Didymograptus geminus*, *Diplograptus teretiusculus*, *Diplograptus perexcavatus* ?, *Janograptus* sp., *Climacograptus* sp., *Cryptograptus* sp., *Lonchograptus ovatus*, etc.

β) Subzone of *Pterograptus elegans*, *Didymograptus geminus*, *Diplograptus teretiusculus*, *Diplograptus perexcavatus* ?, *Janograptus* sp., *Climacograptus confertus*, *Climacograptus scharenbergi*, *Dawsonia* sp., etc.

γ) Subzone of *Didymograptus bifidus*, *Climacograptus confertus*, *Climacograptus scharenbergi*, *Cryptograptus* and *Corynoides* sp.

Tullberg's knowledge of the zone of *Didymogr. geminus* was confined to Fågelsång. To the subzone *β*, however, he referred a shale found at Nyhamnsläge, containing among other fossils a small, tuning-fork *Didymograptus*.

In the zone of *Phyllograptus* cf. *typus*, Tullberg had found, in addition to the index fossil, *Didymograptus bifidus*, *Cryptograptus* sp., *Climacograptus confertus* and *Climacograptus scharenbergi* var. The zone was found at Fågelsång, having a thickness estimated at 6 meters.

In 1883 Tullberg (p. 244) also mentioned Orthoceras limestone from Kvarnbäcken at Röstånga (Moberg's loc. IV: b). In 1880 he (1880: 1, p. 88) had assumed this limestone to be Middle Cambrian.

In the description to the map-sheet Trolleholm, Nathorst (1885, p. 16 and 24; cf. Tullberg 1883, p. 243) mentioned that, by a boring made from the bottom of a shaft in Stabbarp coal-mine, situated practically half-way between Röstånga and Fågelsång, a dark shale containing *Phyllograptus* cf. *typus*, *Siphonotreta nucula*, and *Climacograptus* sp. had been found at a depth of 102 m. No limestone, underlying this shale, however, seems to have been found, as dark shales were said to predominate from 94 to 124 m.

In the description to the map-sheet »Lund», de Geer (1887, p. 14—15) recorded from the zone of *Phyllogr.* cf. *typus*: *Phyllogr.* cf. *typus*, *Didymogr.*

bifidus, *Cryptogr.* sp., *Climacogr. confertus*, *Climacogr. scharenbergi* var. and from the zone of *Didymogr. murchisoni* var. *geminus: Didymogr. murchisoni* var. *geminus*, *Diplogr. foliaceus*, *Diplogr.* cf. *hopkinsoni*, *Climacogr.* pl. sp., *Corynoides* sp. De Geer considered the hillocks, Linnarsson's localities 4—7, to be covered with shale gravel, where the shale was supposed to be of only one kind, either frost weathered in situ or to consist of a moraine of shale disintegrated in the place.

For the lower part of the Ordovician, Törnquist, in 1889, gave (p. 312) the following divisions:

The Lower Dicellograptus shale corresponding to E) the Middle Stage of Tullberg or the zones h—o,

The Phyllograptus shale corresponding to F) the Lower Stage of Tullberg.

The Phyllograptus shale containing the genus *Phyllograptus*, throughout, was divided into a lower zone characterized by *Tetragraptus*, and an upper zone, without this genus, the Scanian Orthoceras limestone lying intercalated between these two zones. The zone of *Didymogr. geminus* was referred to the Lower Dicellograptus shale.

According to the description to the map-sheet Simrishamn by Holst (1892, p. 26), boulders belonging to the zone of *Didymogr. geminus* had been observed north of Gislövshammar, which, however, is not very likely.

In the Geological Guide to the Fågelsång-district of 1896, Moberg included in the Middle graptolite shale: the zone of *Glossogr. hincksi* and the *Orthis* shale with the intervening layers. The Scanian Orthoceras limestone, the zone of *Phyllogr.* cf. *typus* and the zone of *Didymogr. geminus* were brought together into a main division, which was considered to correspond to the Orthoceras limestone of Öland. — All outcrops of solid rock known at that time in the Fågelsång-district were mentioned in the Geological Guide, and these localities were indicated by a letter and a number. From the locality E 21 (E 21 b) *Phyllogr.* cf. *typus*, *Didymogr. geminus*, *Climacogr.* cf. *scharenbergi* and *Tetragraptus quadribrachiatus* Hall were mentioned.

In 1901 Moberg described and figured the new species *Pterograptus scanicus* from the locality E 32 a at Fågelsång. In the same year Törnquist brought the zone of *Phyllograptus* cf. *typus* and the Lower graptolite shale together under the name Phyllo-Tetragraptus shale, dividing this shale into five zones, the highest of which was the zone of *Phyllogr.* cf. *typus*.

In 1902 Moberg (1902: 1) considered the name Phyllo-Tetragraptus shale unsuitable, proposing instead the name Didymograptus shale, in which he included the Geminus shale, the zone of *Phyllogr.* cf. *typus* and the Lower graptolite shale. The Geminus shale and the zone of *Phyllogr.* cf. *typus* became the Upper Didymograptus shale, the remainder the Lower Didymograptus shale. The Upper Didymograptus shale was characterized by tuning-fork *Didymograpti*, the Lower Didymograptus shale corresponding to the Lower graptolite shale.

In another paper, the same year, Moberg (1902: 2) mentioned two new outcrops of the Geminus shale in the Fågelsång-district. Not being able to

Correlative table of the locality-denominations at Fågelsång.

Törnquist 1865	a	b	c	d	e	f	g	h		i	k	l	m
Linnarsson 1879				o				1	2	3	4—7	8	
Moberg a. o. 1896–1920	F 5–7?	F 11	F 1	E 23	E 18	E 20	E 21	E 43	E 47	E 17	E 16	E 15	E 3–8

find solid rocks in the hillocks locality E 16, he considered them débris of shale.

Törnquist, in 1906 (p. 506 and 514), adopted Moberg's denomination of 1902: the Didymograptus shale. The Upper and the Lower Didymograptus shale were distinguished, *inter alia*, by the fact that Diprionidian graptolites were to be found in the former, while lacking in the latter.

Geminus shale from Röstånga was mentioned for the first time in literature by Olin in 1906 (p. 15, 16 and 23) from Kyrkbäcken. The following fossils were found: *Didymogr. geminus*, *Climacograptus* sp. and *Orbicula* sp.

In 1907 Moberg recorded fossils (trilobites) from the Orthoceras limestone, in the southernmost limestone quarry at Fågelsång. This locality is here named E 21 a, a misprint for E 21 b, according to Moberg's guide of 1910. — Geological guides to Fågelsång and Röstånga were published by Moberg in 1910.

In 1911 Törnquist described *Didymogr. bifidus* Hall and *Didymogr. lentus* Törnq., sp. nov. from the zone of *Phyllogr.* cf. *typus* at Fågelsång (the localities E 23 and E 21 b). From the same zone he also mentioned a variety of *Didymogr. bifidus*, *Didymogr.* cf. *indentus* and *Clonograptus* (?) sp.

Pterograptus elegans Holm and *Pterograptus scanicus* Mbg were fully described by Hadding in 1911. *Pterogr. elegans*, *Didymogr. geminus*, *Diplogr. perexcavatus*, *Climacogr. scharenbergi*, *Cryptogr.* sp. and *Didymogr.* cf. *nicholsoni* var. *planus* Elles and Wood were recorded from the Geminus shale at Röstånga.

In his treatise in 1913 concerning the Lower Dicellograptus shale, Hadding (p. 22) claims that the underlying as well as the overlying strata had been exposed by his excavations at Röstånga, and that the zone of *Glossogr. hincksi* is probably developed here. At Hadding's locality, III: 1 (p. 18—19), the following fossils had been found: *Didymogr. geminus* (abundantly), *Cryptogr. lanceolatus* Hdg?, *Diplogr. perexcavatus* ?, *Climacogr. scharenbergi*, *Climacogr.* sp. (badly preserved specimens), *Pterogr. elegans* (abundantly) and *Obolus* sp. These layers were considered to belong to the middle part of the Geminus shale. From the locality III: 2 (according to Hadding, probably the lowest part of the zone of *Glossogr. hincksi;* p. 22), a few fossils, small *Obolus*-species, *Cryptogr.* sp. and *Climacogr.* sp. were mentioned. Immediately north of the section III: 2, *Didymogr. geminus* was found in solid rock in the brook.

In 1915 Hadding (1915: 1) gave a thorough account of the genera *Glossograptus*, *Lonchograptus* and *Cryptograptus* and described their structure. *Glossogr.* sp., *Pterogr. elegans*, and other fossils, were found to occur together with *Lonchogr. ovatus* in the zone of *Didymogr. geminus*.

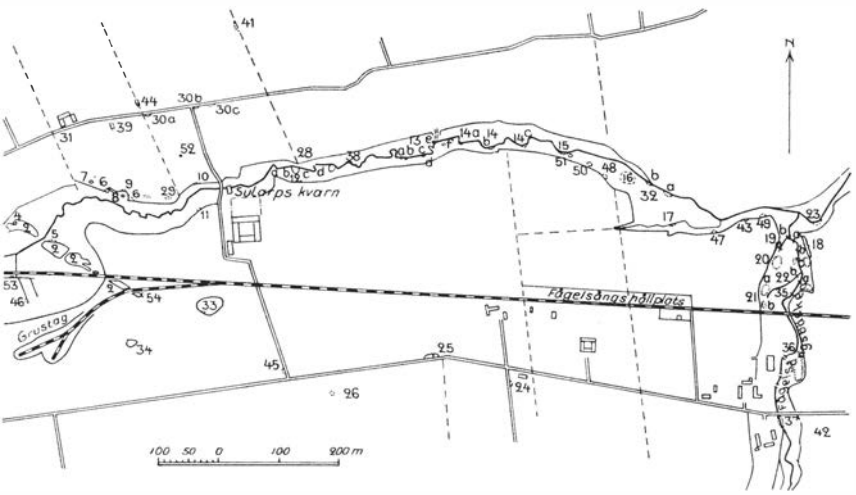
Funkquist, in 1919, showed that the Upper Didymograptus shale and the Lower Dicellograptus shale are lacking in Southeastern Scania. At Fågelsång the Limbata limestone was found to underlie the zone of *Phyllograptus* cf. *typus*.

In 1923 Troedsson enumerated the following species from the zone of *Phyllogr.* cf. *typus* at Fågelsång: *Didymogr. lentus*, *Did. bifidus*, *Did. indentus*, *Phyllogr.* cf. *typus* and *Diplogr. dentatus appendiculatus* Tqt; cf. Elles 1898, p. 519. (The last-mentioned form of Törnquist's Collection may probably be identified as *Cryptogr. lanceolatus*, cf. p. 40.)

II. Description of the Localities.

1. Fågelsång.

For many years geologists have paid special attention to the Ordovician shales in the Fågelsång-district because of their rich fauna and rather homogeneous facies-development. Among these deposits, the Upper Didymograptus shale has on several occasions been a subject for rather animated discussions in literature. No detailed investigation of this shale, however, was hither-



Textfig. 2. Map-sketch of Fågelsång, with old and new outcrops of the Upper Didymograptus shale and the adjoining layers in the district (with the exception of loc. F 3 and loc. F 12?). (Mainly after Moberg 1910: 1, pl. 2, Special map, square E.)

to carried out, and many mistakes have been made, concerning the stratigraphy as well as the fauna. Fortunately, through digging, it was possible for me to uncover considerable series of strata, and these layers were then investigated, one stratum after the other.

The following description of the localities does not only include those localities which show extensive profiles and have been thoroughly investigated, but also those where the exposed layers were of an inconsiderable thickness, and on which only a small amount of work was expended. — To complete my observations, I refer to Moberg (1896 and 1910: 1).

Locality E 5.

The rock is a steel-grey, hard, thinly splitting shale, contact-metamorphosed (»baked») by diabase. The following fossils have been found.

Didymogr. geminus
Pterogr. elegans
Climacogr. scharenbergi
» *angustatus*
» *celsus*
Amplexogr. maxwelli
Cryptogr. lanceolatus
» *tricornis*
Obolus ornatus
Lingula dicellograptorum

The shale belongs to the zone of *Pterograptus elegans*.

E 16.

In order to establish whether the hillocks in the glen bottom of Sularpsbäcken, mentioned by Linnarsson as early as 1879, were composed of shale in situ, a cutting was made in the southern part of the hillock, just opposite the new locality E 48. The following profile was measured.

Clayey sand with pieces of shale	0.5 m
A »Scholle» of shale (without sand)	0.3 »
Shale, mixed with sand	0.2 »
Clayey, alluvial sand, with fragments of plants (*Equisetum* etc.)	2.5 »
Dark sand, with pieces of shale	0.7 »
Shale, probably in situ	0.2 »
	4.4 m

Furthermore, in the western hillock, two small cuttings were made, in which nothing but disintegrated shale with some content of sand was found. — On account of these investigations, it may be said to be established that the hillocks, referred to above, do not consist of solid shale, but of alluvial deposits.

E 17.

The rock is a dark, thinly splitting shale. Solid layers are difficult to find because of the position of the locality in the bottom of a glen. Fossils:

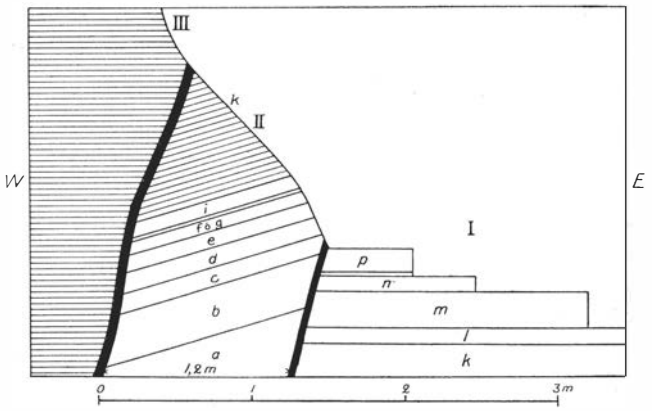
Didymogr. geminus
» » var. *latus*
Pterogr. elegans
Glyptogr. teretiusculus
Amplexogr. maxwelli
Lonchogr. ovatus
Obolus ornatus

The strata belong to the subzone of *Pterogr. scanicus*.

A deep cutting was made in the southern slope of the valley, 30 m southwest of this locality. Shale in situ, however, was not found.

E 21 a.

This locality is the same as the middle limestone quarry at Fågelsång. In the western wall of the quarry, a cutting was made at the same time as the quarry was pumped dry of water, revealing two parallel, northerly—southerly faults, separated by a block measuring 1.2 m in width. Textfigure 3 denotes



Textfig. 3. Section from the western part of the locality E 21 a, Fågelsång.

the three portions separated by the faults, the strata being indicated by I, II and III (from older to younger). The dip of the strata and of the faults is evident from this sketch. The thickness of the breccias is 5 à 6 cm.

III. The westernmost part of the quarry consists of shale, lying almost horizontal, in which the following subzones were found.

Subzone of *Azygogr. falciformis:* Greyish-black, rather thinly splitting shale . . . . . 1.0 m
Subzone of *Phyllogr. nobilis:* Blackish-grey or dark-grey, rather hard shale having an earthy appearance and irregular, uneven bedding planes . . . . . 2.0 »
3.0 m

II. The 1.2 m broad part between the breccias. The strata here dip 18° in N 71°W. The following section was measured.

k) Shale, dark-grey, rather irregularly stratified, belonging to the lowest part of the subzone of *Phyllogr. nobilis* . . . . . 0.60 m
j) Marl, greyish-yellow . . . . . 0.01 »
i) Limestone-bed, or, more precisely, a layer of more or less confluent balls of limestone, embedded in a dark-grey, somewhat calcareous shale. The balls which consist of a dark-grey, compact, very siliceous limestone have yielded fragments of brachiopods and annelidan-jaws . . . . . 0.07 »
h) Marl . . . . . 0.01 »
g) Limestone, blackish-grey, crystalline . . . . . 0.02 »
f) » , greyish-black, argillaceous; *Acrotreta* cf. *nana* . . . . . 0.04 »
e) Shaly clay, grey . . . . . 0.02 »
» » , blackish-grey, with small lenses of a grey, compact, almost cherty, pyrite-bearing limestone . . . . . 0.04 »
Shaly clay, light-yellow . . . . . 0.02 »
d) Bank of limestone, light-grey, hard and compact, with black, argillaceous parts and aerugo-green spots, rich in glauconite . . . . . 0.09 m
c) Marl, greenish-yellow . . . . . / Marl shale, grey . . . . . / » » , light-yellow . . . . . 0.09 »
b) Bed of limestone, brownish dark-grey . . . . . 0.26 »
a) » » » , » » . . . . . 0.35 »
1.62 m

In the layer g, one example of *Megalaspis limbata* and, in the layers a and b, *Megalaspis* sp., *Orthoceras* sp., *Acrotreta* cf. *nana*, and *Leptaena* sp. have been found.

I. In the true limestone quarry; dip 3° in S 52°W.

p)	Argillaceous limestone, greyish-black, with brachiopods	0.13 m
o)	Marl	0.02 »
n)	Limestone, argillaceous and shaly	0.07 »
m)	» , blackish-grey (= the ordinary Orthoceras limestone)	0.18 »
l)	» , » » » » » »	0.08 »
k)	» , » » » » » »	0.22 »
j)	» , » » » » » »	0.15 »
i)	» , » » » » » »	0.09 »
h)	» , » » » » » »	0.09 »
g)	» , » » » » » »	0.11 »
f)	Marl shale, light-grey	0.01 »
e)	Limestone, blackish-grey, hard, with brachiopods	0.18 »
d)	Marl shale	0.01 »
c)	Limestone, blackish-grey	0.90 »
b)	Shaly clay (?) drilled	0.05 »
a)	Limestone (?)	0.01 »
		2.30 m

In the limestone beds g—m, the following fossils have been found: *Megalaspis limbata* (common), *Nileus armadillo* Dalm., *Niobe* sp., *Orthoceras* sp., *Acrotreta* cf. *nana*, *Lingula* sp., and *Leptaena* sp.

The limestone bed h constitutes the bottom of the quarry in its southern part. In the middle part, however, the quarrying seems to have gone somewhat deeper. This was going on throughout the first half of the nineteenth century, during which time blocks of limestone were taken up, and, at the place, made into tombs, table tops, door-steps, etc. In the year 1860, however, the then owner of Fågelsång had to discontinue the quarrying, because of serious competition from Komstad in south-eastern Scania, where blocks of stone were to be obtained at about half the price, due to the easy access of limestone and more favourable groundwater conditions. Later on, however, in 1873, the quarry is said to have been pumped dry, and about fifty loads were quarried. — The operations in the two other limestone-quarries at Fågelsång were discontinued long before 1860.

E 21 b.

This locality indicates the southernmost limestone-quarry at Fågelsång. The strata here dip 14° in S 60°W. The following section was measured.

Shale, dark-grey, rather thinly splitting, belonging to the lower part of the subzone of *Phyllogr. nobilis*	0.80 m
Limestone-bed or a layer composed of balls of limestone (cf. loc. E 21 a, II); the following fossils were found: annelidan-jaws (single jaws of *Drepanodus*-type), *Acrotreta* cf. *nana* and *Leptaena* sp.	0.08 »
Shaly clay, dark-grey	0.03 »
Limestone	0.03 »

Shaly clay, dark-grey or light-grey	0.05 m
Limestone	0.05 »
Shaly clay, dark-grey	0.08 »
Limestone, light-grey, dark and aerugo-green spots (= d in E 21 a, II)	0.06 »
Shaly clay, dark-grey or light-grey	0.10 »
Limestone, dark-grey	0.13 »
Marl shale, dark-grey or light-grey	0.38 »
Orthoceras limestone, dark-grey	0.80 »
	2.59 m

According to Moberg (1907, p. 258), the quarry was pumped dry and cleaned out in 1907. On this occasion a boring was said to have been made to a depth of 4.2 m in limestone.

E 23.

This locality indicates the earliest known outcrop of the Geminus shale, and probably also of the shales as a whole at Fågelsång. The steep wall of shales, 5 m in height, is usually, or at least at times, covered with débris from the overlying Quaternary deposits. In 1913 the following section was measured (cf. Appendix No. 1).

	Weathered shale	0.2 m
a—b)	Shale, somewhat weathered, cut through by two fissures converging downwards	1.0 »
	Breccia (almost horizontal)	0.2 »
d—g)	Shale, black, soft, thinly splitting. — In the lower part, an almost vertical fissure, filled with breccia, 3 cm in thickness. Only a slight dislocation seems to have taken place here, there being neither faunistical nor lithological divergences between the sides of the fault	1.6 »
h—k)	Shale, black or greyish-black, somewhat harder and usually thinly splitting. — In the middle of the stratum, a curved fracture-plane	1.6 »
l—m)	Shale, blackish-grey, with rather irregular bedding planes	0.7 »
		5.3 m

The lower part of the section is on a level with the water surface of the rivulet, when the water-level is low. The layers a—g belong to the subzone of *Phyllograptus glossograptoides;* the layers h—k to the subzone of *Azygograptus falciformis*, and the layers l—m to the subzone of *Phyllograptus nobilis* (the upper part).

E 25.

The shale, occurring at the bottom of the ditch, is steel-grey, hard and baked. According to Moberg (1910: 1, p. 70), the strata belong to the Lower Dicellograptus shale, which must be due to a misprint (cf. Moberg 1896, p. 20). The following fossils have been found.

Didymogr. robustus (sparse)
» *nicholsoni* »
» *geminus* (abundant)
Pterogr. elegans »
Phyllogr. glossograptoides (sparse)
Climacogr. scharenbergi (common)
Climacogr. angustatus (sparse)
Amplexogr. maxwelli (common)
Cryptogr. lanceolatus (sparse)
» *tricornis* (common)
Obolus ornatus (abundant)
Lingula dicellograptorum (sparse)

The shale belongs to the middlemost part of the subzone of *Phyllograptus glossograptoides.*

E 32 a.

The rock is a black, soft, thinly splitting shale, with numerous fossils, at times preserved in relief. The shale is to be seen on the southern bank of the rivulet for a length of 10 m. — The strata belong to the upper part of the subzone of *Pterograptus scanicus*.

E 36.

Dark-grey, thickly splitting shale. Dip 18° in S 30°W. Fossils occur rather sparsely.

Didymogr. lentus
» *bifidus*
Climacogr. angustatus
Obolus ornatus

Probably belongs to the upper part of the subzone of *Phyllograptus nobilis*.

E 37.

Black, soft and thinly splitting shale, in which a band or lenticle of an argillaceous limestone measuring 1 cm in thickness, has been found. Dip 15° in S 35°W. Fossils:

Didymogr. robustus
» *nicholsoni*
» *geminus*
» *murchisoni*
Climacogr. angustatus
Glyptogr. teretiusculus
Amplexogr. maxwelli
Lonchogr. ovatus
Obolus ornatus
» cf. *sularpensis*
Acrotreta nana
Caryocaris sp.

Belongs to the subzone of *Phyllogr. glossograptoides*.

E 43.

The rock is a blackish-grey, rather thickly splitting shale, which is quite strongly weathered. Fossils:

Didymogr. robustus
» *geminus*
» *murchisoni*
Pterogr. elegans
Climacogr. angustatus
Amplexogr. maxwelli
Lonchogr. ovatus
Obolus ornatus

Belongs to the subzone of *Phyllogr. glossograptoides*.

E 46.

According to the investigations by Funkquist and myself, Orthoceras limestone in situ is not to be found here. (Funkquist 1919, p. 44.)

E 47 (new locality).

In 1913 I made a cutting on the southern slope of the valley between the localities E 43 and E 17, 37 m southwest of the outlet of the little rivulet of this place into Sularpsbäcken. The strata dip 8° in S 35°W and are generally water-bearing, by which the rock as well as the fossils have become preserved remarkably well. The strata have a thickness of 5.6 m, the uppermost 1.1 m

being weathered, and the lower part of the section lying 0.8 m below the surface of the rivulet. The shale, which is black and soft, and more or less thinly splitting, is usually rich in nodules of pyrite of various sizes. About 0.7 m from the lower part of the section, there is an undulatory lens of pyrite, 12 mm thick, enclosed by a mantle of a dark-grey, sparry limestone, about 4 or 5 mm thick. The lens seems to consist of nodules of pyrite grown together. 2.9 m below the upper part of the shale-wall (in the layer i), a lens 5 cm thick, consisting of blackish-grey, bituminous, crystalline limestone with small laminae of shale, was observed. — The upper part of the section (the layers a—f) belongs to the subzone of *Pterogr. scanicus* and the lower part (layers g—v) to the subzone of *Phyllogr. glossograptoides.*

E 48 (new locality).

In the attempt to locate the transition beds between the Upper Didymograptus shale and the Lower Dicellograptus shale, three cuttings (E 48, 50 and 51) were made on the southern slope of the valley, between the localities E 15 and E 32. These cuttings, however, did not give the desired results. At all these places, layers belonging to the zone of *Climacograptus putillus* were met with. As these localities, however, are of interest for other reasons, as they, for example, make it possible to establish the extension of the different zones, as well as the tectonical conditions in the Fågelsång-district, they will be mentioned here.

The locality E 48 is situated 93 m east of the locality E 15, in the southern part of the valley at the same place, where L. Ribbing made an excavation to a depth of at least 5 m (according to Moberg 1902: 2, p. 305). By my digging in 1913 the following section was measured, starting from the upper limit of the slope of the valley.

Sand, diluvial	2.9 m
Boulder clay, North-eastern moraine	3.2 »
Dark sand, in the lower part, with pieces of shale	0.7 »
Black, soft, rather thick-laminated shale in situ	0.4 »
	7.2 m

The shale dips 3 à 4° in N 56°W and the surface of the rock lies 43.6 m above sea-level and 5.5 m above the water-level of Sularpsbäcken, when the level of the water is low. On the rock, distinct striae of the land-ice have been observed, running in two different directions, the older and not very distinct striae in N 18°E, the younger and more distinct, in N 60°E. In the shale, the following fossils have been found.

Dicellogr. vagus Hadding (abundant in one layer)
Climacogr. putillus Hall (common)
» *scharenbergi* (common)
Glyptogr. teretiusculus (sparse)
Orthogr. propinquus (common)
Cryptogr. lanceolatus (rare)
Obolus ornatus (abundant)
» *fimbriatus* (common)
Lingula dicellograptorum (common)
Acrotreta nana (common)

Belongs to the zone of *Climacograptus putillus.*

E 49 (new locality).

30 m east of the locality E 43, a cutting was made on the southern slope of the valley in order to find the part of the Upper Didymograptus shale, that, with regard to the age, ought to lie between the shales in the localities E 23 and E 47. The strata here, however, as well as in the locality E 43, lie above the ordinary ground-water level, the shale therefore being strongly weathered. — *Didymograptus geminus* has been found here.

E 50 (new locality).

A cutting was made in the middle of the slope, 48 m east of the locality E 15. Below a hard and sandy moraine-clay, a shale in situ was found, belonging to the zone of *Climacograptus putillus*. The rock consists of a black, soft, thinly splitting shale dipping 8° in S 55°W. Fossils:

Nemagr. subtilis Hadding (sparse)
Climacogr. putillus (sparse)
» *scharenbergi* (sparse)
Glyptogr. teretiusculus (common)
Orthogr. propinquus (sparse)
Cryptogr. lanceolatus »
Obolus ornatus (common)
» *fimbriatus* »
» cf. *sularpensis* (common)
Lingula dicellograptorum (sparse)
Acrotreta nana (common)

E 51 (new locality).

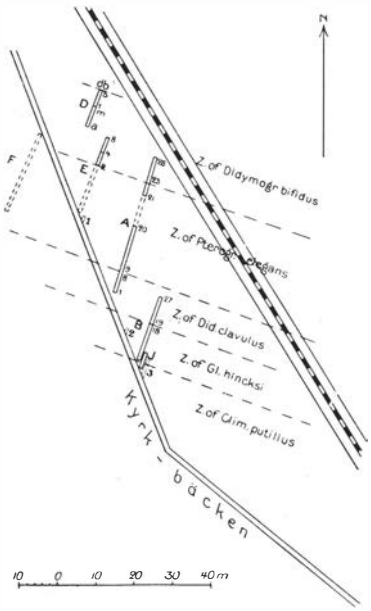
This locality is situated 22 m east of the locality E 15. On account of the dip, that was earlier observed in the locality E 15 (2—4° in south-western direction; Hadding 1913, p. 13), the bed immediately covering the Upper Didymograptus shale ought to be found here. The strata that were here exposed by digging in the lower part of the slope, 0.5—1 m above the level of the rivulet, correspond, however, to the upper part of the locality E 15 and belong to the lower part of the zone of *Climacograptus putillus*. The dip of the shale is 7° in S 84°E, and the rock consists of a black, soft, thinly splitting shale. — The following fossils have been found.

Azygogr. incurvus n. sp. (common)
Dicellogr. vagus »
Climacogr. putillus (sparse)
» *caudatus* Lapw. (common)
» *scharenbergi* (abundant)
Glyptogr. teretiusculus (sparse)
Diplogr. linnarssoni Tullb. (common)
Cryptogr. lanceolatus (sparse)
Obolus ornatus (abundant)
» *sularpensis* (common)
Lingula dicellograptorum (sparse)
Acrotreta nana (sparse)

2. Röstånga.

The Geminus shale from this place was first mentioned by Olin (1906), later by Moberg (1910: 2) and Hadding (1911 and 1913); a close investigation, however, has been made neither here nor at Fågelsång. The dip is on an average 39° in S 20°W. In the attempt to obtain the whole series of strata and their limit layers, large ditches (A—J), 0.8 à 0.9 m broad, were made in the spring

and autumn of 1919 (textfig. 4). The ditches were dug in a direction about straight opposite the dip of the layers. The thickness of the strata is only approximate. Shale in situ was generally met with at a depth of 0.7—1.1 m below the surface, under a cover of moraine-clay.



Textfig. 4. Sketch map showing the cuttings A—J by Kyrkbäcken at Röstånga. For further information as to the place indicated on this map, I refer to Hadding 1913 (p. 19, figs. 6 and 7).

The cutting B.

This cutting was begun 2 m north-west of Hadding's cutting No. 3 by Kyrkbäcken (the Church Brook), whereupon it was continued 18 m in N 19°E. The thickness of the strata was estimated at 10 m, and the following layers (from south to north or from younger to older) were met with, the figures within parenthesis indicating the dip, which here shows some range.

Zone of *Glossograptus hincksi*	Thickly splitting shale	0.35 m
	Thinly and easily splitting shale	0.60 »
	Thickly splitting shale (35° in S 14°W)	0.40 »
	Thinly splitting shale (37° in S 9°W)	0.90 »
	Thickly splitting shale (32° in S 25°W)	0.75 »
	Thickly splitting shale, poor in graptolites (37° in S 16°W)	1.30 »
	Thickly splitting shale (35° in S 14°W)	1.50 »
		5.80 m
Zone of *Didymograptus clavulus*	Thickly splitting shale (35° in S 16°W)	1.50 m
	Thinly » »	1.60 »
	Breccia (in the layer No. 25)	0.15 »
	Thinly splitting shale (55° in S 7° W; 50° in S 4° E)	1.25 »
		4.50 m

The shale is rather soft and greyish-black in colour, sparsely containing concretions of pyrite. As appears from the description of the section, a breccia 0.15 m broad, was met with in the northern part of the cutting. The dip of the fault-plane is 68° in S 28°W, and its strike N 62°W. The breccia recurs in the southern part of the cutting indicated by A (in the layer No. 2), where its breadth and the dip of the fault-plane are about the same. There is no likelihood of any considerable dislocation, the effect of this one being greatly reduced, as the strike of the fault-plane and that of the strata almost coincide. Nor is there any great difference between the dip of the fault-plane and that of the bedding planes, and the dislocation should therefore be disregarded, especially since there are neither lithological nor faunistical differences between the two sides. The dislocation may probably be thought of as a glide that set in, in connection with the uplift of the strata in the Röstånga-

district, when the great dislocations along the south-western flank of Söderåsen took place.

A.

In the northern part of the cutting B, a great many large boulders were found in the moraine, which made digging difficult, on account of which a new cutting was made, beginning close by Kyrkbäcken, 20 m north-northwest of Hadding's locality No. 3. The cutting was 38 m in length, and the thickness of the strata was estimated at 23 m. The Quaternary deposits consist of moraine-clay measuring a thickness of 0.6—0.9 m. 20 to 28 m from the southern part of the cutting, however, we find peat, mud, and sand of considerable thickness. The series of strata is as follows.

Zone of *Didymograptus clavulus*	Greyish-black, thinly splitting shale (39° in S 25°W)	0.50 m
	Breccia (layer No. 2)	0.15 »
	Greyish-black, thinly or thickly splitting shale (39° in S 8° E); in the upper part has been found a round, compressed concretion of impure limestone with a core of pyrite (diameter = 10 cm and maximum thickness = 3 cm); in the layer No. 6, a 20 cm thick breccia running in N 32° W	2.70 »
		3.35 m
Zone of *Pterograptus elegans*	Greyish-black, thickly or more thinly splitting shale; concretions of pyrite occur in the shape of balls or bands; one of these bands assumed a thickness of 3—4 cm (39° in S 16° E; 30° in S 11° W)	7.80 m
	For a distance of 8.0 m, outcrops have not been encountered; this hiatus thus corresponds to a series of strata of	5.00 »
	Dark-grey, rather thickly splitting shale, with concretions of pyrite (one of these bands had a thickness of 14 mm); in the upper part of the layer No. 24, a lens of limestone (11 cm thick, diameter = 70 à 80 cm)	2.50 »
		15.30 m
Subzone of *Azygograptus falciformis*	Dark-grey, thickly splitting shale, rich in pyrite (35° in S 29°W)	1.95 m
	The same rock, but poor in fossils (the layers No. 25—28)	2.80 »
		4.75 m

In the lower part of the layer No. 20, was found a lens of an impure, bituminous limestone 15 cm thick, containing in its lower part nodules of pyrite (maximum 2 à 2.5 cm). In the lens there were some very nice vertical fissures up to 2 à 10 mm broad, filled by white calcite, which was partly weathered. In the interior of the lens, were also some horizontal laminae of shale, thin as paper, and about 8 »paper-thin» seams of fine-grained pyrite. The lens had a diameter of about one m.

E.

In search for the layers that were not found in the middle part of cutting A, another cutting was made, beginning at Hadding's locality No. 1 and running from there 21 m in north-northeastern direction. The Quaternary deposits were everywhere moraine-clay. For quite a distance, however, solid rock

could not be found because of unfavourable groundwater conditions, digging being impossible below a depth of 1.3 m. As to the remaining part of the cutting, shale in situ was found at 0.7 m below the surface.

The following section was measured.

Subzone of *Phyllograptus glossograptoides*	Greyish-black, thinly splitting shale (Haddings loc. No. 1; in the rivulet)	0.2 m
	Rock in situ not met with; calculated thickness	8.0 »
		8.2 m
Subzone of *Azygograptus falciformis*	Dark-grey, thickly splitting shale, rich in pyrite (37° in S 20° W, 43° in S 17° W)	1.5 m
	The same rock, but poor in fossils (the layers No. 4—8)	3.6 »
		5.1 m

D.

In cutting D, the continuation of the layers in E was obtained. The cutting measured a length of 10 m, and the thickness of the strata was calculated at 6 m. The cutting terminates in its northern part with a hillock consisting of a diabase dyke.

Subzone of *Azygograptus falciformis*	The rock is a dark-gray, thickly splitting shale, rich in pyrite; in the upper part, a lens of limestone with a maximum thickness of 11 cm; (36° in S 21° W, 37° in S 22° W)	6.2 m
	Diabase	

The shale is contact-metamorphosed within a distance from the diabase of 3.8 m (measured perpendicularly to the diabase dyke).

F.

Immediately west of Kyrkbäcken, a cutting was made, in search for the middle part of the zone of *Pterograptus elegans*. To judge from the dip of the strata, this horizon in the Geminus shale ought to be met with in the ditch dug here. Even this attempt, however, was futile. The strata, sought for, seem to occur at a relatively great depth (below 1.5 m), which was impossible to reach because of unfavourable ground-water conditions. These strata are thus very difficult to find, the outcrops possibly being eroded away by the land-ice, possibly because of their softness (shaly clay, etc.). The Quaternary deposits consist of boulder-clay. In the southernmost part of the cutting a greyish-black, thinly splitting shale with a dip of 44° in S 11°E was met with. The shale belongs to the zone of *Pterograptus elegans*.

As reported to me, solid rock of shale is supposed to have been found in the well belonging to the farm, where the cuttings, just referred to, had been made. The farm is indicated as Röstånga No. 8 and lies about 100 m south-southwest of the church. The well is situated in the farm-yard and has a depth of 7.1 m. The well was pumped dry in 1920, and it was then found that the well was paved with stones, except for the lower 0.4 m, which was found to consist of shale in situ belonging to the subzone of *Azygograptus falciformis*. The strata here dip 10° in S 3°W. The shale was thickly splitting, had irregu-

lar bedding planes and was not baked by the diabase. — In another well belonging to the farm, immediately north-west of this one, diabase has been found, according to the owner.

[**IV: b** (Moberg 1910: 2).

In order to ascertain if the limestone that had been found at this place in the brook Kvarnbäcken (the Mill stream) was solid, diggings were made which indicate that the limestone, in all probability, is merely a large boulder in moraine.

3. Åkarpsmölla.

According to the publication of Lunds geologiska fältklubb (the meeting of October 26, 1915) A. Hadding had, in 1909, found the Geminus shale close to the diabase dyke at Åkarpsmölla in Konga parish, as well as northeast of this place. The shale was situated 220 m north-northwest of the mill, and had been exposed by a cutting made during the laying of the decauville rails from Konga moor (the factory of moss-litter) to Kågeröd railway station. The rock was a thinly splitting, somewhat baked, weathered shale, dipping 23° in S 28°E. The fossils, collected by Hadding, were as follows (according to my own determinations).

Didymogr. geminus (common)
» *bifidus* (rare)
» *obscurus* (abundant)
Azygogr. falciformis »
Glyptogr. teretiusculus (rare)
Amplexogr. maxwelli »
Cryptogr. tricornis (rare)
» *tricornis* var. *longispinus* (rare)
Drepanodus sp. (rare)
Obolus ornatus (common)
Lingula dicellograptorum (common)
Acrotreta nana (sparse)

The shale belongs to the upper part of the subzone of *Azygograptus falciformis*.

4. Nyhamnsläge.

Because of the reports in the geological literature of the occurrence of Geminus shale at Nyhamnsläge, I visited this place and the neighbourhood in the summers of 1916 and 1919. On both occasions, I found several boulders consisting of Upper Didymograptus shale at a place on the beach situated about 300 m north of the diabase dyke, north of Nyhamnsläge. This seems to indicate that this shale may be found in situ on the sea-bottom, not far from the beach. All boulders seem to be of about the same age and consist of a black, bituminous, thinly splitting shale. The following fossils have been found.

Didymogr. robustus (sparse)
» *nicholsoni* »
» *lentus* »
» *bifidus* (common)
» *geminus* (sparse)
» *acutus* (sparse)
» *obscurus* (abundant)
Azygogr. falciformis (sparse)
Phyllogr. angustifolius (rare)
» *nobilis* (sparse)
» *typus* var. *parallelus* (rare)
Climacogr. scharenbergi (common)
» *angustatus* (common)
Glyptogr. teretiusculus (rare)

Amplexogr. maxwelli (sparse)
Cryptogr. tricornis (abundant)
» » var. *longispinus* (common)
Lasiograptus (*Thysanograptus*) sp. (abundant in a boulder)
Drepanodus sp. (rare)
Obolus ornatus (abundant)
» cf. *deltoideus* (rare)
» cf. *sularpensis* (rare)
Caryocaris sp. (rare)

The zone of *Didymogr. bifidus* thus seems to be represented in the Cambro-Silurian district, south of Kullen.

III. Description of Species.

In this description, the locality and the associates of the different species are not included. As to these, I refer to the Appendices No. 1 and 2 (tables X and XI) and Chapter IV (p. 43). For more detailed description of most of the earlier known species, I refer to Elles and Wood (1901—1918) and the references given in that work.

Didymograptus robustus n. sp. Pl. I, figs. 1—4. Pl. II, figs. 1—2.

The stipes attain a considerable length; fragments of a length of 10—20 cm are not uncommon. They originate near the apex of the sicula and grow horizontally. The stipes widen gradually. The width at their origin is 1.0—1.2 mm (measured at the aperture of the first theca), 1 cm from the sicula 1.6—1.8 mm, 2 cm 1.8—2.0, and 3 cm 2.0—2.2 mm. The maximum breadth observed is 3.7 mm.

The sicula has a length of 1.5—2.0 mm. The thecae number 8—10 (in the proximal part 11) in 10 mm, inclined at 30—40°, and overlapping about $^2/_3$—$^3/_4$ of their length, the latter being about four times the width of the thecae. The apertural margin is slightly concave and perpendicular to the ventral margin, which, in compressed specimens, is often prolonged into a short denticle.

To this species the examples pl. II, figs. 1—2 have also been referred. Fig. 2 only differs from the typical specimens in its somewhat smaller size; the stipes have a width at their origin of 0.8 mm and 1 cm from the sicula 1.3 mm. In fig. 1 the breadth of the stipes is the same as in fig. 2, the stipes, however, not growing horizontally. They are here curved and therefore more similar to *D. superstes* Lapw.

Affinities: *D. robustus* is readily distinguished from *D. superstes* by, e. g., the greater width of the stipes in the initial as well as in the distal parts, and by the overlapping of the thecae.

Horizon: Rare—common in the whole Upper Didymograptus shale. Complete specimens are rare.

Didymograptus nicholsoni Lapworth. Pl. II, figs. 3—6.

The stipes have a length of at least 5 cm. They are small, rather straight and rigid, but sometimes bent a little backwards. The angle of divergence

is 110—160°. The width of the stipes is 0.4—0.6 mm at their origin, 2 cm from the sicula 0.7 à 0.8 mm, and the maximum width is 0.9—1.2 mm. The thecae number 9—10 (rarely 11) in 10 mm, inclined at 15—30° and overlapping about $^1/_2$ of their length. The sicula is about 1.6 mm in length.

H o r i z o n : Occurs sparsely in the zone of *Pterogr. elegans* and in the subzone of *Azygogr. falciformis*.

Didymograptus lentus Törnquist. Pl. II, figs. 7—8.
Törnquist 1911, p. 430, pl. 5, figs. 10—15.

Occurs sparsely—commonly in the zone of *Didymogr. bifidus*.

Didymograptus bifidus (Hall). Pl. II, figs. 9—15.
Törnquist 1911, p. 427; Bulman 1931, p. 33.

In addition to the earlier descriptions, the following notes may be given. The rhabdosome length is 1.5—4 cm (usually 2—3 cm). The stipes widen slowly from 0.4—0.6 mm (measured at the aperture of the first theca) proximally to a maximum of 1.5—2 mm. The stipes sligtly increase in width for almost the whole of their length; 1 cm from the sicula, the width is only 1.2—1.5 mm. The stipes, which are rather slender, diverge the first centimeter of their length and then usually become parallel. In the distal parts, however, they sometimes diverge or converge. The thecae number 15—16 (usually 15, sometimes 14) in 10 mm. The thecae are smaller than in *D. geminus*, their length being four times their width, inclined at 40—50° and overlapping $^2/_3$—$^3/_4$ of their length. The apertural margins are distincly concave in compressed specimens, giving the graptolite a characteristic notched appearance.

H o r i z o n : Occurs commonly—sparsely in the zone of the same name.

Didymograptus geminus (Hisinger). Pl. III, figs. 1—7.
Tullberg 1882: 1, p. 16; Bouček 1926, p. 3; Bulman 1931, p. 36.

The rhabdosome length is commonly 2—3 cm. The proximal end is narrow, 0.5—0.8 mm in width. One cm from the sicula, the stipes have a breadth of 1.8—2.0 mm, and the maximum width is commonly 2.5 (2—3) mm. The sicula is rather narrow and tapering, and 2.5 mm in length. The proximal end is commonly symmetrical and often finely rounded. The stipes diverge at a primary angle of about 90—100°. The widening of the stipes is rather rapid, and the stipes almost always diverge. The dorsal wall of the stipe is commonly bent somewhat outwards in the distal region.

The thecae number 13—14 (seldom 12 or 15) in 10 mm, inclined at 40—60° and overlapping $^2/_3$—$^3/_4$ of their length, this being three times their width. The apertural margins are normal, somewhat concave, and the denticles are short.

Tullberg, Elles and Wood, and many others, regard *D. geminus* as a variety, or mutation, of *D. murchisoni*. Typical examples of the two species, however, show such great difference that they should undoubtedly be separated

from each other, as two different species. Nevertheless, there are numerous intermediate forms between the two species, likewise such forms are to be found between *D. geminus* and *D. bifidus*. During the formation of the Upper Didymograptus shale, the tuning-fork *Didymograpti* have been exceedingly abundant, as they appear in great numbers in these deposits consequently showing a great fluctuation and many successive transitions.

Tullberg, as well as Elles and Wood, state that the thecae number in *D. geminus* should be constant or 12 in 10 mm, the report probably being based on observations made on a very limited number of specimens.

H o r i z o n : Occurs abundantly—sparsely in the two upper zones of the Didymograptus shale and in the uppermost part of the subzone of *Azygogr. falciformis*, but has not been found in the subzone of *Phyllogr. nobilis*.

Didymograptus geminus var. *latus* nov. Pl. III, figs. 8—11.

The stipes always diverge and have a length of 1.5—3.5 cm, their maximum width being 2.5—3.5 mm. The initial width of the stipes is 0.8—1.0 mm, and the primary angle is about 90°. The proximal end is not so finely rounded as in *D. geminus*. The thecae number is 13—14 in 10 mm. The sicula has a length of about 2—2.5 mm.

A f f i n i t i e s : The variety differs from *D. geminus* in the rapid widening of the stipes. Thus, only 1 cm from the sicula, the width of the stipes is 2.5—2.7 mm (at *D. geminus* 1.8—2.0 mm). The variety may be considered an intermediate form between *D. geminus* and *D. clavulus*. It greatly resembles *D.* aff. *amplus* described by Bulman 1931 (p. 38).

H o r i z o n : The variety has been found in the subzone of *Pterogr. scanicus* in the localities E 32 a, E 47 and E 17 at Fågelsång. At Röstånga one specimen has been found in the same horizon.

Didymograptus murchisoni (Beck). Pl. IV, figs. 1—6.

Bulman 1931, p. 34; Haberfelner and Bončev 1934, p. 32.

The stipes are robust, 4—6 cm in length, with a maximum breadth of 2.5—4 mm. The width at their commencement is 1.0—1.2 mm, and 1 cm from the sicula 1.8—2.2 mm. The sicula is large and rather blunt; it attains a length of about 3 mm. The primary angle of divergence of the stipes is less than 90° and most commonly 40—55°. The proximal end of the rhabdosome is robust. The stipes are even and straight and usually parallel along the greater part of their length, beginning at 1.5 cm from the sicula. Sometimes they somewhat diverge; in rare cases, they may cross each other near their distal ends. It is characteristic of the stipes, that they gradually widen in the first half of their length, after which they are generally of constant breadth.

The thecae number 12—14 in 10 mm, inclined at 50—60° and overlapping about $^3/_4$ of their length. The length of the thecae is about three times their width. Only compressed specimens have been found, and on these the aper-

tural margin is concave, and the ventral margin drawn out into a rather strong, but short denticle.

Horizon: Occurs sparsely—commonly (together with *D. geminus*) in the zone of *Didymogr. clavulus*, in the zone of *Pterogr. elegans* and in the uppermost part of the subzone of *Azygogr. falciformis*.

Didymograptus murchisoni var. *speciosus* nov. Pl. III, figs. 12—15.

The rhabdosome length is 2—3 cm. The stipes diverge at a primary angle of 80—100°. The sicula has a length of approximately 2.5 mm. From a width of 0.8—1.0 mm at their commencement, the stipes gradually widen to a maximum breadth, which in general attains about 2 (2.5) mm. One cm from the sicula, the width is 1.6—2.0 mm. The stipes slightly increase in width for almost the whole of their length. They are even and straight and usually seem to diverge somewhat. The thecae number 14—16 in 10 mm, and are inclined at 55—65°. Their length is three to four times their width, and the amount of overlap is about $^2/_3$.

Affinities: The variety is closely related to *D. murchisoni*, also to *D. geminus* and *D. bifidus*. From *D. murchisoni* it differs, however, in the more obtuse proximal end, by being smaller and the thecae number in 10 mm. From *D. geminus* it differs in a gradual widening of the stipes, a more robust proximal part, and the thecae number in 10 mm. It corresponds to *D. bifidus* as to the thecae number, etc., but is considerably more robust and has a thicker periderm, while *D. bifidus* is slenderer and has a thinner periderm.

Horizon: The variety occurs sparsely—commonly in the zone of *Didymogr. clavulus* and in the zone of *Pterogr. elegans*.

Didymograptus clavulus Perner. Pl. V, figs. 1—5.

Perner 1895, p. 39; Bouček 1926, p. 4, fig. 2; Bouček 1932, p. 6, figs. h—i.

The stipes are narrow at their origin, in proportion to the width they subsequently attain; at first they measure 1.2—1.6 mm, but in the large specimens they widen very rapidly to 5—6 mm. One cm from the sicula, the width is 4.0—4.4 mm. The rhabdosome length is 2—4 cm. The stipes are always somewhat divergent; their ventral edges are straight, but the dorsal edges, on the contrary, are distinctly curved. The periderm has probably been rather thick and stable. At times, it shows a fine corrugation or a slender frilling, presumably due to compression. The sicula is about 3.5 mm in length and has a width at its aperture of 1 mm. The proximal end of the rhabdosome is pointed, and the primary angle of divergence of the stipes is 70—80°.

The thecae number 14—15 in 10 mm. In their proximal ends they are inclined at 40—45°, but in their distal ends they are somewhat curved inwards. The thecae are thus slightly curved, with the exception of the proximal thecae, most of which are nearly straight. The thecae are long and narrow. About 1.5 cm from the sicula, their length is 5—7 times their width, overlapping

here $^4/_5$—$^5/_6$ of their length. The apertural margin is practically straight, and the denticle is short and tapering.

Affinities: The Swedish specimens correspond very well to the descriptions and figures of the Bohemian form given by Perner and especially by Bouček. The species resembles *D. amplus* Elles and Wood in many respects but has a much greater number of thecae in the same unit of length. The dorsal wall of the stipes is furthermore distinctly curved in *D. clavulus*.

Horizon: Common in a layer at Röstånga, in the middle part of the zone of the same name.

Didymograptus acutus n. sp. Pl. V, figs. 9—14.

The stipes are 1—1.5 (2) cm in length and have an almost uniform widh of 1.4—1.8 mm, throughout their length. The initial width of the stipes is 0.5—0.8 mm. The stipes diverge at a primary angle of about 80° and then become slightly diverging or parallel. The sicula is slender, long and narrow, and about 3 mm in length. The number of thecae in 10 mm is 13—15. The thecae are inclined at about 40°, the length being two and a half or three times their width, and are furthermore free one half their length or somewhat less. Apertural margins are straight, and the denticle is distinct. The distance between the dorsal margins is 4—8 mm.

Affinities: *D. acutus* is allied to *D. geminus* but differs in its smaller size and in the slenderer and narrower stipes. It differs, also, in a more parallel growth of the stipes and in a greater uniformity of their width. (In these respects it resembles *D. pandus* and also *D. stabilis*.) The thecae overlap by only about half their length, which gives the graptolite a pricklier appearance than *D. geminus*. *D. acutus* differs from *D. pandus* in the smaller length of the rhabdosome (half the length of this species), the somewhat more closely approximated stipes, and a slight increase in width. The species is related to the English species *D. nanus* Lapw., from which it differs by a greater number of thecae, a greater distance between the dorsal walls of the stipes, and somewhat broader stipes.

Horizon: Rare—common in the zone of *Pterogr. elegans*.

Didymograptus pandus Bulman. Pl. V, figs. 7—8.

Bulman 1931, p. 39, textfig. 15; pl. II, figs. 7—9.

The species has been found in the subzone of *Pterogr. scanicus* at Fågelsång and in the zone of *Didymogr. clavulus* at Röstånga. It occurs rather sparsely.

Didymograptus stabilis Elles and Wood. Pl. V, fig. 6.

Bulman 1931, p. 39.

A few examples have been found in the upper part of the subzone of *Phyllogr. glossograptoides* at Fågelsång.

Group of

	Sub-group of			
	D. bifidus	D. geminus	var. latus	D. murchisoni
Form of stipe	Parallel	Divergent	Divergent	Parallel
Width in mm: Proximal end	0,4—0,6	0,5—0,8	0,8—1,0	1,0—1,2
Width in mm: 1 cm from sicula	1,2—1,5	1,8—2,0	2,5—2,7	1,8—2,2
Width in mm: 2 » » »	1,5—1,8	2,3—2,7	3,0—3,2	2,2—2,6
Width in mm: Maximum	2	2—3	3,5	2,5—4
Increase of stipe	slow	rapid	very rapid	slow
No. of thecae in 10 mm	15—16	13—14	13—14	12—14
Inclination of thecae	40—50°	40—60°	40—60°	50—60°
Overlap » »	$^2/_3$—$^3/_4$	$^2/_3$—$^3/_4$	$^3/_4$—$^4/_5$	$^3/_4$
Ordinary length in cm of rhabdosome	2—3	2—3	1,5—2	4—6

Didymograptus miserabilis Bulman.
Bulman 1931, p. 40; pl. II, fig. 12.

In the locality E 47 at Fågelsång or in the lower part of the subzone of *Pterogr. scanicus* and the upper part of the subzone of *Phyllogr. glossograptoides*, I have found some examples of a slender *Didymograptus* sp. that, in all probability, belong to *D. miserabilis*. The length of the rhabdosome is only $^1/_2$—1 cm, the stipes have a breadth of 0.5—0.6 mm, and the thecae number about 7 in 5 mm.

Didymograptus obscurus n. sp. Pl. VI, figs. 1—6.

The stipes are parallel, have a uniform breadth, and a length of 0.5—1.5 cm. Their constant width is 0.6—0.8 mm, except in the proximal end, where the width is 0.3—0.4 mm. The sicula is long and slender; it measures about 2.8 mm in length and has a width at its aperture of 0.2—0.3 mm. The proximal part is rounded, and the stipes diverge at a primary angle of 90° or somewhat more.

The thecae number 13—14 in 10 mm. When compressed, the cuttings at the apertures of the thecae are very characteristic. The cuttings are usually rounded and semi-circular, and it is often impossible to distinguish them (cf. pl. VI, fig. 3), the ventral edge sometimes appearing whole, without notches. The periderm is very thin. This, in connection with its small size and the slenderness of the rhabdosome, makes a close study of the form and appearance of the thecae rather difficult.

Affinities: *D. obscurus* resembles *D. climacograptoides* Holm MS (Bulman 1931, p. 41) in its general shape, but may be distinguished by the thecae

D. murchisoni.

D. bifidus		Sub-group of *D. indentus*				
var. speciosus	D. clavulus	D. acutus	D. pandus	D. stabilis	D. miserabilis	D. obscurus
Nearly parallel	Divergent	Nearly parallel	Divergent	Parallel	Parallel	Parallel
0,8—1,0	1,2—1,6	0,5—0,8	(0,7)	0,5—0,7	0,5	0,3—0,4
1,6—2,0	4—4,4					
2,0—2,4	5—6					
2 (2,5)	6	1,4—1,8	1,2—1,5	1,4—1,5	0,5—0,6	0,6—0,8
slow	very rapid	nearly uniform	uniform	uniform	uniform	uniform
14—16	14—15	13—15	14	13—14	14	13—14
55—65°	40—45°	40°	40°	40°	40°	
$^2/_3$	$^4/_5$—$^5/_6$	$^1/_2$—$^2/_3$	$^1/_2$	$^1/_2$		
2—3	2—4	1—1,5	2—3	2—3	0,5—1	0,5—1,5

number in a given unit of length and by the appearance of the apertures of the thecae. *D. obscurus* thus has a much shallower curvature than the other species.

Horizon: Occurs commonly—sparsely in the zone of *Didymogr. bifidus* and in the lowest part of the subzone of *Phyllogr. glossograptoides.*

Janograptus laxatus Tullberg. Pl. VI, figs. 7—8.

Tullberg 1880, p. 315; pl. 11, figs. 3—9.
Hadding 1913, p. 35, pl. I, figs. 19—22.

Occurs sparsely—commonly in the two upper zones of the Upper Didymograptus shale and in the zone of *Glossogr. hincksi.*

Janograptus gracilis n. sp. Pl. VI, figs. 9—10.

Complete specimens or long fragments of stipes have not been found, only two proximal parts and some fragments of stipes. The width of the stipes seems to be constant and is 0.6—0.8 mm. The stipes are not horizontal but somewhat reclined. They thus form a parabolic curve, their apex being the proximal end. The sicula is unknown, and the proximal end corresponds to that of *Janogr. laxatus.* The thecae number is 7—8 in 10 mm, the angle of inclination 20—25°, and they overlap for $^1/_3$—$^2/_5$ of their length. The apertural margin of the theca is straight and forms an angle of 80—85° with the ventral wall, this also being straight.

Affinities: The species is related to *Janogr. laxatus,* but is distinguished by half as broad stipes and more remote thecae; the overlap is not so great, and the thecae are inclined at a more acute angle.

Horizon: Sparse in the zone of *Pterogr. elegans.*

Tetragraptus quadribrachiatus (Hall). Pl. VI, fig. 11.

Of this species I have found two examples in the lower part of the subzone of *Phyllogr. nobilis* in the loc. E 21 b at Fågelsång. I have also found four specimens in an old collection (1892) of graptolites from this locality.

Pterograptus elegans Holm.
Holm 1881, Hadding 1911.

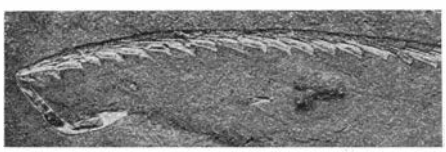
The species occurs sparsely—abundantly in the zone of the same name.

Pterograptus scanicus Moberg.
Moberg 1901, Hadding 1911.

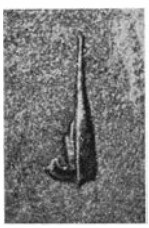
The species occurs commonly—sparsely in the subzone of the same name.

Azygograptus falciformis n. sp. Pl. VI, figs. 12—16; textfigs. 5 and 6.

The stipe is slender at its origin, being 0.2—0.4 mm in breadth, but it widens rapidly up to a maximum width of 1—1.8 (usually 1.2) mm. It widens most rapidly in the first 4—5 mm. The width, 1 cm from the sicula, is 1 mm. The stipe may have a length of 3—6 cm. The thecae are rather long and narrow, and their length is generally 2.5 and breadth 0.4 mm. The thecae number 8—9 (in the proximal part 10) in 10 mm, and overlap for about $^1/_2$ their length (textfig. 5). At the aperture of each theca, there is, at least on compressed examples, a rounded excavation in the ventral wall in the next younger theca. Otherwise, the ventral wall of the theca is straight, and their distal part is, when compressed, drawn out into a fine point or bristle, 0.3—0.4 mm in length, and usually directed straight outwards, or often curved backwards like a hook.



Textfig. 5. *Azygograptus falciformis* n. sp. Distal portion of a stipe in relief. 3/1. — Fågelsång, E 21 a, d.



Textfig. 6. *Azygograptus falciformis* n. sp. Young example showing the sicula with nema and the first theca in relief. 12/1. — Fågelsång, E 23, k.

The sicula measures 0.8—1 mm in length. At the apex, it is provided with a nema, 1.2 mm in length. The aperture of the sicula has a width of 0.1 à 0.2 mm and is, on both sides, often supplied with a very fine and short turned-down setiform appendage (0.1—0.2 mm in length). The first theca originates 0.2 mm from the apex of the sicula and then continues, closely pressed to the side of the sicula, almost to the aperture, where it suddenly curves

straight outwards, although turned a little downwards. One of my examples is a very young specimen, which is preserved in full relief; it consists only of the sicula and the earliest theca (textfig. 6). The distal part of this theca, however, is not here directed outwards from the sicula but curved upwards in a semi-circular arc. During the period of growth, the theca thus seems to have had a distal part, which was more or less rolled up. Later on, however, the latter gets its final position in the direction of the stipe, when the next theca is budding.

On compressed specimens, the sicula has a decidedly greater width than was mentioned above, the proximal part of the first theca not being distinguishable from the sicula. The two earliest thecae are directed almost straight outwards, or somewhat obliquely downwards. After the third theca, however, the stipe turns somewhat upwards and in the distal part obliquely downwards, the stipe thus obtaining a remarkably even and fine sickle-form.

Affinities: *Azygogr. falciformis* differs considerably from earlier described *Azygograptus*-species with the exception of *A.* (*?*) *oelandicus* (Bulman 1936, p. 46). It somewhat resembles *A. mobergi* Hadding (1913) with regard to the form of the thecae. From this species it is easily distinguished by the thecae number in 10 mm, the width of the stipe, the position on the sicula at which the stipe originates, the aspect of the thecae in the distal part, etc.

Horizon: Sparse—abundant in the subzone of the same name, but occurs also sparsely in the uppermost part of the subzone of *Phyllogr. nobilis*.

Azygograptus incurvus n. sp. Pl. VI, figs. 17—20.

Of this species one usually only finds fragments, i. e. the greater part of the stipe with the exception of the proximal end, and I only managed to come across two rather badly preserved examples with sicula, together with several fragments.

The sicula seems to have a length of about 1 mm, and the stipe arises close to the aperture of the sicula. The proximal part of the first theca is closely pressed to the side of the sicula and directed downwards towards its aperture. The distal part, however, is turned outwards and somewhat upwards. The stipe has a length of 1—2 cm, and is vigorously curved and semi-circular throughout its length. The width is in the proximal part 0.1—0.2 mm and in the distal part 0.4—0.6 mm.

The thecae number is 7—8 in 10 mm. The thecae are long and narrow, and the ventral wall of each theca has a rounded excavation at the aperture of the next older one.

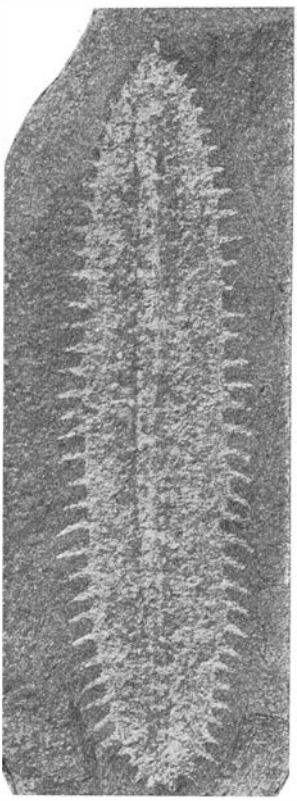
Affinities: *Azygogr. incurvus* somewhat resembles *A. mobergi* Hdg. It may, however, be readily distinguished from that species by the semi-circular rhabdosome and more closely-set thecae.

Horizon: *Azygogr. incurvus* has been found at the locality E 51 (0.5—1 m above the level of the rivulet), in the lower part of the zone of *Climacogr. putillus*. Professor Hadding has informed me that the species also oc-

curs in the locality E 15, 1.5—2 m above the zone of *Glossogr. hincksi*. The species was not mentioned by Hadding in 1913, as he could obtain only fragmentary specimens.

Phyllograptus angustifolius Hall. Pl. VI, fig. 21.
Holm 1895, p. 29; Törnquist 1904, p. 12; Bulman 1936, p. 39.

The rhabdosome is 2.5—2.7 cm in length. The greatest breadth, 4—5 mm, is attained at about 5—7 mm from the sicula. From here the rhabdosome gradually narrows upwards, towards the distal end, which is rather pointed. The thecae number 11—12 in 10 mm. The length of the thecae is two—three times their width, and the inclination of their proximal part is about 50°. The curved form of the thecae and the nature of their distal part agree with the observations made on English specimens.



Textfig. 7. *Phyllograptus typus* var. *parallelus* Bulman. 3/1. — Nyhamnsläge, boulder.

Horizon: *Ph. angustifolius* is represented by only two specimens from the Upper Didymograptus shale. One is from the locality E 23 (layer f) in the lower part of the subzone of *Phyllogr. glossograptoides*. The other example has been found, associated with *Didymogr. bifidus*, in a boulder of shale at Nyhamnsläge. The species really belongs to the Lower Didymograptus shale, but Holm has also found it in the Lower Asaphus limestone at Hälludden in northern Öland. *Ph. angustifolius* thus shows a rather great vertical range. (*Ph. angustifolius* is here considered identical with *Ph. densus* Tqt.)

Phyllograptus typus var. *parallelus* Bulman.
Textfig. 7.
Bulman 1931, p. 44, textfig. 18; pl. III, figs. 3—7.

In boulders at Nyhamn I have found a few examples of a *Phyllograptus* species that surely is *Ph. typus* var. *parallelus*. The largest example has a length of 3.3 cm; the breath of the rhabdosome is 8 mm and the thecae number 10 in 10 mm. The thecal spines are about 1.5 mm in length. — Associated with this variety, the following fossils were found in the same boulder: *Didymogr. obscurus* (abundant), *D. bifidus*, *Azygogr. falciformis*, *Cryptogr. tricornis* and *Obolus ornatus*.

Phyllograptus nobilis Harris and Keble. Pl. VI, figs. 22—25.
Harris and Keble 1932, p. 41, pl. VI, figs. 3 and 4.

The rhabdosome is broad ovate to elliptical, broadest in the centre and often somewhat less pointed in the distal, than in the proximal end. A few

large specimens, however, have a somewhat pear-shaped outline with a somewhat broader proximal part. The rhabdosome is 0.6—2.5 cm in length and the breadth is 3—9 mm, the length commonly being 1—1.6 cm and the breadth 5 mm. The thecae number is 11 in 10 mm for the large specimens, and 6—7 in 5 mm for the medium-sized and smaller specimens. The length of the theca is four to five times the width. The thecae are curved (partly sigmoid) throughout their length. The aperture margin is concave, and the ventral wall of the thecae is prolonged into a distinct denticle. The thecae are not in contact for quite their full length.

Affinities: The Swedish specimens correspond well to the description and figures of the Victorian form given by Harris and Keble. Earlier the Swedish species has always been called *Phyllogr.* (cf.) *typus*. From this species, however, it differs by its smaller size, a greater number of thecae in a given unit of length, the often sigmoid curvature of the thecal walls, and the nature of the aperture.

Horizon: Common in the subzone of the same name and has been found at Fågelsång and in boulders at Nyhamn. One specimen has been found in the subzone of *Phyllogr. glossograptoides* (loc. E 23, d—f) at Fågelsång.

Phyllograptus glossograptoides n. sp. Pl. VI, figs. 26—33.

The rhabdosome is ovate — more prolonged ovate in the large specimens. In these, the sides of the rhabdosome are often parallel, with the exception of the proximal and distal part, where the rhabdosome is always evenly rounded. The species has a length of 0.5—1.7 cm. The breadth is always greatest in the centre of the rhabdosome, amounting to 3—5 mm.

The thecae number 12—14 in 10 mm; the smallest specimens have a greater number (8 in 5 mm). In specimens, with a length of about 1.5 cm and a width of about 4 mm, the following observations have been made (in the centre of the rhabdosome). The length of the thecae is 1.2—1.4 mm and the width 0.7 mm. Their proximal part is inclined at 35° towards the axis of the rhabdosome. The thecae are decidedly curved, though slightly, throughout their length, as is the case with *Ph. angustifolius*. The amount of overlap is $^1/_2$—$^2/_3$. The aperture of the theca is somewhat concave and is prolonged into a sharp triangular denticle of about 0.6 mm in length. The sicula and the two earliest thecae are distinctly directed downwards. Virgula and nema have never been observed.

Affinities: The species differs from the earlier described *Phyllograptus*-species by the fact that the thecae are not in contact throughout their length, the overlap thus being much less; the specimens have obtained a *Glossograptus*-like appearance by the compression. Only compressed examples have been found, in which only two thecal lines have been possible to discern. Along the axis of the rhabdosome, however, a scarcely detectable swelling shaped like a list, 0.8 mm in width, may be observed. Thus, this represents the dorsal wall of a third thecal line. In exceptional cases, the dorsal part has also been observed as a lengthened interspace between the two visible

thecal lines not filled up by the graptolite. In this case, the cut evidently has passed through the common canal of the third thecal line. — The species seems to have been mentioned by Tullberg in 1882 and 1883, and by Hadding in 1915, under the name of *Glossograptus* sp.

H o r i z o n : Common to abundant in the lower and partially in the middle part of the subzone of the same name.

Climacograptus scharenbergi Lapworth.
Hadding 1913, p. 50, pl. III, figs. 20—27.

The species occurs commonly—sparsely in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*, at Röstånga.

Climacograptus angustatus n. sp. Pl. VII, figs. 1—6.

The rhabdosome is 0.5—3, usually 0.8—1.5 cm in length, and the breadth is 1—1.5 mm. The proximal end has a width of 0.5—0.7 mm and is evenly rounded and blunt. The widening of the rhabdosome occurs within the first 6 mm from the proximal end, beyond which the rhabdosome has parallel sides, these being particularly even and straight. The median septum may be observed in compressed examples on the axis of the rhabdosome as a distinct furrow, which often has a somewhat inclined course, particularly in the proximal part. The sicula is 0.5 mm in length. The virgella or the apertural spine of the sicula is prominent, but narrow, and often about 3 mm in length. The distal end of the rhabdosome is prolonged into a virgula, with a length of about 12 mm. The periderm is thin and usually supplied with fine longitudinal striae, and this gives the species an especially characteristic appearance.

Thecae number (10) 11—12 in 10 mm. The thecae obviously alternate and overlap about $^1/_2$ their length. The width of the theca is 0.3—0.4 mm, and its length is about 1.8 mm. The apertural margin is straight, or somewhat concave and horizontal, or very nearly perpendicular to the axis of the rhabdosome. The upper portion of the ventral wall of the theca is straight—slightly curved outwards (in compressed examples, straight and vertical); the middle portion is convex and turns inwards, towards the centre of the rhabdosome. The lower portion, or the overlapped part of the ventral wall, is commonly straight (in the lowest part, somewhat curved) and directed downwards and somewhat obliquely inwards. The excavations occupy one quarter of the width of the rhabdosome.

A f f i n i t i e s : The species is closely related to *Cl. putillus* (Hall). It may be considered the predecessor of this species within the Upper Didymograptus shale. The two species are distinguished by the number of thecae in 10 mm, different striae of the periderm, the length of the rhabdosome, etc.

H o r i z o n : Common—abundant in the whole Upper Didymograptus shale (sparse, however, in the subzone of *Phyllogr. nobilis*) and occurs also rather commonly in the zone of *Glossogr. hincksi*, at Röstånga.

Climacograptus celsus n. sp. Pl. VII, figs. 7—11.

The rhabdosome is long and narrow, measures 3—4 cm in length and widens within the first 10 mm to its maximum width of 1.4—1.8 mm. It is about 0.8 mm wide near its origin, and the proximal end is rounded. The septum is straight and noticeable as a sharp furrow, and the distal end of the rhabdosome is produced into a virgula, 1—2 cm in length, usually inflated, with a maximum width of 0.8 mm. The virgella seems to have a length of about 1 mm.

The thecae number 10—11 in 10 mm. The free edge is somewhat curved and slightly inclined, and the apertural margin is somewhat introverted. The excavations are shallow, and occupy one-seventh of the breadth of polypary. The periderm is thin and has often longitudinal striae.

Affinities: In its general form and the characters of the thecae, *Cl. celsus* seems to resemble *Cl. antiquus* Lapw. rather much. It is, however, narrower and has a short virgella without membrane. Moreover, no spines on the basal thecae have been observed.

Horizon: Occurs sparsely in the zones of *Didymogr. clavulus* and *Pterogr. elegans* and in the uppermost part of the zone of *Didymogr. bifidus*.

Orthograptus propinquus (Hadding).
Hadding 1913, p. 47. pl. III, figs. 11 and 12.

Occurs sparsely in the zone of *Glossogr. hincksi*, at Röstånga.

Glyptograptus teretiusculus (Hisinger). Pl. VII, figs. 12—15.
Tullberg 1882: 1, p. 18; Hadding 1913, p. 43.

The rhabdosome has a length of 3—8 cm and a breadth of 2.5—3.6 mm. The thecae number 9—11 in 10 mm. The proximal end of the rhabdosome is rounded and has a breadth of 1.2 mm. The virgella is about 2 mm long and rather robust. The widening of the rhabdosome occurs within the first 10 or 20 mm from the proximal end, beyond which the sides of the rhabdosome are parallel.

The species corresponds very well to the descriptions and figures given by Tullberg and Hadding (forma γ).

Horizon: Occurs commonly—sparsely in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*, at Röstånga.

Amplexograptus maxwelli Decker. Pl. VII, fig. 16. Pl. VIII, figs. 1—8.
Decker 1935, p. 242; pl. I, figs. 1—7 and 1 a—6 a.

The rhabdosome has a length of 2—5 cm and a breadth of 1.8—2.0 mm. The tapering proximal end is rounded, 1 mm in the initial width and possesses a virgella about 3 mm in length.

In rare cases, a membrane, 1.5—2 mm long, emanating from the apertural part of the sicula, has been observed in the proximal part of the virgella. The

ventral walls of the rhabdosome diverge slowly in the first 6—12 mm from the proximal end, after which they become parallel, occasionally converging slightly in the distal part of the rhabdosome. The septum is most often visible in compressed examples as a straight furrow and is distally continued as a virgula, often 2 cm in length.

The thecae number 10—12 (usually 11) in 10 mm. The thecae are of typical Amplexograptid type. When preserved in relief, they thus have a characteristic *Diplograptus*-appearance. Compressed, they are of the general *Climacograptus* type, though not quite typical (cf. Hadding 1913, p. 45, *Diplogr. perexcavatus*), the excavations of the ventral wall not being horizontal or perpendicular to the axis of the rhabdosome but directed obliquely downwards, although some thecae occasionally present the Diplograptid appearance. In compressed specimens, the ventral edges of the thecae have a straight upper part, parallel to the axis of the rhabdosome, and a concave lower part directed inwards. The upper part usually meets the lower one at a sharp angle, from which an arched line proceeds above the lower part of the ventral edge and continues inwards to the central part of the rhabdosome.

The thecae are inclined at about 30°, and the amount of overlap is about $^1/_2$. The excavations are deep, rather wide and oblique. They occupy about $^1/_4$—$^1/_3$ the width of the rhabdosome. The apertural margins are slightly concave. — The species is common in the greater part of the Upper Didymograptus shale, but only a few examples, preserved in relief or moderately compressed have been found, all other examples being compressed and exhibiting the characteristic *Climacograptus* appearance.

A synrhabdosome of *A. maxwelli* is shown in pl. VIII, fig. 8. It has been found in the lower part in the locality E 47 at Fågelsång. The rhabdosomes radiate from a centre, and their number is 17. A couple of them are scalariform preserved; the others presenting a normal aspect (bi-profile). The rhabdosomes seem to be of different ages; the length ranges from 0.4 to 2.6 cm and the width from 1.0 to 1.7 mm. They all have a virgula, 3—6 mm in length. These virgulae seem to be combined with each other, and the centre of the synrhabdosome hereby obtains the appearance of an entangled multitude of threads. No traces of pneumatophor, gonangiae, etc. have been found. The synrhabdosome has a diameter of 5.5 cm. The rhabdosomes are not grouped evenly around the centre, but are, for the most part, gathered within $^2/_5$ of the circumference of the synrhabdosome.

Another, though smaller, synrhabdosome (diameter = 1.5 cm), probably of the same species, has been found in the upper part of the subzone of *Phyllogr. nobilis* in the locality E 21 a. It is, however, preserved in pyrite and partly covered by it, which makes a close examination impossible. On the impression of the same, however, a slight circular elevation, 3 mm in diameter, and probably the impression of the pneumatophor, may be discerned in the middle of the synrhabdosome.

Affinities: My observations of the species agree very well with the description given by Decker. The specimens of this author, however, have

been collected from a tough limestone, and it was difficult for him to secure other than small fragments. Decker's figures are therefore not so clear as to permit of a sure identification. In spite of this, I am of the opinion that the Swedish specimens are identical with the species of Oklahoma.

The species closely approaches *A. differtus* Harris and Thomas (1935). It is also obviously allied to *A. perexcavatus* Lapw. and may be considered as the predecessor of this species. From this, however, it may be distinguished by the possession of fewer thecae (10—12) in 10 mm, the smaller breadth (1.8—2 mm), and the somewhat more pointed proximal part. The specimens of *A. perexcavatus* in the Upper Didymograptus shale have a breadth of 2—2.7 mm (compressed examples), and the thecae number is 13—15. Moreover, *A. perexcavatus* has pronounced spines on the two basal thecae. Such spines I have observed only in a few cases in *A. maxwelli*, and the spines are, furthermore, very small and slight. The American specimens of *A. maxwelli* have two delicate lateral spines (according to Decker).

In the Swedish literature, the species has earlier been referred to *Diplogr.* (»*Climacogr.*») *confertus* (Linnarsson 1879, Tullberg 1882 etc.). From this, however, it differs in having broader excavations and fewer thecae.

Horizon: Common—abundant in the two lower zones of the Upper Didymograptus shale. In the subzone of *Phyllogr. nobilis* and partly in the subzone of *Azygogr. falciformis*, the species is often rather short, 1—2 cm in length, and has a thecae number of 11—13 in 10 mm. — Transient forms between *A. maxwelli* and *A. perexcavatus* are common in the upper part of the zone of *Pterogr. elegans*.

Amplexograptus perexcavatus (Lapworth).

Hadding 1913, p. 45, pl. II, figs. 21—24.

Occurs commonly in the zone of *Didymogr. clavulus* and in the zone of *Glossogr. hincksi*, but sparsely in the upper part of the subzone of *Pterogr. scanicus*, at Röstånga.

Cryptograptus tricornis (Carruthers). Pl. IX, figs. 1—5.

Hadding 1913, p. 40, pl. II, figs. 13, 14.
Hadding 1915: 1, p. 325, pl. 6, fig. 15.

The examples correspond to the descriptions given by Elles and Wood, Hadding, etc. The rhabdosome has a length of 1—3 cm and a uniform breadth of 1.5—2.0 mm. The thecae number 10 in 10 mm, and the thecae are seldom visible. The proximal end has two distinct, but rather short basal spines, with a maximum length of 1 mm. The virgula is often thin as a thread, with a length of about 1 cm. Sometimes, however, it is longer and inflated (1—2 cm long and 1.—1.5 mm broad), as is the case with *Cr. lanceolatus*.

Horizon: Rare—abundant in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*.

Cryptograptus tricornis var. *longispinus* nov. Pl. VIII, fig. 13.

The variety differs from the typical species as to the basal spines, which are long, somewhat curved and directed obliquely downwards in the proximal part. These spines, which have a length of 2—2.5 mm, recall rather much those of *Climacogr. bicornis* Hall, being more curved, however, and thus becoming directed rather straight downwards in their distal parts.

Horizon: Occurs sparsely in the zone of *Didymogr. bifidus*.

Cryptograptus lanceolatus Hadding. Pl. VIII, figs. 11—12.

Hadding 1913, p. 40, pl. II, figs. 10—12.
Hadding 1915: 1, p. 324, pl. 6, fig. 16.

In Törnquist's Collection, Geol.-Min. Inst. Lund, there are a few graptolite specimens labelled *Diplograptus dentatus* var. *appendiculatus* Tqt. The examples are badly preserved and, according to the opinion of Professor Hadding and myself, belong to the species *Cr. lanceolatus*.

Horizon: Abundant—rare in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*.

Glossograptus hincksi (Hopkinson). Pl. VIII, fig. 9.

Hadding 1913, p. 38, pl. II, figs. 1—7.
Hadding 1915: 1, p. 310, pl. 5, figs. 1—7.

One example has been found in the Upper Didymograptus shale: at the loc. E 47, Fågelsång; the subzone of *Pterogr. scanicus*.

Lonchograptus ovatus Tullberg. Pl. VIII, fig. 10.

Tullberg 1880: 2. — Hadding 1915: 1, p. 313, textfig. 3, pl. 5, figs. 10—13.

Tullberg had found two specimens of this species, his description of genus and species being based on these. The examples were found in the localities E 23 and E 43, one at each place, and in the horizon indicated by Tullberg as β, the zone of *Didymogr. geminus*.

In 1907 Hadding found an example in the locality E 37 (Moberg 1910: 1). In 1915 he described the genus as well as its species, basing the description on the three examples mentioned, and the specimens which I had collected in the locality E 23. Hadding pointed out the great resemblance of this genus to the genus *Glossograptus*, expressing the view that the only known species of *Lonchograptus* probably ought to be assigned to the genus *Glossograptus;* the genus *Lonchograptus* should thus expire.

Horizon: Occurs sparsely—commonly in the whole zone of *Pterogr. elegans* and is also characteristic of this zone.

Obolus ornatus Hadding.

Hadding 1913, p. 58, pl. V, figs. 1 and 2.

The species occurs abundantly in the whole Upper Didymograptus shale. It is the most common species in these shales. It measures 2.0—2.6 mm in

length and breadth. The width is the same as the length, or somewhat smaller (compressed specimens).

Obolus deltoideus Hadding.
Hadding 1913, p. 58, pl. V, figs. 3 and 4.

Occurs rarely—commonly in the zones of *Pterogr. elegans* and *Glossogr. hincksi*.

Obolus fimbriatus Hadding.
Hadding 1913, p. 59, pl. V, figs. 9—12.

Sparse—common in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*.

Obolus cf. *sularpensis* Hadding. Pl. IX, fig. 6.
Hadding 1913, p. 60, textfig. 22.

Has been found sparsely in the zones of *Didymogr. bifidus* and *Pterogr. elegans* at Fågelsång and in the zone of *Glossogr. hincksi* at Röstånga.

Lingula dicellograptorum Hadding.
Hadding 1913, p. 60, pl. V, figs. 14 and 15.

Rare to abundant in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*.

Lingula ? sp. Pl. IX, fig. 7.

A few specimens have been found in the zone of *Didymogr. clavulus*.

Acrotreta nana Hadding.
Hadding 1913, p. 61, pl. V, figs. 20—23.

Rare—abundant in the whole Upper Didymograptus shale.

Leptaena sp. Pl. IX, fig. 8.

The width is 2.0 and the length 3.8 mm. In the layer B 21 at Röstånga the examples, however, are larger, or 3.5×7.5 mm. — Occurs rarely in the zone of *Didymogr. clavulus* and abundantly in the lower part of the zone of *Glossogr. hincksi*.

Discina sp. Pl. IX, figs. 9—10.

Rare—sparse in the zone of *Pterogr. elegans* at Fågelsång.

Caryocaris sp. Pl. IX, figs. 11—15.

Rare—abundant in the whole Upper Didymograptus shale and in the zone of *Glossogr. hincksi*.

Annelidan-tracks. Pl. IX, fig. 16.

In an old collection, annelidan-tracks have been found on a bedding plane of shale from the locality E 32 a at Fågelsång, the subzone of *Pterogr. scanicus*.

Megalaspis limbata Sars and Boeck. Textfig. 8.
Angelin 1878, p. 18, pl. XVI, figs. 3—3 a.

Several pygidia of this species have been found in the Orthoceras limestone on the locality E 21 a at Fågelsång.

Textfig. 8. *Megalaspis limbata* Sars and Boeck.
Pygidium. 1/1. — Fågelsång, E 21 a, I.

IV. Palaeontological Review (table).

Fossils [(+) indicates that the fossil is not characteristic of the zone in question.]	Z. of Glossogr. hincksi	Z. of Didymogr. clavulus	Z. of Pterogr. elegans		Z. of Didymogr. bifidus		Fägelsång	Röstånga	Åkarpsmölla	Nyhamnsläge
			Subz. of Pterogr. scanicus	Subz. of Phyllogr. glossograptoides	Subz. of Azygogr. falciformis	Subz. of Phyllogr. nobilis				
Spongiae										
Sponge spicules	+							+		
Graptolithina										
Didymograptus robustus n. sp.		+	+	+	+	+	+	+		+
» nicholsoni Lapw.			+	+	+	(+)	+	+		+
» lentus Törnq.					+	+	+	+		
» bifidus (Hall)					+	+	+	+	+	+
» geminus (His.)		+	+	+	+		+	+	+	
» » var. latus nov.			+				+	+		
» murchisoni (Beck)		+	+	+	+		+	+		
» » var. speciosus nov.		+	+	+			+	+		
» clavulus Perner		+						+		
» acutus n. sp.			+	+			+	+		
» pandus Bulman		+	+				+	+		
» stabilis Elles and Wood				+			+			
» miserabilis Bulman			+	+			+			
» obscurus n. sp.				(+)	+	+	+	+	+	+
Janograptus laxatus Tullb.	+	+	+	+			+	+		
» gracilis n. sp.			+	+			+	+		
Tetragraptus quadribrachiatus (Hall)						+	+			
Pterograptus elegans Holm			+	+			+	+		
» scanicus Mbg			+				+	+		
Azygograptus falciformis n. sp.					+	(+)	+	+	+	+
Phyllograptus angustifolius Hall				(+)		(+)	+			+
» typus var. parallelus Bulman						(+)				+
» nobilis Harris and Keble				(+)		+	+			+
» glossograptoides n. sp.				+			+	+		
Climacograptus scharenbergi Lapw.	+	+	+	+	+	+	+	+		+
» angustatus n. sp.	+	+	+	+	+	+	+	+		+
» celsus n. sp.	(+)	+	+	+	+		+	+		
Orthograptus propinquus (Hdg)	+	(+)						+		
Glyptograptus teretiusculus (His.)	+	+	+	+	+	+	+	+		+
Amplexograptus maxwelli Decker			+	+	+	+	+	+	+	+
» perexcavatus (Lapw.)	+	+	+				+			

Fossils [(+) indicates that the fossil is not characteristic of the zone in question.]	Z. of Glossogr. hincksi	Z. of Didymogr. clavulus	Z. of Pterogr. elegans		Z. of Didymogr. bifidus		Fågelsång	Röstånga	Åkarpsmölla	Nyhamnsläge
			Subz. of Pterogr. scanicus	Subz. of Phyllogr. glossograptoides	Subz. of Azygogr. falciformis	Subz. of Phyllogr. nobilis				
Cryptograptus tricornis (Carr.)	+	+	+	+	+	+	+	+	+	+
» » var. longispinus nov.					+	+	+	+	+	+
» lanceolatus Hdg	+	+	+	+	+	(+)	+	+		
Glossograptus hincksi (Hopk.)	+		(+)				+	+		
Lonchograptus ovatus Tullb.			+	+			+	+		
Lasiograptus (Thysanograptus) sp.						+				+
Vermes										
Drepanodus sp.					+	+			+	+
Brachiopoda										
Obolus ornatus Hdg	+	+	+	+	+	+	+	+	+	+
» deltoideus Hdg	+		+	(+)			+	+		
» fimbriatus Hdg	+	+	+	+	+	+	+	+		
» cf. sularpensis Hdg	+			+	+	(+)	+	+		
Lingula dicellograptorum Hdg	+	+	+	+	+	(+)	+	+	+	
Lingula? sp.		(+)						+		
Acrotreta nana Hdg	+	+		+	+	+	+	+	+	
Leptaena sp.	+	+						+		
Discina sp.			(+)	+			+			
Gastropoda										
Pleurotomaria rotunda Hdg	+	(+)						+		
Cephalopoda										
Orthoceras sp.	+							+		
Phyllocarida										
Caryocaris sp.	+	+	+	+	+	+	+	+		+

In the zone of *Glossograptus hincksi* in Scania there also occur, according to Hadding: *Diplograptus linnarssoni* Tullb., *Dicellograptus vagus* Hdg and *Glossograptus scanicus* Hdg.

V. General Review.

The Upper Didymograptus shale (Moberg 1902), which is limited to western Scania, is well characterized by the rich occurrence of tuning-fork (pendent) *Didymograpti*. Such species, however, also occur in the upper part of the Lower Didymograptus shale, although more rarely. From these strata *D. flagellifer* Tullb. is mentioned from south-eastern Scania (Gislövshammar), and *D. minutus* Törnq. from Dalecarlia and, possibly, also from south-eastern Scania (Törnquist 1879, 1890, 1901; Holst 1892). These two species, however, have not been found in the Upper Didymograptus shale. The report of an occurrence of *D. geminus* in boulders, north of Gislövshammar (Holst 1892), is probably due to a confusion of this species with *D. flagellifer*, which occurs in boulders probably originating from solid strata in the place.

Moberg (1902, p. 44) mentions the following fossils as examples of tuning-fork *Didymograpti* in the Upper Didymograptus shale: *D. geminus*, *D. indentus*, *D. bifidus* and *D. minutus*. The species named *D. indentus* is no doubt *D. obscurus*. The report that *D. minutus* occurs in these strata is probably due to a mistake.

Because of its position between the Lower Didymograptus shale and the Lower Dicellograptus shale, the Upper Didymograptus shale may show more or less conformity with these shales, with regard to the fauna. The following table shows the vertical distribution of the different genera of graptolites in the Didymograptus shales and in the Lower and Middle Dicellograptus shales in Sweden.

The table indicates, to some extent, that, in faunistical respect, the Upper Didymograptus shale has a greater affinity with the overlying shales than with those underlying. — The transition to the Lower Dicellograptus shale is gradual and rather imperceptible, the dying out of the tuning-fork *Didymograpti* being the sole indication of the limit. Between the Lower and the Upper Didymograptus shale, we find the Orthoceras limestone of western Scania. Lithological variations, together with a certain time-interval between the formation of the Lower and the Upper Didymograptus shale, are factors which, no doubt, must have had some influence on the faunistical character of these series of strata. Besides *Didymograpti*, the genera *Phyllograptus*, *Tetragraptus*, and *Azygograptus* continue in the Upper Didymograptus shale. *Phyllograptus angustifolius* and *Tetragraptus quadribrachiatus* are species from the Lower Didymograptus shale, occurring rarely, or sporadically,

	Lower Didymograptus shale	Upper Didymograptus shale	Lower Dicellograptus shale	Middle Dicellograptus shale
Isograptus	+			
Maeandrograptus	+			
Bryograptus	+			
Trichograptus	+			
Dichograptus	+			
Clonograptus	+			
Temnograptus	+			
Anthograptus	+			
Schizograptus	+			
Holograptus	+			
Tetragraptus	+	(+)		
Phyllograptus	+	+		
Didymograptus, extensiform	+	+	(+)	
Didymograptus, pendent	(+)	+		
Azygograptus	+	+	+	
Lonchograptus		+		
Pterograptus		+		
Cryptograptus		+	+	
Janograptus		+	+	
Glossograptus		(+)	+	
Climacograptus		+	+	+
Diplograptus		+	+	+
Lasiograptus		(+)	+	+
Nemagraptus			+	
Desmograptus			+	
Dicranograptus			+	+
Dicellograptus			+	+
Leptograptus				+
Corynoides				+
Pleurograptus				+

in the lower part of the Upper Didymograptus shale. The genus *Azygograptus* is met with in the Lower and the Upper Didymograptus shale, as well as in the Lower Dicellograptus shale. The genera *Lonchograptus* and *Pterograptus* are limited to the middle part of the Upper Didymograptus shale. In its entirety, and particularly in its upper part, this series of strata has many species in common with the lower zones of the Lower Dicellograptus shale. The Upper Didymograptus shale thus shows a greater affinity, in faunistical as well as lithological respects, with the Lower Dicellograptus shale, than with the Lower Didymograptus shale.

The Upper Didymograptus shale is found at Fågelsång, Röstånga, Åkarpsmölla, by a deep boring at Stabbarp, and as boulders, although probably from beds in the place, at Nyhamnsläge. The shale is, of old (Linnarsson 1879), divided into two zones characterized by *Didymograptus geminus* and

Phyllograptus typus. In 1882 Tullberg found three subzones (γ—α) in the first-named zone. These, however, do not seem to be founded on detailed field investigations and, broadly speaking, give a rather incorrect account of the vertical distribution of the different species.

The old zone of *Didymograptus geminus*, which, above all, is characterized by *D. geminus* and *D. murchisoni*, seems to measure nearly twice the thickness of the whole Lower Dicellograptus shale. Moreover, there are several well-characterized horizons here. Consequently, this zone ought not to be maintained any longer; the denomination »the Geminus shale», however, may possibly still be used as a collective name for the two upper zones of the Upper Didymograptus shale, proposed below. *Phyllograptus typus* has surely not been found in the Upper Didymograptus shale in Scania, and therefore this species cannot be used as index fossil.

As a result of my investigations, I propose the division of the Upper Didymograptus shale into the following three zones, with subzones, given below in descending order:

Zone of *Didymograptus clavulus* Perner
- » of *Pterograptus elegans* Holm
  - Subzone of *Pterograptus scanicus* Moberg
  - » of *Phyllograptus glossograptoides* n. sp.
- » of *Didymograptus bifidus* (Hall)
  - Subzone of *Azygograptus falciformis* n. sp.
  - » of *Phyllograptus nobilis* Harris and Keble

A zone of *Didymogr. clavulus* also occurs in Bohemia (cf. Bouček 1926). In Sweden, however, the species has only been found in a layer in the middle part of the zone, and thus this species cannot be said to be characteristic of the zone as a whole. All other fossils occurring in this zone have a rather great vertical distribution and appear also in either the overlying or the underlying zone. From the overlying zone, the zone of *Didymograptus clavulus* is distinguished by the occurrence of tuning-fork *Didymograpti*. From the underlying zone, it may be separated because of the absence of the genera *Pterograptus* and *Lonchograptus*, as well as by the somewhat general appearance of *Lingula dicellograptorum*. *Amplexograptus perexcavatus* is common; *A. maxwelli* occurs only in the lowest part of the zone. *Acrotreta nana* and *Leptaena* sp. have been found sparsely in the upper part.

The zone of *Didymograptus clavulus* is found only at Röstånga, where it seems to have a thickness of about 6 m.

The intermediate zone has been denominated the zone of *Pterograptus elegans* (cf. Tullberg 1882, the subzone β). But *Lonchograptus ovatus* might also have been used as index fossil. This species and *Pterograptus elegans* are both very suitable as index fossils and are found rather well distributed in this zone. *Pterograptus elegans*, however, seems to have a greater horizontal distribution and occurs somewhat more commonly than *Lonchograptus ovatus*. Although occurring much more rarely (only one specimen), the latter has also been found

in the middle part of the subzone of *Azygograptus falciformis* at Röstånga. *Glyptograptus teretiusculus* is common in the upper half of the zone, *Amplexograptus perexcavatus* occurs sparsely in the uppermost part, and *A. maxwelli* is common in the whole zone.

The zone of *Pterograptus elegans* may be divided into two subzones, the younger characterized by *Pterograptus scanicus* and the older by *Phyllograptus glossograptoides*. *Pterograptus scanicus* is common in the first-mentioned subzone at Fågelsång where *Didymograptus geminus* var. *latus* have also been found. *Phyllograptus glossograptoides* occurs abundantly—commonly in the lower part of the older subzone, but has also been found at Fågelsång, although sporadically, in the upper part of the same subzone. In the lower part, *Lingula dicellograptorum* is common.

The zone of *Pterograptus elegans* has been found at Fågelsång and Röstånga. Because of the dislocations of the strata, and the thickness of the Quaternary deposits, etc., it was impossible to follow the zone, one stratum after the other. Its thickness at Röstånga is probably about 15 m. The thickness at Fågelsång has been estimated at about 12 m.

Didymograptus bifidus has a great horizontal distribution and is an old index fossil in many countries. This species therefore has been chosen as index fossil for the lower part of the Upper Didymograptus shale in Scania. *Didymograptus bifidus*, *D. obscurus* and *D. lentus* are characteristic for the zone, which may be divided into two subzones, the younger characterized by *Azygograptus falciformis* and the older by *Phyllograptus nobilis*.

In the subzone of *Azygograptus falciformis*, this fossil and usually also *Acrotreta nana* are common. *Didymograptus geminus* and *D. murchisoni* occur in the uppermost part of the subzone. In lithological respect, the subzone is somewhat differently developed at Fågelsång and Röstånga. In the former place, the rock consists of an almost black and, as a rule, thinly splitting shale, while in the latter place, a dark-grey, thickly splitting shale, rich in concretions of pyrite, is met with. The thickness of the subzone seems to be about 2 m at Fågelsång and about 11 m at Röstånga. In the last district, there is a layer measuring about 4 m in thickness, poor in fossils, and lying 2 m below the zone of *Pterograptus elegans*, and in this, one generally finds only *Obolus ornatus*.

In the subzone of *Phyllograptus nobilis* the index fossil is fairly common. *Didymograptus geminus* and *D. murchisoni* do not occur here. In 1896 (p. 19) Moberg states that, among other fossils, *Didymograptus geminus* and *Tetragraptus quadribrachiatus* are said to have been found in the locality E 21 b, i. e. in the lower part of the subzone, at Fågelsång. I have examined the material from this locality, collected by Moberg and Grönwall in 1892—1893, but looked in vain for *Didymograptus geminus*. The fossils, thus labelled, were found to consist solely of examples of *Didymograptus bifidus*. Four specimens of *Tetragraptus quadribrachiatus* were also found in the collection. Of this species, I myself have found two examples in the same locality.

The shale in the lower part of the subzone of *Phyllograptus nobilis* is dark-

grey, and, in the upper part of the zone, blackish-grey and therefore lighter in colour than the Geminus shale, where the colour is black or greyish-black.

The subzone is only found in situ in the Fågelsång-district, where it is accessible, however, only in its upper and lower parts. The thickness may be estimated at about 5 m. — North of Nyhamnsläge, boulders with *Didymograptus bifidus*, *Azygograptus falciformis* and *Phyllograptus nobilis*, have been found.

The transition layers between the Upper Didymograptus shale and the lower Dicellograptus shale are only known from Röstånga. Between the zone of *Didymograptus clavulus* (the northern part of the cutting B) and the zone of *Climacograptus putillus* (Hadding's locality No. 3), there is a series of strata 7 m thick, which, in all probability, represents the zone of *Glossograptus hincksi*. Only one example of the index fossil, however, has been found (in the southern part of B, layer No. 1), and this fossil will therefore probably be met with only very rarely. Fossils, not earlier found in these strata, are *Climacograptus angustatus*, *Cl. celsus* (in the lowest part) and *Leptaena* sp., the latter occurring commonly in the lower and the middle part of the zone. The genus *Dicellograptus* has not been found, but this genus rarely or sparsely occurs in the whole Lower Dicellograptus shale and particularly in its lower part (Hadding 1913). — A layer, poor in fossils and measuring a thickness of 1.3 m, occurs in this zone, 1.5 m from its lower limit. This layer has earlier been found by Hadding in his locality No. 2.

Otherwise, of the Lower Dicellograptus shale the zone of *Climacograptus putillus* has been found in three new localities, E 48, 50 and 51 at Fågelsång. In the last locality, a species, not yet described, namely *Azygograptus incurvus*, has been met with.

As to the strata underlying the Upper Didymograptus shale, several examples of *Megalaspis limbata* (pygidia) have been encountered in the upper Orthoceras limestone beds of the old quarry in the locality E 21 a at Fågelsång, during the investigations of Funkquist and myself (Funkquist 1919, p. 44). These limestone beds, however, do not direct underlie the Upper Didymograptus shale but are separated from the latter by a transition layer, varying between 0.4 and 1.1 m in thickness and consisting of limestone beds, interbedded with marl, shaly clay and marl shale (loc. E 21 a and b). These limestone beds are, from a lithological point of view, different from the true Orthoceras limestone, and contain annelidan jaws, *Acrotreta* cf. *nana*, *Leptaena* sp., *Orthoceras* sp., etc., and, in addition, a pygidium of *Megalaspis limbata*. — The conditions in the localities E 21 a and b at Fågelsång thus prove that the zone of *Didymograptus bifidus* is underlain by the zone of *Megalaspis limbata*.

As has been pointed out before, the subzone of *Azygograptus falciformis* is very differently developed at Fågelsång and at Röstånga, both as regards thickness and lithological character. The thickness seems to be about six times larger within the Röstånga, than within the Fågelsång district. On comparing the character of the shale of the intermediate zone of the Upper Didymograptus shale, we find that the strata at Röstånga are oftener developed

as mudstones, splitting into thick layers, and of somewhat lighter colour, (greyish-black or blackish-grey) than is the case with the corresponding strata at Fågelsång, where the shale is almost black and usually splitting rather easily into thin layers, and somewhat softer. The graptolite fauna, not the brachiopods, however, seems to be dependent on the nature of the shale, the graptolites being more common at Fågelsång than at Röstånga. In the most thinly splitting shale, e. g. in the locality E 32 a at Fågelsång, where the shale is also black and soft, the graptolites are so numerous, that they almost entirely cover the bedding planes. A heavy sedimentation indicated by more thickly splitting, somewhat lighter shale and a sparser occurrence of graptolites are circumstances that here seem to be rather intimately connected. At Åkarpsmölla and Nyhamnsläge, the graptolite fauna is rather rich, the rock consisting of a black, thinly splitting shale.

In Appendices No. 1 and 2 (tables X and XI) exhibiting the vertical distribution of the fossils, I have endeavoured to show the occurrence and frequency of the different species within the various horizons or levels of the same zone. Comparing the two tables, we find that, as a rule, there is a great similarity in the vertical distribution of the different fossils in the two districts.

As appears from the results of my investigations presented above, it was not possible for me to examine the series of strata of the Upper Didymograptus shale in its entirety, due to adverse field conditions referred to above, which greatly impeded the work. In spite of these »missing» layers in the stratigraphic column, I think we now have as intimate knowledge of the Upper Didymograptus shale in Scania, its stratigraphy, and fauna, as is possible to obtain at present.

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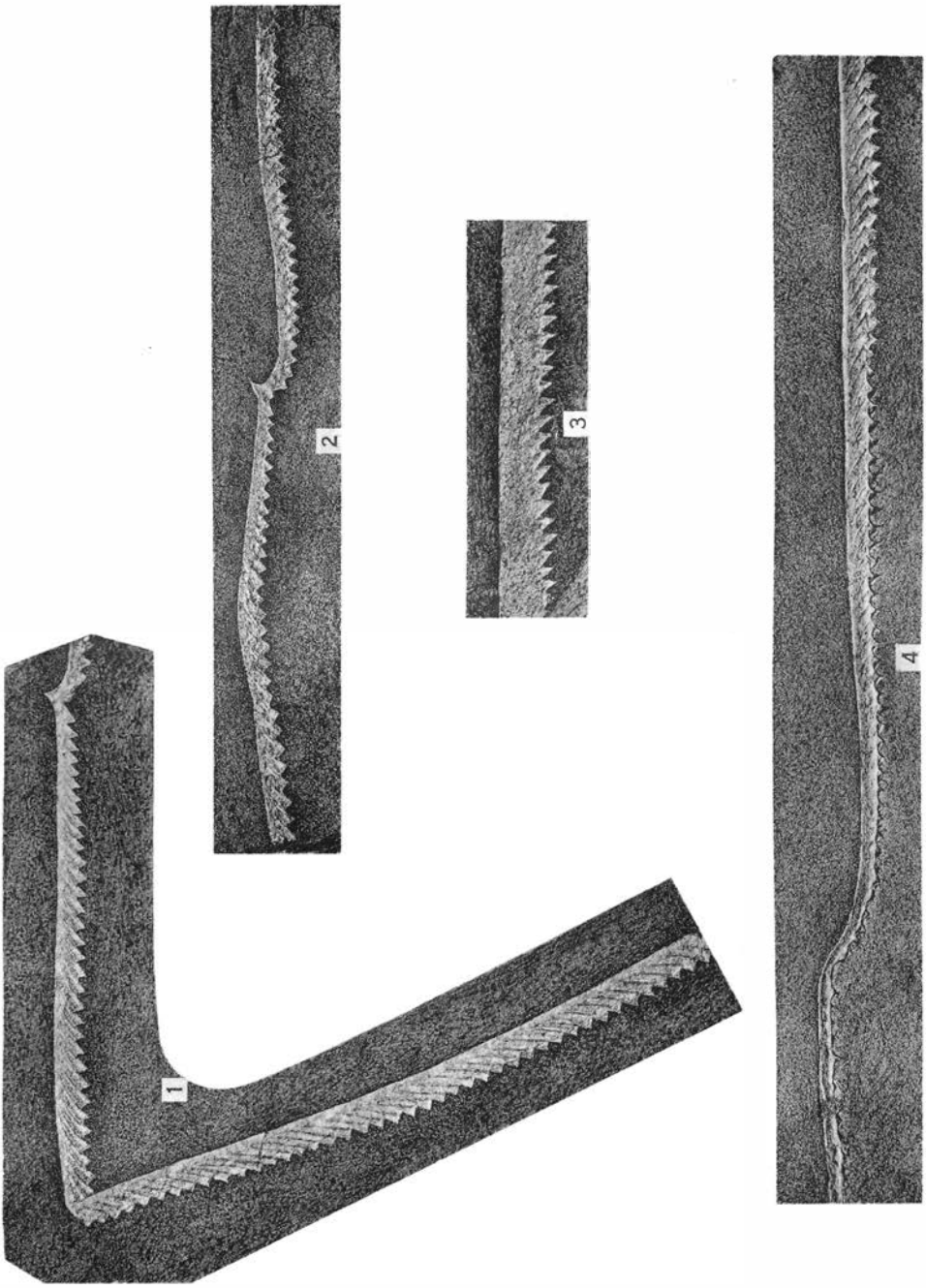
Explanation of Plates.

The type specimens of all figures are preserved in the Geological-Mineralogical Institute at the University of Lund. All figures are magnified 2 times. Unless otherwise stated, the fossils are compressed and not in relief.

Plate I.

Didymograptus robustus n. sp.

Fig. 1.	Typical specimen. *Holotype*.	Fågelsång, E 47 q.
» 2.	» »	» , E 47 t.
» 3.	Fragment of stipe, distal part.	» , E 23 e.
» 4.	In the proximal part obliquely compressed specimen.	» , E 32 a.



M. Ferm and J. W. Englund phot.
J. W. Englund and R. Norlin ret.

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Plate II.

Didymograptus robustus n. sp.

Fig. 1. Various specimen. Fågelsång, E 23.
» 2. Smaller specimen. » , E 23 f.

Didymograptus nicholsoni Lapworth

Fig. 3. Fågelsång, E 23.
» 4. » , E 23 e.
» 5. » , E 47 p.
» 6. » , E 23 h.

Didymograptus lentus Törnquist

Fig. 7. Proximal part in relief. Fågelsång, E 21 a, a—g.
» 8. Distal part of stipe in relief. » , E 21 a, III: d.

Didymograptus bifidus (Hall)

Fig. 9 and 10. Typical specimens. Fågelsång, E 21 b, old collection, from 1892.
Fig. 11. Typical specimen in half relief. Fågelsång, E 21 b, the lower part.
» 12. Typical specimen in half relief. Fågelsång, E 21 b, collection from 1892.
» 13. Younger rhabdosome, in full relief, obverse view. Fågelsång, E 21 a, h.
» 14 and 15. Younger rhabdosomes, in half relief, reverse view. Fågelsång, E 21 b, collection from 1892.

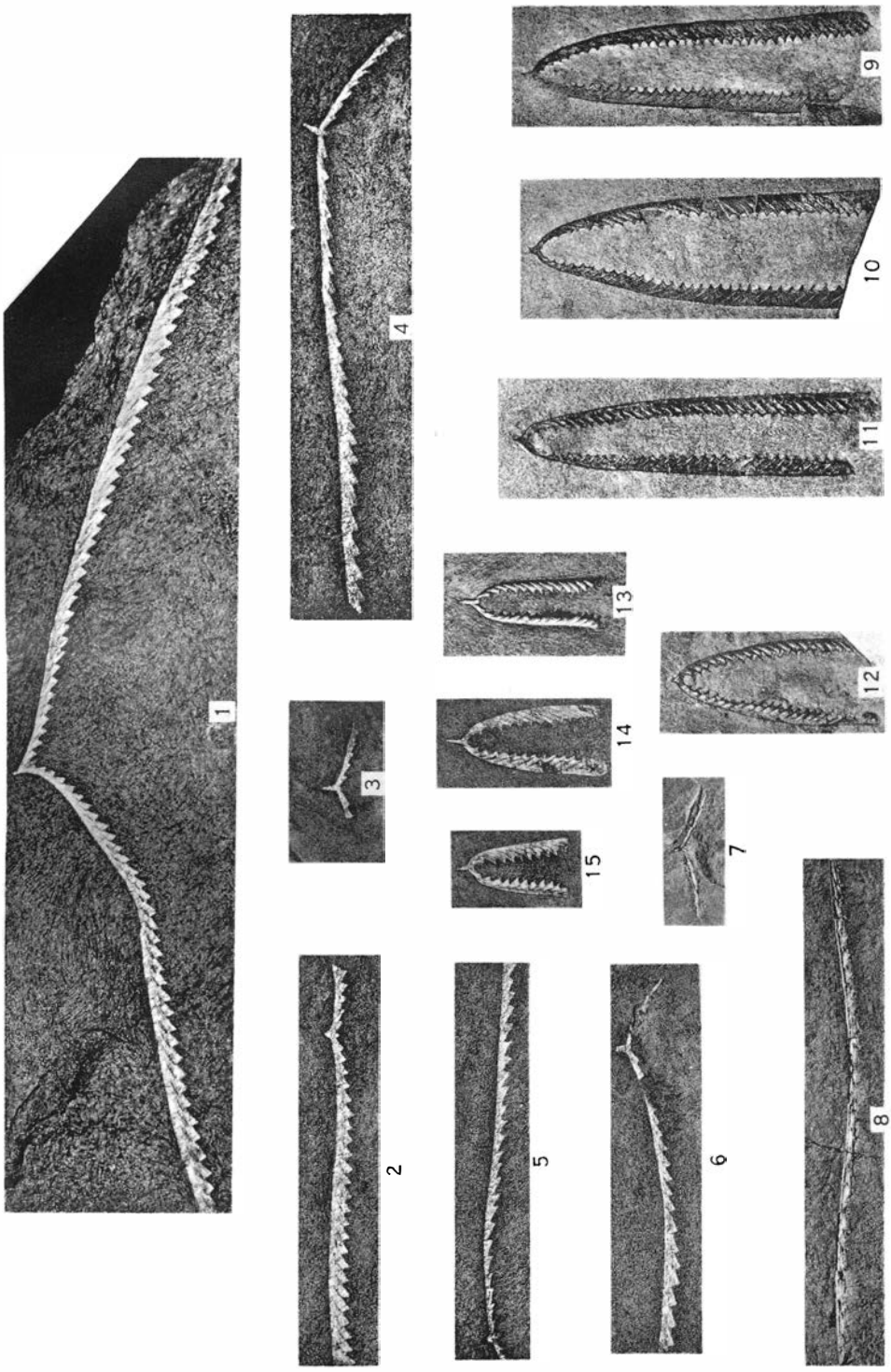

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Plate III.

Didymograptus geminus (Hisinger)

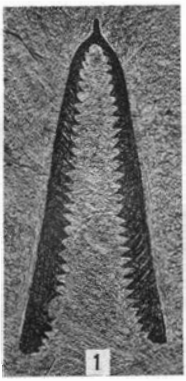
Fig. 1. Typical specimen. Fågelsång, E 47 h.
» 2. » » » , E 47 d.
» 3. » » » , E 47 h.
» 4. » » Nyhamnsläge, boulder.
» 5. Younger specimen. Fågelsång, E 23 h.
» 6. » » » , E 23 f.
» 7. » specimens. » , E 47 p.

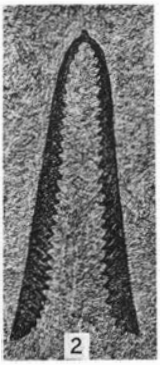
Didymograptus geminus var. *latus* nov.

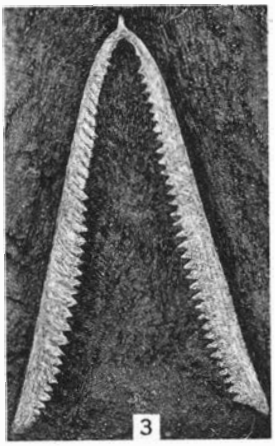
Fig. 8. Typical specimen. *Holotype*. Fågelsång, E 47 f.
» 9 and 10. Typical specimens. » , E 32 a.
» 11. Younger specimen. Röstånga, A 14.

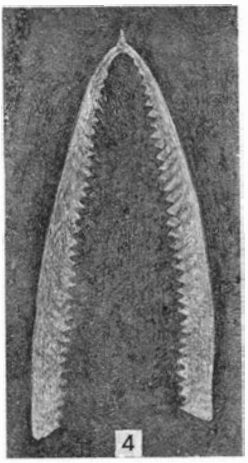
Didymograptus murchisoni var. *speciosus* nov.

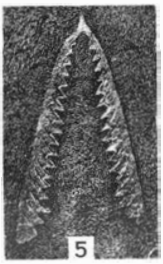
Fig. 12. Typical specimen. *Holotype*. Röstånga, A 1.
» 13. Specimen with distinctly diverging stipes. Fågelsång, E 47 t.
» 14. Example transitional to *D. murchisoni*. Fågelsång, E 47 k.
» 15. Specimen slightly differing from the typical form by more rapidly widening stipes; transitional to *D. geminus*. Fågelsång, E 47 e.

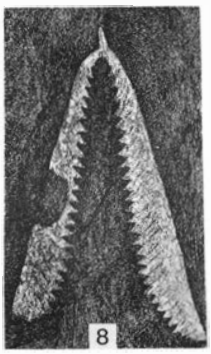


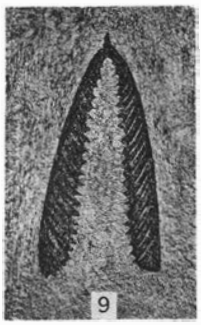


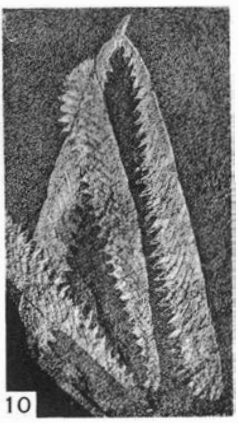


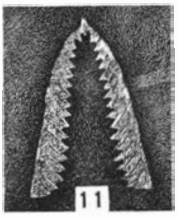


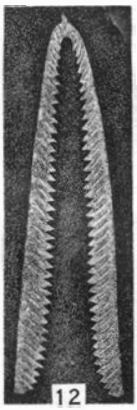


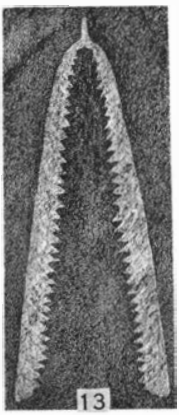


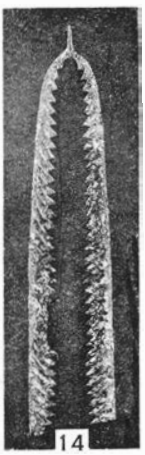












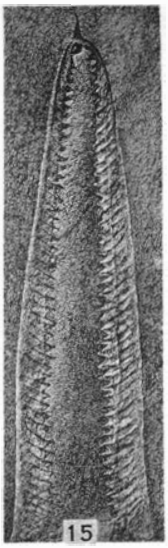


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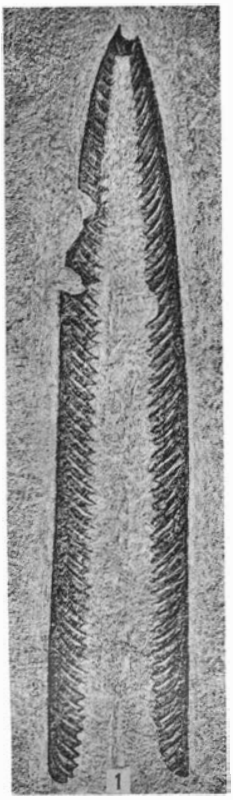
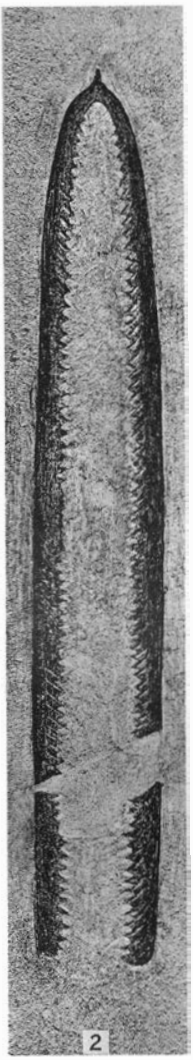
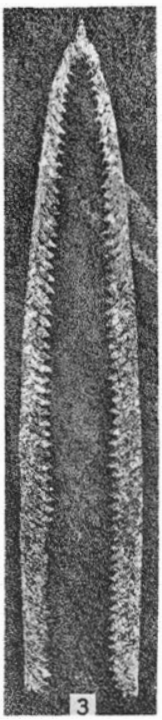
Plate IV.

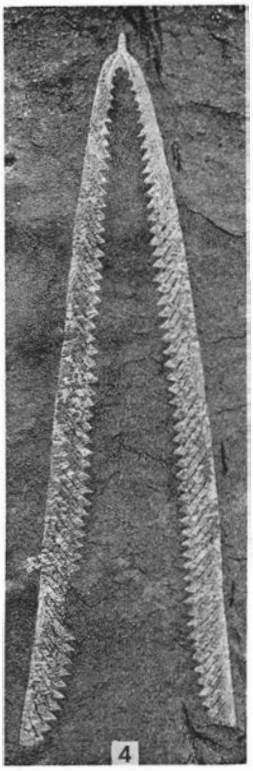
Didymograptus murchisoni (Beck)

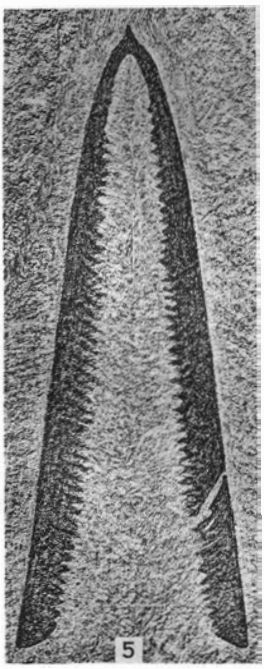
Fig. 1. Typical specimen. Fågelsång, E 47 d.
» 2. » » » , E 47 p.
» 3. » » » , E 23 f.
» 4. Example with diverging stipes. » , E 47 g.
» 5. » » » » » , E 47 u.
» 6. Form intermediate between *D. murchisoni* and *D. geminus*. Fågelsång, E 47 d.











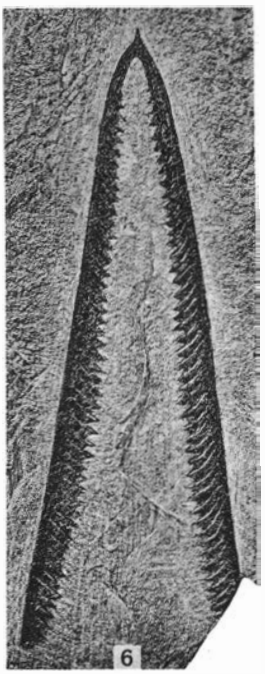


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Plate V.

Didymograptus clavulus Perner

Fig. 1—5. Röstånga, A 3.

Didymograptus stabilis Elles and Wood

Fig. 6. Fågelsång, E 47 g.

Didymograptus pandus Bulman

Fig. 7. Fågelsång, E 47 d.
» 8. Moderately compressed. Fågelsång, E 47 d.

Didymograptus acutus n. sp.

Fig. 9. *Holotype*. Fågelsång, E 47 q.
» 10. Fågelsång, E 47 k.
» 11. » , E 47 q.
» 12. Nyhamnsläge, boulder.
» 13. Fågelsång, E 47 h.
» 14. » , E 47 g.

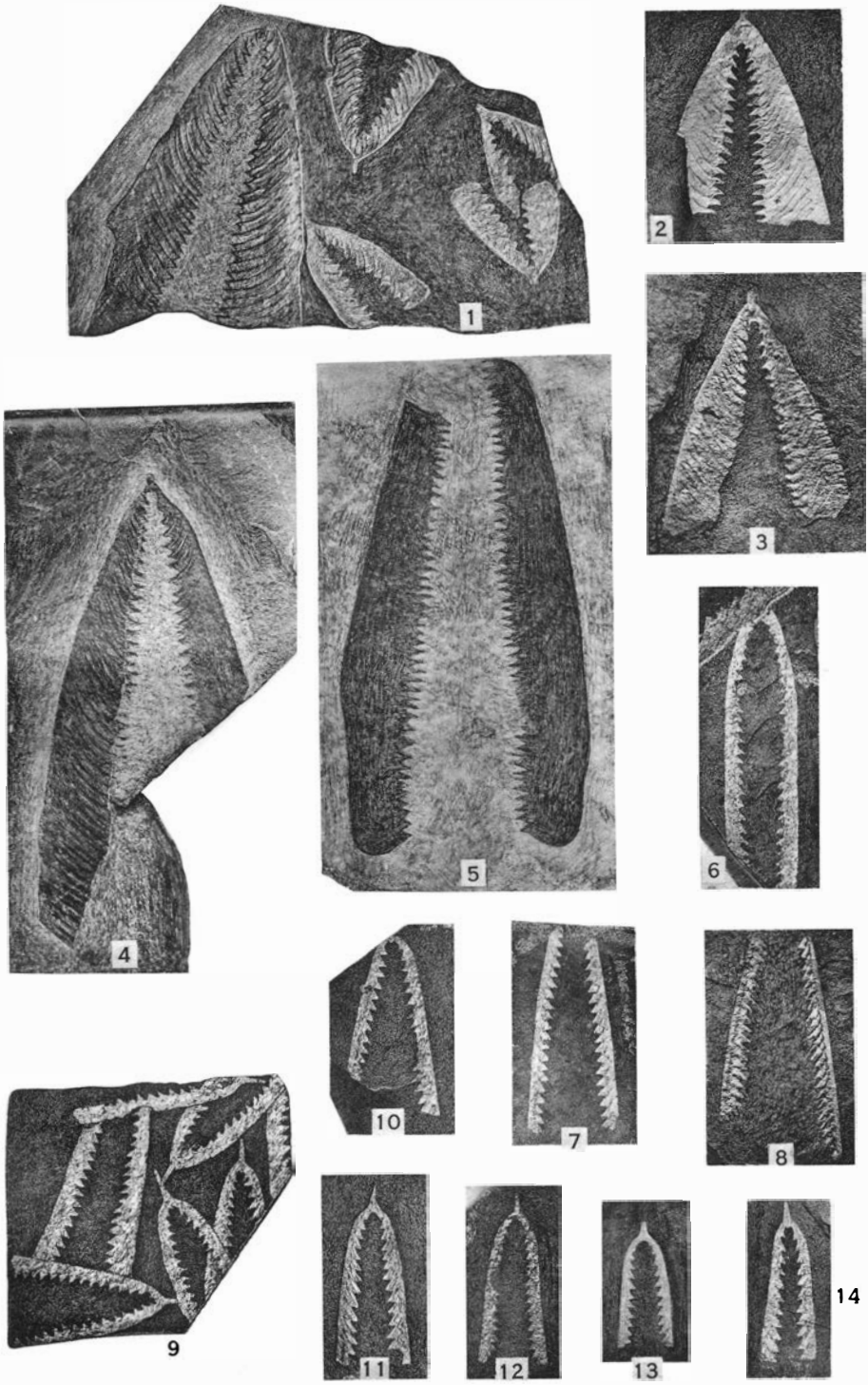

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Plate VI.

Didymograptus obscurus n. sp.

Fig. 1. Typical specimen. *Holotype*. Fågelsång, E 21 b; old collection, from 1892.
» 2. Typical specimen. Fågelsång, E 23 k.
» 3. » » Nyhamnsläge, boulder.
» 4. » » Fågelsång, E 21 b; collection from 1892.
» 5. Young specimen in relief. Fågelsång, E 23 k.
» 6. Specimen with divergent stipes, the divergence probably being due to the mode of embedment. Röstånga, D 2.

Janograptus laxatus Tullberg

Fig. 7. Proximal part. Röstånga, A 9.
» 8. Examples with smaller stipes. Fågelsång, E 47 p.

Janograptus gracilis n. sp.

Fig. 9. Proximal part. Röstånga, A 15.
» 10. » » *Holotype*. » » »

Tetragraptus quadribrachiatus (Hall)

Fig. 11. Proximal part. Fågelsång, E 21 b, collection from 1892.

Azygograptus falciformis n. sp.

Fig. 12. *Holotype*. Röstånga, D 2.
» 13. Röstånga, D 2.
» 14 and 15. Röstånga, D 1.
» 16. Röstånga, D 2.

Azygograptus incurvus n. sp.

Fig. 17. Typical specimen; complete with the exception of the proximal end. *Holotype*. Fågelsång, E 51.
» 18. Ditto. Fågelsång, E 51.
» 19 and 20. The proximal part. Fågelsång, E 51.

Phyllograptus angustifolius Hall

Fig. 21. Fågelsång, E 23 f.

Phyllograptus nobilis Harris and Keble

Fig. 22. Fågelsång, E 21 a, b—g.
» 23 and 24. Fågelsång, E 21 a, h—i.
» 25. Fågelsång, E 23 d—f.

Phyllograptus glossograptoides n. sp.

Fig. 26. Typical specimen. Fågelsång, E 47 q.
» 27. » » » » E 23 d—f.
» 28. » » *Holotype*. » » » »
» 29. Young specimen. » » » »
» 30. » » » » E 25.
» 31 and 32. » » E 23 d—f.
» 33. Distal fragment. » » »

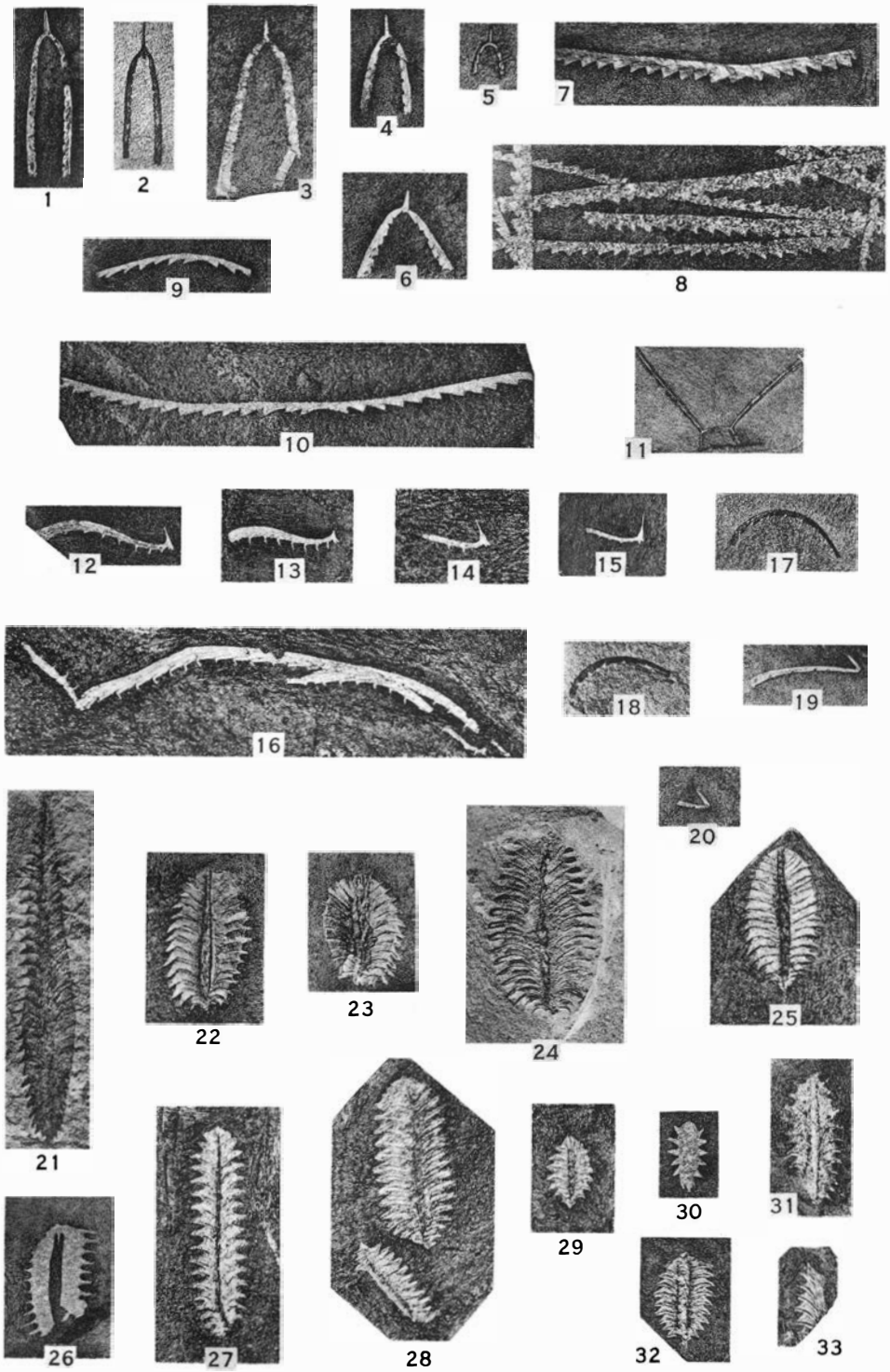

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Plate VII.

Climacograptus angustatus n. sp.

Fig. 1. Typical specimen. Röstånga, B 16.
» 2. » » Fågelsång, E 47 j.
» 3. » » *Holotype.* » , E 23 f.
» 4. Fågelsång, E 47 n.
» 5. » , E 47 k.
» 6. Form with unusually broad rhabdosome and deep excavations (rare). Fågelsång, E 47 m.

Climacograptus celsus n. sp.

Fig. 7. *Holotype.* Fågelsång, E 47 q.
» 8. Fågelsång, E 47 s.
» 9. » , E 23 h.
» 10. » , E 47 t.
» 11. Röstånga, B 16.

Glyptograptus teretiusculus (Hisinger)

Fig. 12 and 13. Röstånga, A 11.
» 14. Fågelsång, E 47 v.
» 15. » , E 47 o.

Amplexograptus maxwelli Decker

Fig. 16. Specimen, showing the characteristic *Climacograptus* appearance. Fågelsång, E 23 b.

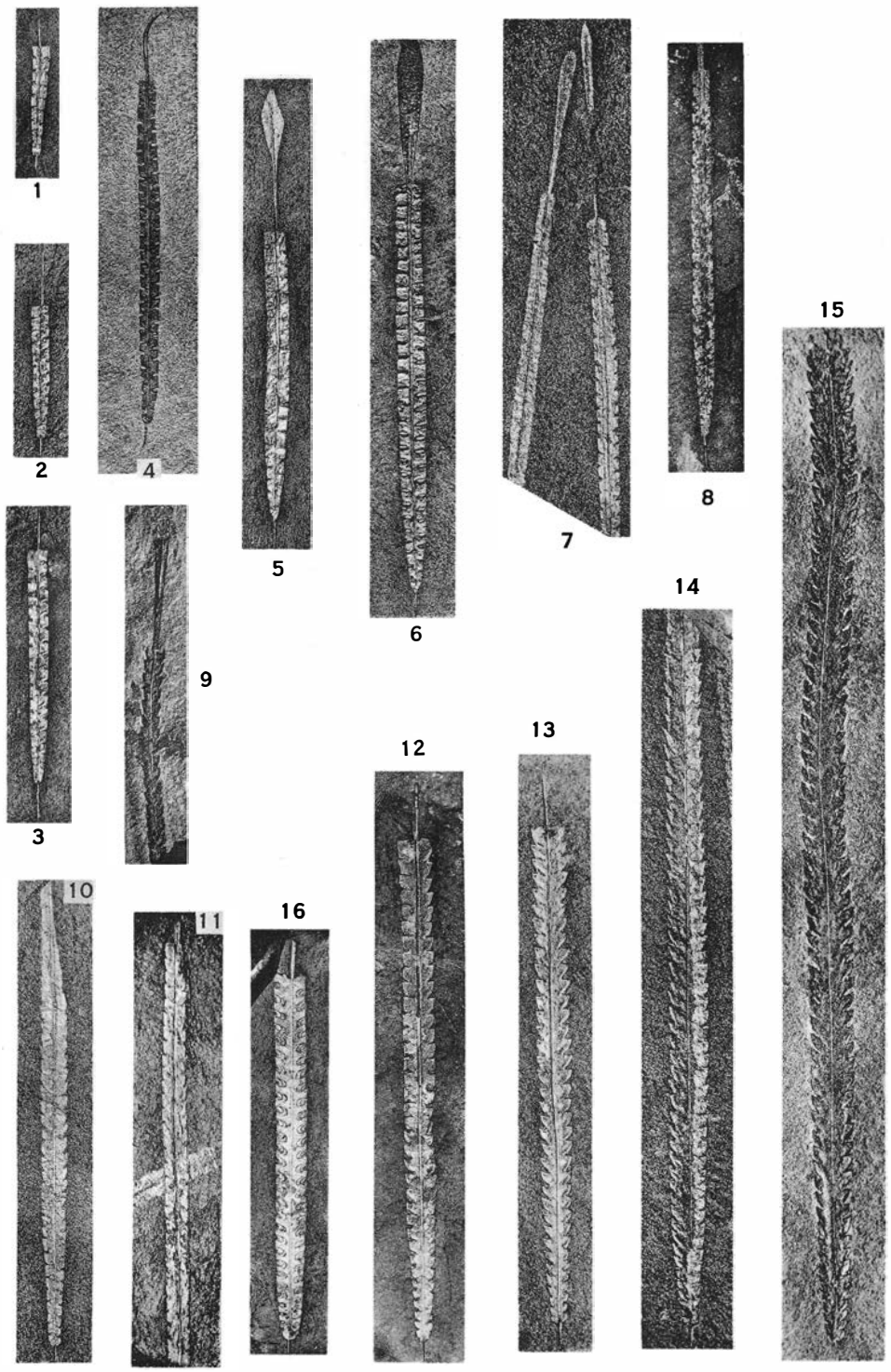

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Plate VIII.

Amplexograptus maxwelli Decker

Fig. 1. The proximal end of *Climacograptus* type; the distal end showing more the appearance of *Diplograptus*. Fågelsång, E 23 f.
» 2. Moderately compressed; *Diplograptus* appearance. Fågelsång, E 21 b; collection from 1892.
» 3. A smaller specimen; moderately compressed. Fågelsång, E 21 b; old collection.
» 4. Ditto. Fågelsång, E 21 b; old collection.
» 5. Ditto, fragment. Fågelsång, E 21 b; old collection.
» 6. Specimen with deep excavations. Fågelsång, E 47 c.
» 7. Specimen with shallow excavations — a result of compression. Fågelsång, E 47 j.
» 8. Synrhabdosome. Fågelsång, E 47 o.

Glossograptus hincksi (Hopkinson)

Fig. 9. Complete specimen, preserved in half relief and showing thecal spines. Fågelsång, E 47 a.

Lonchograptus ovatus Tullberg

Fig. 10. Not complete specimen. Röstånga, A 17.

Cryptograptus lanceolatus Hadding

Fig. 11. Young examples, probably belonging to this species. Röstånga, A 17.
» 12. Proximal part with the long and inflated virgula. Fågelsång, E 23 f.

Cryptograptus tricornis var. *longispinus* nov.

Fig. 13. *Holotype*. Fågelsång, E 21 a, b—d.


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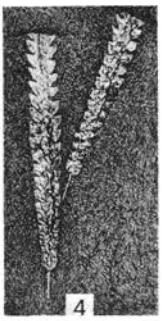
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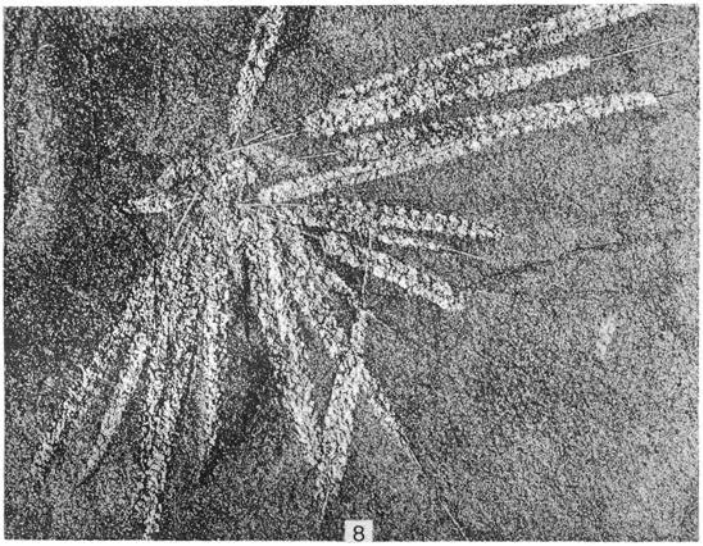
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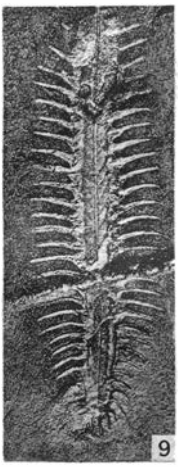
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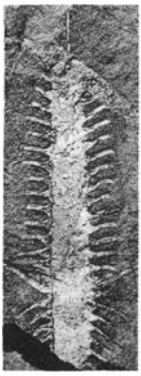
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Plate IX.

Cryptograptus tricornis (Carruthers)

Fig. 1. Scalariform view, showing basal spines and inflated virgula (not complete). Fågelsång, E 23 f.
» 2. Laterally compressed examples with inflated virgula. Fågelsång, E 47 d.
» 3. Young example. Röstånga, A 17.
» 4. » » Fågelsång, E 47 g.
» 5. » » » , E 23 a.

Obolus cf. *sularpensis* Hadding

Fig. 6. Dorsal valve. Fågelsång, E 21 a, a.

Lingula ? sp.

Fig. 7. Röstånga, A 3.

Leptaena sp.

Fig. 8. Röstånga, B 11.

Discina sp.

Fig. 9. Fragment. Fågelsång, E 47 p.
» 10. » » , E 47 l.

Caryocaris sp.

Fig. 11. Röstånga, E 2.
» 12 and 13. Fågelsång, E 23 d.
» 14. Fågelsång, E 23 f.
» 15. » , E 32 a.

Annelidan-tracks

Fig. 16. Fågelsång, E 32 a; collected by Moberg 1898.


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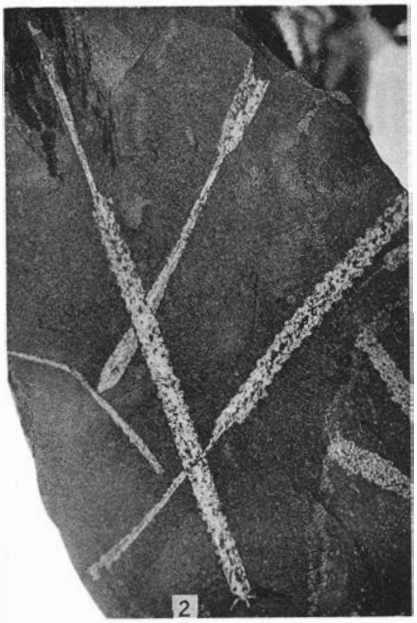
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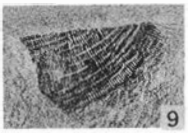
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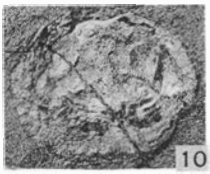
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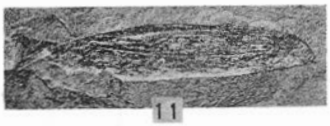
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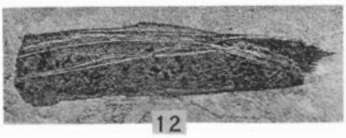
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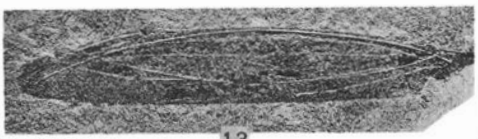
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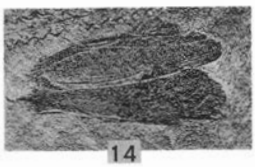
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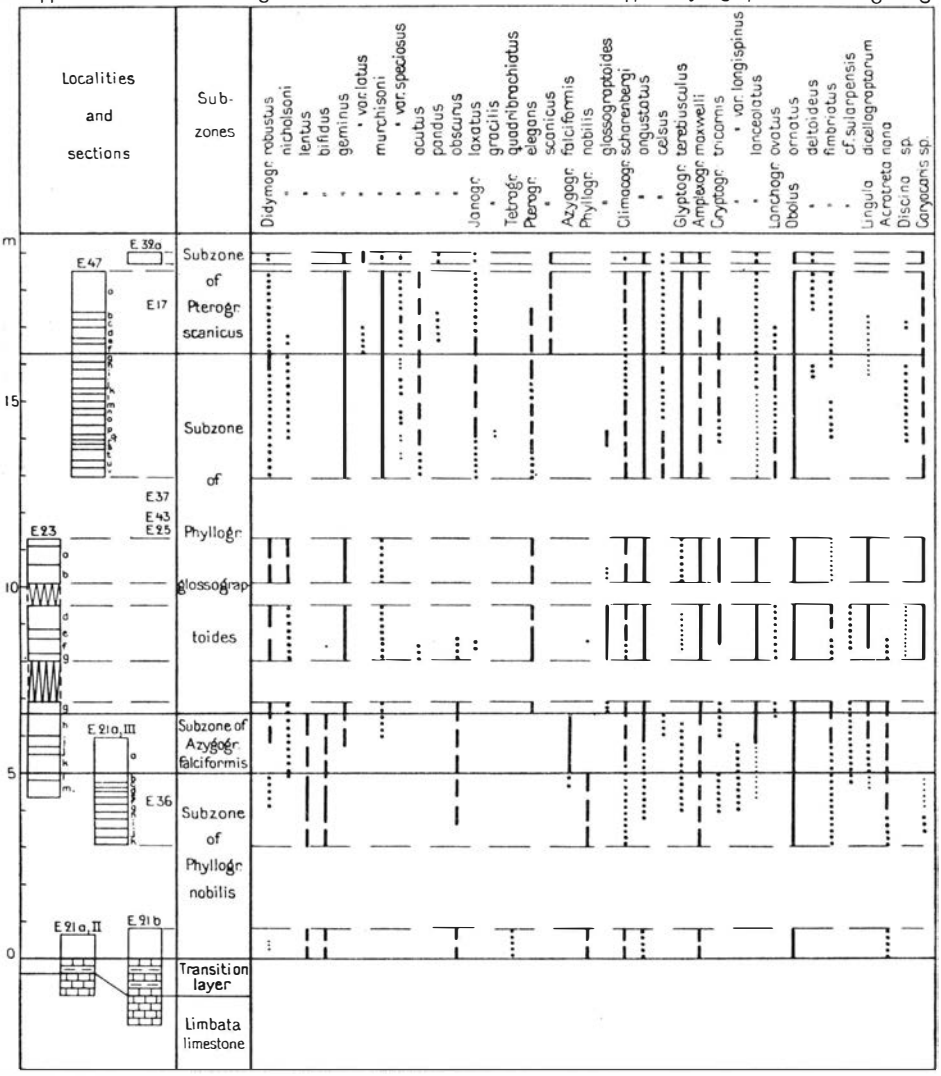
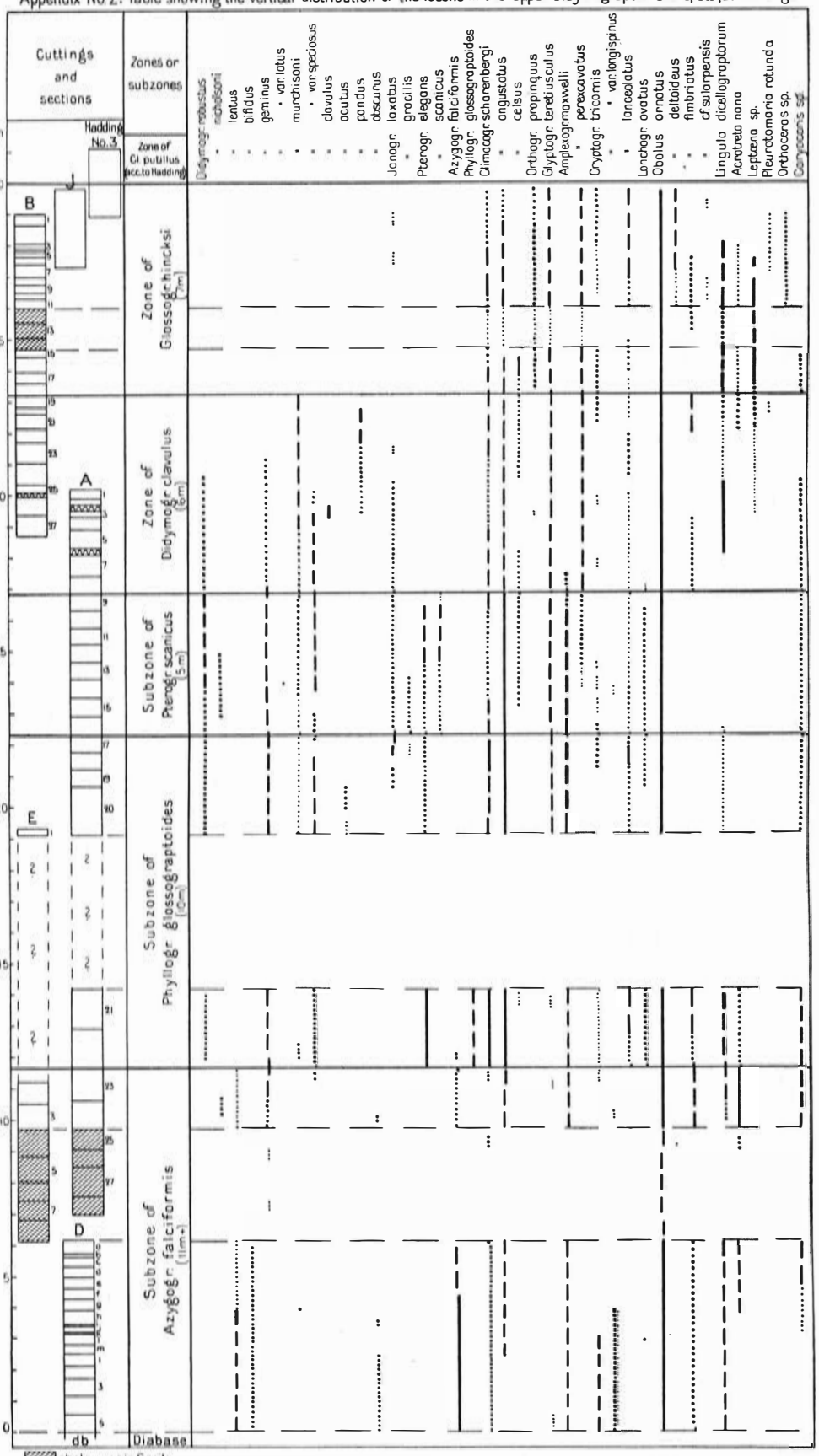
Appendix No. 1: Table showing the vertical distribution of the fossils in the Upper Didymograptus shale at Fågelsång



Appendix No 2: Table showing the vertical distribution of the fossils in the Upper Didymograptus shale, etc., at Röstånga



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