

# PLANKTONIC CRUSTACEANS FROM THE LOWER DIDYMOGRAPTUS SHALE (3b) OF OSLO

BY

LEIF STØRMER

WITH 1 FIGURE IN THE TEXT AND 1 PLATE

The rich graptolite fauna of our Lower Didymograptus Shale or Phyllograptus Shale, has been revised by Miss Astrid Monsen in the previous paper in this volume of Norsk Geologisk Tidsskrift. The present article deals chiefly with certain non-graptolite fossils which have been found together with the graptolites in the shale. In the last chapter a few remarks are given on the thick basal zone (3 b  $\alpha$ ) which deviates from the typical black shales.

More general interest has recently been devoted to the fossils associating with the graptolites in the typical graptolite shales. Ruedemann (1934) in his memoir on the the "Paleozoic Plankton of North America", has compiled and considerably extended our knowledge of these forms. It appears that not only the planktonic graptolites, but also members of the associating groups have world-wide distribution indicating strongly a similar floating habitat. Representatives of many invertebrate groups are found in the typical graptolite shales, but they are not the same as those of the homotaxial limestone facies and certain typical benthonic forms are altogether missing. The planktonic nature is also indicated by the small size, thin chitinous shells and the development of long spines in certain forms.

Fossil seaweed (*Sphenophycus*) has also been found, and Ruedemann draws an interesting parallel between the organic assemblage of the graptolite shales and the modern Sargasso-seas.

Next to the graptolites the most characteristic fossils of the graptolite shales, are remains of small crustaceans belonging to the Order Phyllocarida (= Archaeostraca). Quite a number of genera and species of these forms, only occurring in graptolite shales, have been erected (cf. Gürich 1929, van Straelen and Schmitz 1934, Chapman 1934, and Ruedemann 1934).

The most interesting and best known genus is *Caryocaris*, occurring chiefly in Ordovician graptolite shales, but found also in the Silurian (Ruedemann 1934, 1935). Abdominal remains of these small crustaceans were once (Gurley 1896) regarded as aberrant graptolites, but later Ruedemann (1921) demonstrated their true crustacean nature, and now rather complete specimens of *Caryocaris curvilatus* are known (Ruedemann 1934, pl. 22, fig. 8—9).

The genus *Caryocaris* has a very considerable geographical distribution. Species referred to the genus have been recorded from: Alaska, Canada, many different localities in U. S. A.; Peru; England, Scotland, Ireland, Belgium, Bohemia<sup>1</sup>; Australia, Tasmania, and New Zealand. The range of one species is, on account of fragmentary material, difficult to establish with accuracy, but according to the descriptions, certain species such as *C. wrightii* and *C. marri* are found both in Europe and Australia (perhaps the former also in U. S. A.), and *C. curvilatus* from several localities on both sides of the North American continent. The considerable distribution and the occurrence only in graptolite shales, present good evidence for the assumption of a true planktonic habitat of the mentioned crustaceans.

### **The non-graptolite fossils of the Lower Didymograptus Shale.**

The typical graptolite shale contains a large number of graptolite species (cf. Monsen 1937), but other fossils are practically unknown. Only inarticulate brachiopods have been recorded together with the graptolites. Brøgger (1882, p. 20) mentions also the occurrence, in the limestone beds in the lower part of the shale, of trilobite fragments which he refers to *Niobe* aff. *laeviceps* Dalm., *Megalaspis* sp. and *Symphysurus* sp. As pointed out in the last chapter, however, this fauna must be regarded as belonging to the limestone facies and not to the black shale facies which is not developed in the lower part of the Lower Didymograptus Shale.

In addition to the mentioned fossils, the Paleontological Museum in Oslo has a collection of more doubtful fossils which are described below as possible plant remains.

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<sup>1</sup> Recently also from Sweden: G. Ekström: Upper Didymograptus Shale in Scania. Sveriges Geol. Unders. Ser. C. N:o 403, 1937 p. 41.

New and interesting fossils from our Lower Didymograptus Shale fauna have recently been found by the amateur collector Mr. Gunnar Henningsmoen. In a collection of graptolites presented to the Museum, he had certain thin-shelled black fossils which I determined as remains of crustaceans. More material was later obtained from the same locality and a few specimens were also submitted to me by Miss Monsen who kindly selected them from among her graptolite material. I wish to express my gratitude to Mr. Henningsmoen for placing at my disposal the material found by him. The crustacean remains are described below.

### PLANT REMAINS (?)

Pl. fig. 1.

The figured specimen shows the characteristic branched stems which may be interpreted as remains of algae. The structures are rather distinct when the specimen is embedded in a liquid. The stems show no distinct surface structures. The section is flat elliptic with a thickness usually of about 1 mm; 3 mm has also been noticed but this is probably due to an oblique imbedding of the specimen.

A thin section shows the somewhat darker "stems" in the lighter matrix. The borders are not distinct, but are indicated by tiny thin flakes of black shale (?). In one of the branches the flakes show a certain concentric arrangement suggesting, perhaps, part of an original structure.

With its rather irregular thickness and uneven branching of the stems, the form does not seem to represent ordinary trails, neither organic nor inorganic.

Occurrence: The described fossil is common in the Lower Didymograptus Shale, especially where thin layers of black shale alternate with lighter, greyish beds. It is known from Oslo, Slemmestad and Ramtonholmen, but may probably be found in many localities of the Lower Didymograptus shale in the Oslo Region.

Observations: As pointed out by Ruedemann (1934) plant remains have been noticed in several cases in typical graptolite shales. The Norwegian remains are rather different from the prevailing wedge-shaped fronds of *Sphenophycus* (l. c. pl. 3) and differ also from the branched forms described recently by Hundt (1935) from a Downtonian graptolite shale.

ORDER *PHYLLOCARIDA* PACKARDSuborder *Ceratiocarina* J. M. ClarkeFAMILY *CERATIOCARIDAE* SALTERGenus *Caryocaris* Salter*Caryocaris* cf. *monodon* (Gurley)

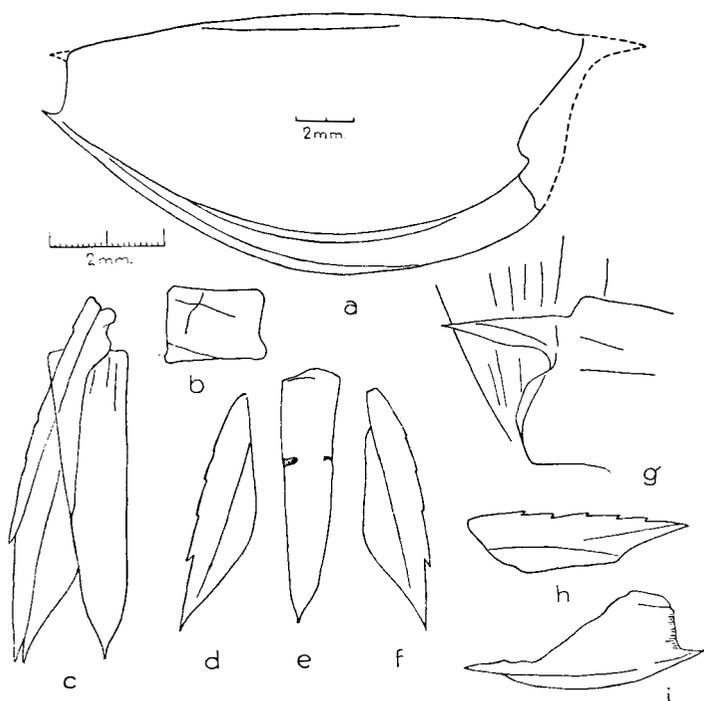
Pl. fig. 2–5, text-fig. a–i.

Cf.: *Caryocaris monodon* (Gurley), Ruedemann 1934, p. 93, pl. 22, Fig. 10–14.

In contrast to the glistening stipes of graptolites, the crustacean fragments, consisting of detached carapaces and abdominal joints, appear as dark lustreless bodies with very thin and crumbled test which are very difficult to photograph.

**Description:** The outline and general characters of carapace vary considerably, this probably being due to preservation rather than to difference in species. The carapace on pl. fig. 2 and text-fig. a seems to be the most complete. The outline (in lateral view) is subovate with slightly curved dorsal margin and more strongly curved ventral, especially in the anterior portion. The ratio length: width is 2,4 in this specimen. The anterior dorsal margin is slightly serrate and a fragment (text-fig. h) seems to belong to this part rather than representing a cercopod. According to American species, the genus possesses a rostrum. The anterior point is not preserved in the more complete carapaces, but one specimen (pl. fig. 5) shows a pointed, more thick-shelled process (text-fig. g) which may be explained as a rostrum. The ventral margin has a broad rim diminishing in width backwards towards the short transverse posterior margin. Both the dorsal and ventral margin of carapace terminate in a short spine (text-fig. a (the dorsal one broken off during preparation) and i). The posterior margin has numerous short parallel lines (text-fig. i) which may be identical with the bristles or short spines observed in American species.

The surface of carapace generally shows numerous wrinkles as demonstrated in the specimens on the plate. The lines crossing the shell are usually curved and run parallel with the outlines, giving the impression of more specimens (or valves of carapace) intangled into each other. Only the lines bordering the marginal rim are more distinct.



Text-fig. *Caryocaris* cf. *monodon* (Gurley). Fragments from the graptolite-bearing beds of Lower Didymograptus Shale (3 b) of Oslo. a, g, h, i = remains of carapace, b–f of abdomen. The dotted anterior outline of the carapace a is hypothetical. b = abdominal segment, c = telson with cercopod, d, f = cercopods, e = telson, g = probably rostrum, h = part of dorsal serrate margin, i = postlateral point of carapace.

a, g from 3 b  $\alpha$  Galleberg, coll. Astrid Monsen, a–f, h, i from 3 b  $\beta$ –3 b  $\gamma$  Tøien, coll. G. Henningsmoen.

a = Nr. 58861, b = 58798, c = 58806, d = 58841, e = 58868, f = 58805, g = K 608, h = 58843, i = 58860, of Paleont. Museum Oslo.

a, magnified half as much as the rest as indicated by the scale.

As shown on the plate, the shape and size of specimens vary considerably, but the two carapaces on figs. 2 and 3 probably approach nearest to the original form. The ratio length : width is often 3 : 1 and 4 : 1 especially in the small specimens and it is not excluded that they represent another species or variety.

Abdominal remains comprise a separate segment besides specimens of telson and cercopods. The abdominal segment (text-fig. b) has a rectangular outline. Two specimens of the styliform telson are shown on text-fig. c and e. The lateral margins converge slowly

almost to the distal point before which they converge under a larger angle.

Several specimens of the cercopods or stylets have been found. In one case (text-fig. c) it is found attached to the telson. It shows that the length of the cercopod somewhat exceeds the length of telson. The cercopods have a characteristic outline which may be traced in all specimens (text-fig. c, d and f). The plate forms almost an isosceles triangle with an angle of  $140^\circ$  facing the slightly convex lateral margin. The lateral margin is serrate with a distinct, short, backwards-directed spine in the posterior part at a distance from the posterior point of  $\frac{1}{3}$  to  $\frac{1}{4}$  the length of the plate. Three, or possibly four, notches in the lateral margin give the serrate character. The distal point is sharp. Two points seem to be present on the larger specimen on text-fig. c, but it is probably due to a splitting of the test along a median line seen also in other specimens.

Dimensions: Length measured and probable complete length (in brackets) of carapace: (numbers refer to the catalogue of Paleont. Mus. in Oslo) K 680 a = 22 mm (25 mm), K 680 b = 14,5 mm, 58852 = 24 mm, (26 mm), 58845 = 18 mm (21 ? mm), 58861 = 19 mm (21 mm); width of carapace: K 680 a = 4,5 mm, K 680 b = 3,5 mm, 58852 = 10,5 mm, 58845 = 5 ? mm, 58861 = 8,5 mm; length of telson: 58806 = 5,4 mm, 58868 = 4,4 mm; length of cercopod: 58806 = 6,5 mm, 58841 = 4,2 mm, 58805 = 4,2 mm.

Occurrence: Most of the material examined was collected by Mr. Gunnar Henningsmoen from loose shale-pieces, probably more or less in situ, 100 m north of the Paleontological Museum building at Tøien, Oslo. According to Miss Monsen, the graptolite assemblage indicates the zones  $3 b\beta$ — $3 b\gamma$ . A few specimens were also found by Miss Monsen in the zone  $3 b\alpha$  at Galgeberg, Oslo.

Observations: In spite of the fragmentary condition of the remains, it is possible to obtain some information on the morphologic structures and the specific characters. The size and shape of the described remains indicate strongly the genus *Caryocaris*. A complete specimen of *C. curvilata* figured by Ruedemann (1934, pl. 22, fig. 8 and 9) shows the same general characters of carapace and abdomen. In the American form, however, the telson and cercopods are comparatively larger than in the described Norwegian form. The ratio length of carapace: length of cercopod is 2,4:1 and about 4:1 respectively. The difference may indicate that the Norwegian material

contains more than one species (or variety) and that the abdominal remains belong to the smaller one. A specimen, however, of *C. wrightii* found in Belgium (Woodward and Jones 1888—99, fig. 6, p. 91) has carapace and a “trifid caudal appendage” slightly longer than  $\frac{1}{4}$  the length of carapace and thus agreeing with our form. The large caudal appendage of the American form may be characteristic of this particular species if it is not due to preservation.

As seen on pl. fig. 5 the surface of carapace may show numerous curved lines which are hardly due to the preservation of two valves above each other, but may be “natural to the organism” as Chapman (1934, p. 110) expresses it for the New Zealand specimens of *C. marrii*. The ribbing of the test, as well as the shape of carapace, telson and cercopods, may point to a relationship with the Devonian and Carboniferous genus *Dithyrocaris*. The Ordovician genus *Lebescontia* may belong to the same group (cf. Jones and Woodward 1888—99, p. 199).

A specific determination of the Norwegian remains is difficult to carry out because most of the established species, when it comes to more minute details, are very little known. The finer details are not shown in the illustrations and may, in many cases, not be preserved. The common Skiddawian (contemporaneous with our 3 b—c) species *Caryocaris wrightii* Salter and *C. marrii* Hicks (Jones and Woodward 1888—99, p. 89, 92) resemble the Norwegian specimens in size and shape of carapace. The two species differ in width of carapace, a characteristic which Jones and Woodward mention as a possible sexual modification. The considerable variation in the proportions of the Norwegian specimens as well as in specimens of the American *C. raymondi* Ruedemann (1934, pl. 23, 1 and 4), indicates, however, that the difference may be due to the preservation of the flexible shells. The cercopods of *C. wrightii*, known by a Belgian (Jones and Woodward 1888—99, p. 91, fig. 6) and New Zealand specimen (Chapman 1934, pl. 9, fig. 4), show no marginal spines and the species differs therefore (for the present) from the Norwegian species. Most of the other described species of *Caryocaris* (or *Rhinopterocaris* to which several species of the Southern hemisphere have been referred) seem to differ in size and characters of carapace from the present species.

In the American species *C. monodon* (Gurley) (referred to a genus *Dawsonia* interpreted as an aberrant graptolite) the cercopods show marginal spines similar to those in the Norwegian form

(Ruedemann 1934, pl. 22, fig. 11). The Norwegian material has shown that the marginal spines are not short cercopods or stylets (cf. Ruedemann 1934, p. 94) bordering a larger telson, but only spines belonging to the cercopod itself. *C. monodon* occurs in Tetragraptus-beds contemporaneous with the main lower part of our 3 b.

With our present knowledge of the earlier described species, I have not found it appropriate to suggest a new species, but to refer the Norwegian form, though with doubt, to the North American form *Caryocaris monodon* (Gurley). Further research may perhaps show that this and several other species are identical with the genotype *C. wrightii* Salter occurring in contemporaneous beds of several widely separated localities.

**Conclusions on the non-graptolite fossils.** The fragmentary, but yet rather well-preserved material of *Caryocaris* from Oslo, has furnished additional evidence to the almost constant appearance of these crustaceans in the planktonic faunal assemblage of the black graptolite shales. If we would try to find a parallel to these crustaceans in the marine plankton of to-day, one may mention the euphausids which have a wide distribution and are well-known as the main nourishment of the large whales.

It is interesting to notice that pieces of black shale from Tøien, containing fragments of *Caryocaris* and graptolites, almost only have very young larval stages of graptolites, particularly separate siculae. The large amount of young stages of floating forms is very characteristic of true plankton assemblages such as, e. g., in the spring flourishing of the plankton of modern seas.

The possible plant remains are found in abundance in lighter beds alternating with black shale. Is it possible to regard these remains as the ancient "Sargasso"-seaweeds which Ruedemann claims to be a characteristic component of the planktonic graptolite assemblages? If the interpretation as seaweed is correct, it is not unlikely, but the weeds may also have been loosened by wave action from shallow waters of the neighbourhood. The occurrence only in the somewhat lighter shales may perhaps only be a matter of difference in preservation in more or less sulphurous mud.

### Remarks on the basal zone (3 b $\alpha$ ) of the Lower Didymograptus Shale.

Brøgger (1882, p. 18—20) gives a brief description of the petrological character of the shale and points out the presence of blue-grey limestone layers and locally grey to green shale with pyrite and gypsum crystals in the lower part of the sequence. Reusch (1884, p. 110) mentions the light grey shale of the lower part of 3 b at Slemmestad. He describes the peculiar crystals, 1—5 cm in size, which are found together with pyrite in great quantities in the grey shale. The crystals are explained by Reusch as pseudomorphose after gypsum. (These crystals must not be confused with the small, real gypsum crystals which occur between the thin beds of shale both in the graptolite shale and in the Cambrian alum shale.) The pseudomorphoses and the grey shale are found in the Oslo—Slemmestad district and seem significant of the basal part of the Lower Didymograptus Shale.

Miss Monsen (1937) has suggested a division of the Lower Didymograptus Shale into 4 main zones: 3 b  $\alpha$ — $\delta$ , which have their characteristic graptolite assemblages. At Galgeberg, Oslo, the basal zone with *Tetragraptus phyllograptoides* occurs just above greyish shale with “gypsum” crystals. The succession downwards to the Ceratopyge Limestone is not exposed and it is not possible to get information of the thickness of this basal zone at Galgeberg.

In order to determine the thickness of the “gypsum” layers and their stratigraphical distributions in accordance with the graptolite zones, I examined the exposure at Bjerškåsholmen, Slemmestad. In spite of certain tectonic interruption in the middle of the section, the exposure seems to give a fairly complete section of the shale between the limestone zones 3 a  $\gamma$  and 3 c  $\alpha$ . As shown by Brøgger (1882, p. 19) the thickness of 3 b is not less than 24—25 m in this locality.

The upper 13 m of the shale is developed as typical black shale except for the lowermost part which has lighter greyish layers of a few cm thickness, alternating with the black graptolite shale. The lower 12 m of 3 b consists mainly of grey to green shale, often rather compact. The “gypsum” crystals occur in abundance in layers about 3—12 m above the Ceratopyge Limestone. The basal 1,5 m of 3 b has limestone beds with thickness about 10 cm.

Just above the "gypsum" beds, 12,60 m below 3 c $\alpha$ , I recently found specimens of *Tetragraptus* which Miss Monsen kindly determined and identified as *T. phyllograptoides*, although, as Miss Monsen points out, the fusion of the basal portion of the stipes is less than in specimens from Galgeberg, Oslo, and Sweden. *T. phyllograptoides* is the guide fossil of the known basal graptolite zone of 3 b.

The occurrence of *Tetragraptus phyllograptoides*, just above the "gypsum" layers both at Slemmestad and Galgeberg, indicates a distinct stratigraphical distribution of these layers. Following the zonal division proposed by Miss Monsen, the basal zone (3 b $\alpha$ ) of the Lower Didymograptus Shale of Slemmestad has the considerable thickness of 12—13 m, thus corresponding in thickness to all the other graptolite zones of 3 b.

As pointed out by Brøgger (p. 19), the noticed variation in thickness of 3 b in the Oslo Region, to a great extent is due to tectonic pressure. The average thickness of 3 b in Oslo is only 10—12 m according to Brøgger. Mr. O. Large has kindly informed me that he has noticed the "gypsum" layers, though only in a thin layer (40—45 cm) in several (about 10) localities in Oslo. The "gypsum" layers may be more local than the grey shale in which they are found. The occurrence of these beds shows that the evidently thick basal zone of 3 b is characteristic of the Oslo—Slemmestad development and deviates from the upper shale zones in not being a typical black shale.

A gradual change upwards from the lighter to the darker shale may be noticed at Bjerkåsholmen near Slemmestad. At the transition, an alternation of thin (a few cm thick) layers of light and dark shale is found. A similar gradual transition between light and dark deposits is found at the bottom of several recent fjords (Norway) where they indicate a change from ventilated to unventilated bottom waters as shown by Strøm (1936). In one case (l. c. pl. 7) he demonstrates a development of alternating thin black and lighter layers at the transition between the two kinds of deposits, a feature very similar to the above-described conditions in the Lower Didymograptus Shale. Strøm also discusses the parallelism between the recent dark (rotten) deposits and the graptolite shale. The section at Slemmestad may thus demonstrate a gradual change from ventilated to unventilated bottom conditions, a change also expressed in the transition from benthonic (trilobite) to planktonic (graptolite) faunal assemblages.

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## Explanation of plate.

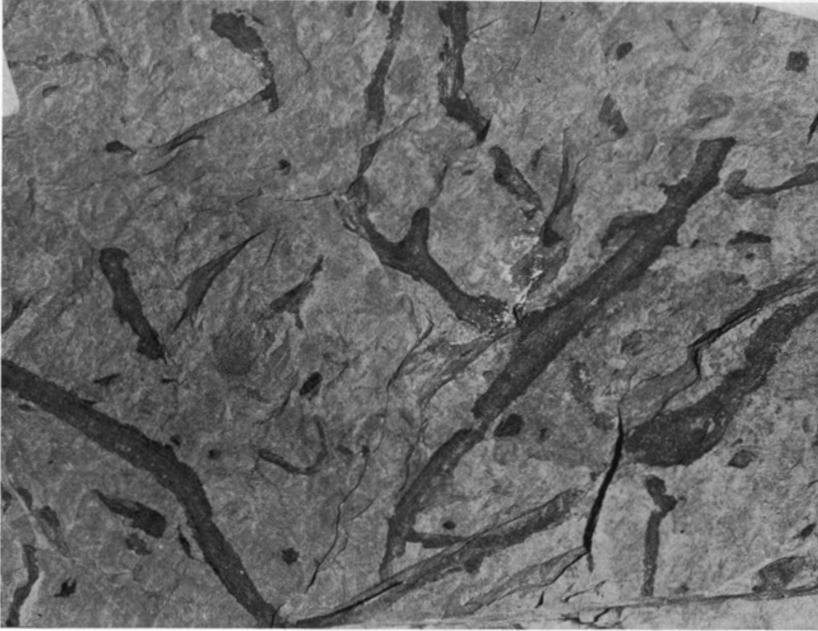
Fig. 1. Possible plant-remains. 1 ×. Lower Didymograptus Shale (3 b). Loose piece, Tøien, Oslo. No. 58832 Paleont. Mus. Oslo. H. F. Grorud coll.

Figs. 2—5. *Caryocaris* cf. *monodon* (Gurley). 1,5 ×. Lower Didymograptus Shale (3 b), figs. 2, 5 from zone 3 b $\alpha$  and figs. 3, 4 from 3 b $\beta$ —3 b $\gamma$ . Figs. 2, 5 from Galgeberg, Oslo, coll. Astrid Monsen 1935; figs. 3, 4 from Tøien, Oslo, coll. G. Henningsmoen 1935. Fig. 2 = No. 58861, 3 = 58852, 4 = 58845, 5 = K 680 of Paleont. Museum, Oslo.

Fig. 1. Photograph of specimen submerged in alcohol.

Figs. 2—5. Photographed in direct sunlight. The specimens were slightly tilted so that the sun-rays, entering at a slight angle to the axis of the camera, were reflected from the surface of the fossil directly into the camera. (The same method was applied by the author in photographing some of Miss Monsen's graptolites figured on the plates in the preceding paper of this volume.)

Figs. 1 and 4 untouched; in figs. 2, 3, and 5 the surrounding rock has been touched up.



1



2



3



4



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