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LECH TELLER

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Project ECOSTRATIGRAPHY

Morphology of some Upper Wenlockian Cyrtograptinae from Zawada 1 profile (NE Poland)

ABSTRACT: Out of an extremely rich graptolite fauna collected from the Wenlockian profile of Zawada *1*, four graptolite species (one new) from the genus *Cyrtograptus* have been selected and morphologically described. A description is also given of the lithology and stratigraphy of the Silurian series obtained from the borehole under consideration.

INTRODUCTION

The adequate coring of the Silurian series (nearly 84 per cent of core samples) in the Zawada 1 borehole has made it possible to obtain one of the most complete Wenlockian profiles from the eastern part of the Peribaltic syneclise. The rock material is represented by strongly calcareous mudstones abounding in a graptolite fauna preserved chiefly as flattened specimens but some fragments bear a semi-relief-like character. This has encouraged the writer to dissolve graptolites by chemical treatment, and this proved successful. The material thus obtained is strongly differentiated as regards its scientific usefulness. Most of the graptolites are highly carbonized and, therefore, do not lend themselves to detailed morphological examinations under transmitted light, but, on the other hand their external structure can be more easily determined than when occurring only in the rock. Moreover, all the measurements can be carried out more conveniently and accurately.

The descriptions presented in this paper are based on specimens which are deformed but bleached enabling a detailed morphological analysis under transmitted light.

The relevant work has been carried out in the Stratigraphic Laboratory of the Institute of Geological Sciences of the Polish Academy of Sciences within the agreement on cooperation in the field of scientific research between the Institute here mentioned and the Oil Research Survey. The writer wishes to express his sincere thanks to the Directors of the Survey for their friendly help in putting at his disposal valuable scientific material.

LITHOLOGO-STRATIGRAPHIC PROFILE

According to the electric logging data the Silurian series has been reached in Zawada *1* profile under the Rothliegende at a depth of 1477.5 m but its coring down to the bottom (1673.5 m) was started from a depth of 1533.3 m. The borehole was drilled to a depth of 1830.3 m reaching the Cambrian deposits.

At a depth of 1673.5 m to 1657.8 m, compact light-beige marly nodular limestones with muddy streaks, referable to the Lower Llandoverian, were reached overlying greenish marly Ashgillian limestones. In the Zawada *1* profile they do not contain any macrofossils and their dissolution by chemical treatment yielded only fragmentary Lower Silurian graptolites.

Between 1657.8 and 1646.7 m there occurs a black argillite locally laminated with an abundance of pyrite and yielding a rich graptolite fauna. It is interbedded with greenish marly limestones. Below the depth of 1637.0 m the graptolite fauna represents the Cephalograptus cometa — Spirograptus spiralis Zones of the Middle and Upper Llandoverian. Among the more important forms here encountered are: *Stomatograptus grandis* (Suess), *M. priodon* (Bronn.), *M. marri* Perner, *Spirograptus spiralis* (Geinitz), *Rastrites approximatus* Perner, *Demirastrites convolutus* Hisinger, *Monoclimacis vomerinus* (Nichol.), *M.* cf. *crenulatus* (Törnq), *Petalolitus* sp., *Cephalograptus cometa* (Geinitz).

At a depth between 1646.7 and 1533.3 m there occurs a light grey calcareous siltstone bearing an abundant graptolite fauna, locally with intercalations (up to 20 cm thick) of light-grey marly limestones. The graptolites encountered between 1637.0 and 1533.3 m provide a complete Wenlockian profile whose total thickness exceeds 103.3 m. It may be reasonably accepted that all the zones of this stage are present. The more important species here observed are:

Cyrtograptus lundgreni Tullb., *C. radians* Törnq., *C. hamatus* (Baily), *C. murchisoni* Carruth., *C.* cf. *insectus* Bouček, *C. urbanekii* nov. sp. Teller, *Monograptus testis* (Barr.), *M. flemingi* (Salter), *Monoclimacis vomerinus* (Nichol.), *M. flumendosae* (Gortani), *M. hemipristis* (Meneghini), *Retiolites geinitzianus* Barr.

It is quite probable that sediments of the lowermost Ludlovian are present in the top Silurian series, not cored.

PALEONTOLOGICAL DESCRIPTIONS

Family **Cyrtograptidae** Bouček, 1933
Subfamily **Cyrtograptinae** Bouček, 1933
Genus *Cyrtograptus* Carruthers, 1867

Cyrtograptus urbanekii sp. nov.
(Pl. 1., Fig. 5, 7—8; Pl. 3, Figs 1, 7; Pl. 4, Figs 6—7; Text-figs 1—5)

Derivatio nominis: This species is named in honour of Professor Adam Urbanek, an eminent Polish graptolitologist.

Holotype: rhabdosome figured in Pl. 1, fig. 5 and in Text-figs 1, 3—5, from Zawada *1* profile, between 1546.5 and 1552.7 m.

Material. — A large number of fragmentary rhabdosomes dissolved from the Wenlockian profile of Zawada *1*. Most of the rhabdosomes are flattened and strongly carbonized, no complete specimen has been obtained.

Stratigraphic position. — Upper Wenlockian — C. lundgreni Zone in the Zawada *1* profile (NE Poland).

Association. — *C. lundgreni* Tullb., *C. hamatus* Baily, *M. testis* Barr., *M. Flemingi* (Salter) and *Monocl. flumendosae* Gortani.

Diagnosis. — An extremely thin cyrtograptid with the procladium dorsally arched. Unknown number of thecal cladia originate from the lateral processes of the procladium thecae. Thecae narrow and very long, with the lobe overlapping the aperture. Two long lateral processes. Sicula narrow and short.

Description. — Procladium very thin and of uniform width throughout its length (Pl. 1, Fig. 5). Dorsally very distinctly arched. Width of procladium equal to that of the particular thecae. Just above the apex of the prosicula it is 0.11 mm, below the aperture 0.2 mm. Including the lobe overlapping the aperture the width increases to 0.3 mm. The figures here given are practically the same throughout the length of the procladium which consists of thecae joined only at their bases and having a common virgula.

The total length of procladium unknown, the specimen chosen for the holotype being only with six completely preserved thecae.

Thecal cladia produced by one of the lateral processes of the procladium of theca *n* (Text-fig. 2). It is hardly possible to determine the character of thecal cladia in the material available to the writer since only two fragments of the procladium bear very short initial parts of the thecal cladia. However, on the presence in the collection of numerous broken up fragments of rhabdosomes with analogously developed thecae, and the absence of fragments with a different type of thecae, it may be reasonably supposed that the thecae on the thecal cladia represented the same type as that on the procladium and have not been differentiated. The material under consideration does not allow the determination of the number of the produced thecal cladia or their regularity.

One of the specimens displays the "diversograptus" stage of growth, while the oppositely directed cladium does not originate from the sicula but from the damaged theca *n* of the procladium or thecal cladium. Hence, we are dealing here with a regeneration of a damaged rhabdosome (Pl. 1, Fig. 7).

Five complete thecae and two fragments of prothecae representing the remains of broken off cladia are preserved on the specimen in Text-fig. 1 undoubtedly belonging to the species here described. Three of the complete thecae belong to the procladium or to the thecal cladium, while the two remaining ones with oppositely directed apertures had been produced on the pseudocladium.

Cyrtograptus urbanekii nov sp.

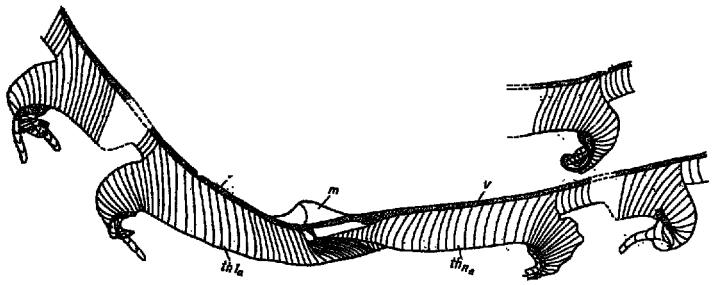

Fig. 1. Broken up and regenerated rhabdosome composed of a procladium or thecal cladium with 3 thecae and a pseudocladium with two thecae. Depth 1540.0—1546.5 m. (Explanations as for Figs 2—5)

The pseudocladium itself is placed at a nearly right angle to the procladium. The damaged area (Pl. 3, Fig. 7) as well as the proximal part of the first theca of the pseudocladium are readily distinguishable by the thickened and bulged out virgula, by the oppositely directed and initially irregularly arranged fuselli, as well as by the structureless cone-shaped membrane dorsally attached to the rhabdosome axis. Most likely this is a useless fragment of the membrane produced by the zooid (Kozłowski 1949, Urbanek 1963).

The strong flattening of the specimen under consideration impedes a detailed examination of the damaged area. It seems, however, that the virgula of theca *n* of the procladium damaged somewhat above its base, grew in the opposite direction while its strong deformation and thickening occurred where the virgula was broken off. At the same time a structureless membrane was produced. A short growth of the virgula is followed by a normal growth along it of the first theca of the pseudocladium. The damaged area of theca *n* of the procladium was initially filled in by fuselli. The fuselli are here more dense and converge at a point which may correspond to the aperture of the damaged theca *n*. The next fuselli of the first theca of the pseudocladium are normally developed while the theca itself is slightly broader in relation to theca *n* of the procladium and markedly dorsally arched.

The metatheca of the first theca of the pseudocladium does not differ in its structural details from the thecae produced on the procladium. The only distinct difference is that in length, it being 1.09 mm while the length of the broken off theca *n* on the procladium is 0.75 mm, and that of theca $n + 1$ and th $n + 2$ is 1.4 mm.

The length of th_2 on the pseudocladium is 1.6 mm being the maximum dimension in relation to the remaining ones.

The width of thecae on the pre- and pseudocladium, that of th_1 on the pseudocladium excepted, is very much the same. At the base it is ± 0.12—0.14 mm, at the aperture ± 0.24—0.25 mm while including the width of the lobe overlapping the aperture it is 0.32 mm. These figures are by 0.1 mm higher in th_1 of the pseudocladium.

Sicula — short, ranging from 1.02 to 1.48 mm, narrow, its apex reaching approximately halfway to th_1 (Text-fig. 3).

Prosicula comprises 2/3 of the length of the whole sicula and is provided with supporting threads. It is 0.68 mm in length. The apertural margin of the prosicula forms a slight thickening (Pl. 8, Fig. 1).

Cyrtograptus urbanekii nov. sp.

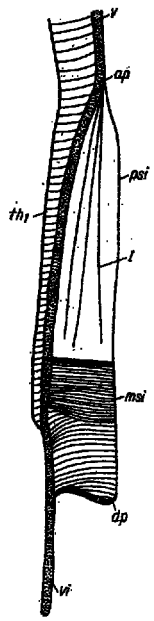

Fig. 3. Sicula of the holotype

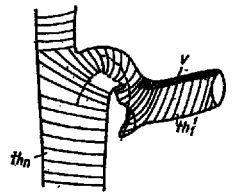

Fig. 2. Th_n of the procladium with the budding first theca of the thecal cladium

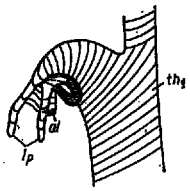

Fig. 4. The first theca of the holotype

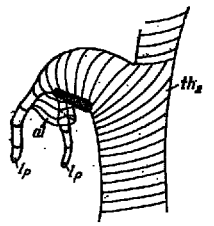

Fig. 5. The second theca of the holotype

ap — apex of prosicula, psi — prosicula, msi — metasicula, dp — dorsal process of metasicular aperture, v — virgula, vi— virgella, l — longitudinal threads on prosicula, lp — lateral process, al — apertural lobe, m — structureless membrane, Th_{1a} — first theca of pseudocladium, th_{na} — theca of the pro- or thecal cladium, th_1, th_2, th_n — succeeding thecae on the pro- or thecal cladium
Fig. 2: Depth 1533.3—1540.0 m, Fig. 3—5: 1546.5—1522.7 m

Metasicula — 0.34 mm in length, ventrally terminating in a virgella 0.3 mm long. No distinct dorsal process. Metasicular aperture gently horizontally sigmoidal. Width of metasicular aperture ranging from 0.18 to 0.23 mm. Fuselli very dense during the initial growth of metasicula and markedly more delicate than those below the porus which are also less condensed (Pl. 3, Fig. 1).

Thecae — uniform on the fragmentary procladia available to the writer, no thecae of thecal cladia observed.

Thecae straight, thin and long, hooked in the apertural area (Text-figs 4, 5).

Th_1 buds form the metasicula at a distance of 0.18 mm from the prosicular aperture. It is extremely thin during the initial period of growth and attached to the prosicula all along its length. At the apex of the prosicula the theca gradually expands attaining just above it a width of 0.11 mm. At the protheca/metatheca boundary the width is up to 0.17 mm. The free ventral wall of th_1 exposed throughout its length, the whole theca up to 1.64 mm long.

Metatheca of th_1 hooked, its dorsal wall prolonged into a lobe overlapping the aperture. Long (0.15 mm) lateral processes built of macrofuselli, similarly as the lobe, but lacking the zigzag suture.

The remaining thecae of the procladium (Pl. 4, Figs 6, 7) approximately the same in length (th_3 — 1.67 mm) and with free ventral walls 1.4 mm long. They are

provided with well developed lateral processes and with lobes overlapping the aperture. Proximally 4 thecae fit in 5 mm.

Remarks. — In its characteristic sicula, shape of thecae and of the rhabdosome, the form here described does not correspond to any of the cyrtograptid species so far reported. A specimen displaying some resemblance in shape and general appearance has been identified by Bouček (1931) as *Cyrtograptus gracilis*. His short and not very concrete diagnosis indicates that this form is somewhat broader (0.5 mm). The descriptions and diagnoses presented by Bouček (1931, 1933) and Bouček & Přibyl (1953 a, b) are however rather vague, and hence of little help, while their diagrammatic drawings do not show any structural details. Therefore, any even tentative comparisons between our form and *C. gracilis* seem most difficult and hazardous.

Bouček (1933) regarded *C. gracilis* as a subspecies of *C. lundgreni*, while in a later paper (1953a) Bouček & Přibyl reinstated this form to the rank of an independent species and gave a somewhat more detailed diagnosis indicating that the rhabdosome width ranges from 0.3 to 0.8 mm and that 6—8 thecae fit in 1 cm. The same authors (1953b) change the generic position of *C. gracilis* assigning this species to the *Diversograptus* genus. This change is based solely on the discovery of specimens with a "diversograptus" stage of growth. The complimentary diagnosis stresses, however, that one of the oppositely directed cladia does not originate from the sicula which is lacking here. Hence we are not dealing with a sicular cladium but with a pseudocladium. The problem of the formation of pseudocladia, the various relevant opinions as well as the correctness of the creation of the genus *Diversograptus* has been discussed at some length by Urbanek (1963).

Cyrtograptus radians Törnquist
(Pl. 1, Figs 1—3; Pl. 3, Figs 2—3, 6; Pl. 4, Figs 1, 5; Text-figs 6—8)

1887. *C. radians;* Törnquist, *Geol. Fören. Förhandl. IX*, 7, pp. 491, Text-fig. 2.
1963. *C. radians;* Bouček, *Monographie d. Obersilurischen Graptolithen aus d. Familie Cyrtograptidae*, pp. 58—60, Pl. 4, Figs 7, 8; Text-fig. 13 b—d.
1975. *C. radians;* Berry & Murphy, *Univers. of California Publ.*, vol. 110, pp. 88—89, Text-fig. 22e.

Material. — A dozen or so of rhabdosomes dissolved from the Wenlockian Zawada *1* profile between 1559.0 and 1582.9 m. Most rhabdosomes flattened and deformed.

Stratigraphic position. — C. radians Zone from the Upper Wenlockian of Zawada *1* profile (NE Poland).

Association. — *C. hamatus* Baily, *M. flemingi* (Salter), *Monocl. flumendosae* (Gortani).

Diagnosis. — Procladium proximally spirally coiled through at least 360 degrees or more. Thecal cladia, beginning with th_{6-10} originating regularly from each theca on the procladium, and as many as 29 thecal cladia may be produced. The most distal part of the procladium without thecal cladia. Thecae biform, sicula narrow and short.

Description. — Procladium thin, proximally spirally coiled through at least 360 degrees or more, sometimes the coiling is doubled through 720 or even more degrees. Distal part of procladium straightened out and lacking thecal cladia. Proximally, near th_2, the width of the procladium including the thecal aperture is 0.75 mm, medially (th_8) increasing slightly to 0.81 mm to retain this value in the remaining part of the procladium (Pl. 1, Figs 1—3).

The width of procladium, measured at the base of thecae, is markedly less, ranging from 0.13 mm at th_2 to 0.18 mm at th_8. The thecal cladium originates from one of the lateral processes of theca *n* (Pl. 1, Figs 1—3; Pl. 4, Fig. 1, 3, 5). In the material available to the writer the first thecal cladium originates from th_7 or th_8, the second and next cladia originating from the next thecae. Width of thecal cladium at th_1 is 0.2 mm, attaining its maximum of 0.3 mm at theca *n*. Length of thecal cladia up to 20 mm but there may be as many as twenty nine cladia (Bouček 1933).

Sicula narrow and short, ventrally very gently curved. Total length ranges from 1.44 to 1.49 mm with the apex reaching to the base of th_2 or slightly below (Text-figs 6—7).

Near the aperture the prosicula 0.60 mm long and from 0.13 to 0.17 mm broad. Apertural margin markedly thickened with one supporting thread.

Metasicula 0.8 to 0.89 mm long, dorsally terminating in a blunt dorsal process, ventrally in a long (0.8 mm) virgella. Occasionally the virgella may divide, the spece in-between being filled by a structureless membrane (Text-fig. 6; Pl. 3, Fig. 3).

Cyrtograptus radians Törnquist (Depth 1555.9—1562.0 m)

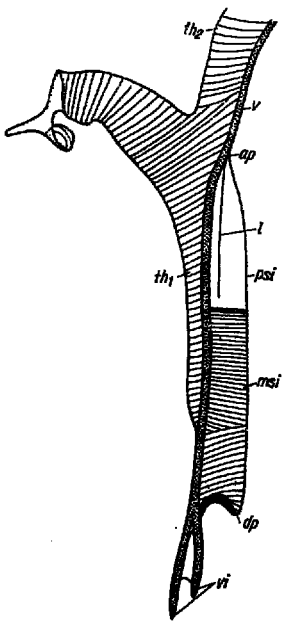

Fig. 6. Sicula. The divided virgella

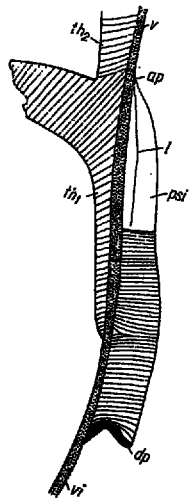

Fig. 7. Sicula

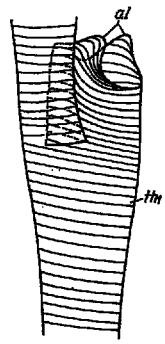

Fig. 8. First theca of the thecal cladium

Explanations as for Figs 2—5

The apertural margin of the metasicula forms a fairly deep incision, the apertural width ranging from 0.23 to 0.38 mm. The fuselli are regularly arranged throughout the length of metasicula (Pl. 3, Figs 2, 3).

Thecae — biform. Th_1 of the procladium buds from the metasicula at a distance of 0.3 to 0.4 mm from its aperture and 0.4 to 0.5 mm from the prosicular aperture. The protheca during the initial growth stage (reaching slightly above the prosicular aperture) extremely narrow, expanding rather markedly and passing into

a long hooked metatheca (Pl. 3, Figs 2, 3). Aperture of metatheca directed downward, overlapped by a lobe — a prolongation of the dorsal wall of theca. Moreover, there also occur two long lateral processes built of macrofuselli. Margin of metathecal aperture distinctly thickened (Pl. 3, Fig. 6). Entire length of th_1 is 1.1 mm, that of th_2 and the next thecae being 1.3 mm. Length of metatheca up to 0.75 mm, this maximum dimension being reached near th_{3-4}. A marked reduction in the length of metatheca from which the first thecal cladium originates.

An analogous structural type may be observed in thecae 6—10 of the proximal part of procladium, all the thecae being isolated from each other and in general appearance resembling the shape of an unequilateral triangle.

Thecae on thecal cladium straight, tubular and long (Text-fig. 8). Their complete length ranges from 1.62 to 1.67 mm, the width at the base and at the aperture being the same and ranging from 0.2 to 0.3 mm. The free ventral wall 1.1 mm long, attached to the dorsal wall of the preceding theca approximately along 1/3 of its entire length. As a result of the strong reduction of metatheca the lateral processes of the lobe overlapping the aperture disappear. The aperture itself is vertically oriented upwards. The apertural margin slightly thickened, two tongue-like lobes developed laterally and occasionally very gently incurved.

Thecae analogous to those on the thecal cladium are likewise characteristic of the distal part of the procladium.

Remarks. — *C. radians* belongs to species known in the literature, but its descriptions are based solely on flattened material, not isolated out of the rock. Owing to lack of precision their usefulness for comparative studies with dissolved material is rather limited.

C. radians is a most characteristic form because of the regularity with which the thecal cladia originate and it is difficult to mistake it for such similar forms as *C. sakmarikus* Koreń, *C. mancki* Bouček, *C. ramosus* Bouček.

Thecae of the proximal part of procladium in structure approach the first 7—12 thecae in the procladium of *C. hamatus*. There is, however, a distinct difference in the length of the metatheca which is much longer in *C. hamatus*. Thecae of thecal cladia in *C. radians* and *C. hamatus* also resemble but in the latter species the tongue-like lateral lobes are less conspicuous.

The siculae of the two species here compared are also essentially similar, the differences being quantitative in character.

Other quantitative differences of our form *C. radians*, as compared with the descriptions by Bouček (1933) or by Berry & Murphy (1975) are of no substantial diagnostic significance since they may be the result of intraspecific changes, of the state of preservation of specimens or of the dimension methods.

Cyrtograptus hamatus (Baily)
(Pl. 1, Figs 4, 6, 9; Pl. 2, Fig. 4; Pl. 3, Figs 4, 5; Text-figs 9—12)

1862. *Graptolithus hamatus*; Baily, *Journ. Geol. Soc. Dublin*, Vol. IX, p. 305, Pl. 4, Fig. 6a, b.
1916. *C. hamatus*; Elles & Wood, *Monogr. of British Grapt.*, pp. 510—511, Pl. 52, Fig. 3, Text-fig. 356.
1933. *C. hamatus*; Bouček, *Monographie d. Obersilur. Grapt.. aus d. Familie Cyrtograptidae*, pp. 46—47, Pl. 5, Figs 9—11, Text-fig. 8a, b.
1954. *C. hamatus*; Cope, *Geol. Mägaz.*, Vol. 41, pp. 319—322, Text-fig. 1a—e,.
1975. *C. hamatus*; Berry & Murphy, *Univers. of Calfiornia Publ.*, Vol. 110, pp. 82—83, Pl. 11, Figs 1, 2.

Material. — Over ten rhabdosomes dissolved from the Wenlockian profile Zawada *1* at a depth between 1540.0 and 1562.0 m. Most rhabdosomes flattened, all incompletely preserved.

Stratigraphic position. — Upper Wenlockian C. lundgreni Zone of Zawada 1 profile (NE Poland).

Association. — *C. lundgreni* Tullb., *C. urbanekii* Teller, *M. testis* Barr., *M. flemingi* (Salter), *Monocl. flumendosae* Gortani.

Diagnosis. — A small cyrtograptid with the rhabdosome proximally strongly arched. Only one fully developed thecal cladium, after whose appearance the axis of the procladium twists at an angle of 180 degrees, while the thecae are shifted to the ventral side. Thecae biform. Sicula narrow and short.

Description. — Procladium thin and proximally arcuately bent. The width increases uniformly until the thecal cladium has originated, and then decreases owing to the presence in the distal part of procladium of a different type of thecae (Pl. 1, Figs 4, 6, 9). Proximally, at the base of th_1, the width including the sicula, is 0.28 mm, while at the aperture of th_1 it attains 0.73 mm. In th_5 the basal width is 0.24 mm, at the aperture 0.85 mm. The distal width of the procladium measured at th_5, above the originating thecal cladium, is 0.24 mm at the base, including the aperture of th_5 it is 0.48 mm.

Between th_{8-13} the procladium twists at an angle of 180° to the axis, owing to which the thecae are shifted from the dorsal to the ventral side of the arch (Pl. 1, Fig. 6; Pl. 2, Fig. 4). The axis twists over a very short distance within the first theca above which the thecal cladium originates. In the material available to the writer, the axial twisting has been observed within th_8, but Berry & Murphy (1975) postulate that the thecal cladium originates between theca 10 and theca 12, hence the axial twist is delayed for one theca and, therefore, occurs correspondingly between theca 11 and theca 13.

Cope (1954) presents a specimen with the thecal cladium originating from th_{11}, hence the axial curve takes place within th_{12}.

The thecal cladium originates from one of the lateral processes of theca *n* (between th_7 and th_{12}) which is transformed into a virgella (Pl. 3, Fig. 5). The appearance of the thecal cladium is retarded by 5—7 thecae in relation to the growth of the procladium. Namely it originates from theca *n* at the time when 5—7 distal thecae have been already formed above theca *n* (Text-fig. 9).

At the base of th_1 the thecal cladium is 0.2 mm broad, at the aperture it ranges from 0.3 to 0.5 mm. The maximum width of the thecal cladium at the aperture of theca *n* is 0.55 mm, being 0.21 mm at its base.

The axis of the thecal cladium meets the distal part of the procladium at an obtuse angle ranging from 110 to 130 degrees.

Sicula — narrow and short (Pl. 1, Figs 4 and 9). Its entire length is from 1.33 to 1.45 mm; the apex reaches the base of th_2 or slightly above it. Prosicula 0.61 to 0.72 mm long, occupies nearly half of the entire length of sicula. The apertural margin is distinctly thickened and also has vertical supporting threads. The width of the prosicular aperture ranges from 0.11 to 0.15 mm (Text-figs 10, 11).

Metasicula, 0.61 to 0.84 mm long, terminates dorsally in a blunt process, ventrally in a short virgella of 0.28 to 0.29 mm. The apertural margin of the metasicula is fairly deeply incised. Width of metasicular aperture from 0.17 to 0.22 mm. The fuselli rather densely but uniformly arranged over the entire length of metasicula.

Thecae — biform. In the proximal part of procladium they occur on the outer side of the arch, after the twist of the rhabdosome axis they are shifted to the concave side (Pl. 1, Figs 4, 6, 9; Pl. 2, Fig. 4). Th_1 of the procladium buds from the metasicula at a distance ranging between 0.20 and 0.35 mm from its aperture and between 0.31—0.45 mm from the prosicular aperture. During the initial phase of growth approximately above the prosicular aperture, the very narrow protheca expands conspicuously passing into an extremely long (0.5 to 0.63 mm) metatheca

whose aperture is hooked. The aperture is overlapped by a lobe which is the prolongation of the dorsal wall, the apertural margin being distinctly thickened. There are two lateral processes built of macrofuselli. The width of th_1 is 0.025 mm at the porus, including the metatheca it is 0.77 mm (Figs 10—11).

Cyrtograptus hamatus (Baily) (Depth 1540.0—1546.5 m)

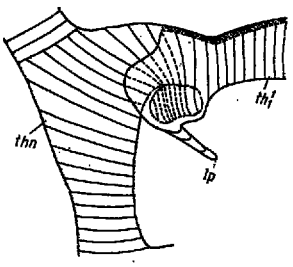

Fig. 9. Budding of th_1' of the thecal cladium

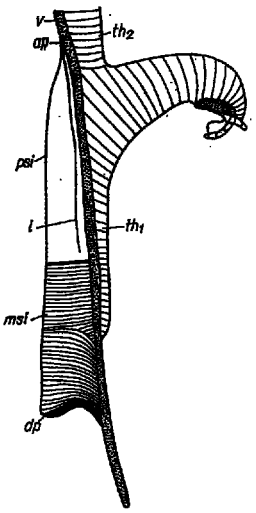

Fig. 10. Sicula with the first theca

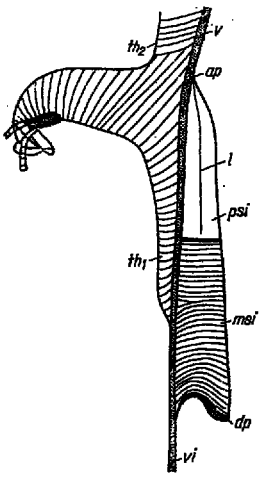

Fig. 11. Sicula with the first theca

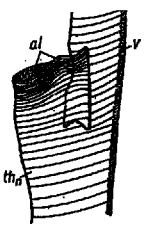

Fig. 12. Distal theca on the procladium

Explanations as for Figs 2—5

An analogous structural type is observable on thecae 7—12 in the proximal part of procladium, although in the successive younger thecae the length of the metatheca is markedly reduced and the position of the aperture is changed from one oriented downwards into an oblique one in relation to the rhabdosome axis. The basal width of the thecae increases, too (0.12—0.18 mm), while the length of the methateca decreases from 0.83 to 0.78 mm. All the thecae are isolated and subtriangular in shape.

The twisting theca of the rhabdosome axis loses its hooked shape and straightens out. The length of the lateral processes is also reduced, but the aperture is still overlapped by the lobe. In relation to the older thecae the one here considered is twisted at a right angle. The next theca of the procladium shows a further reduction of the lateral processes and of the lobe overlapping the aperture. Its position in relation to the axis has been twisted by as much as 180 degrees while a fragment of the ventral wall is superimposed onto the base of the next younger theca (Pl. 2, Fig. 4).

A complete reconstruction is observable on the third theca after the mother theca of the thecal cladium. The strong reduction of the metatheca is followed by the disappearance of the lateral processes, of the lobe overlapping the aperture, while the aperture itself is oriented upwards. Laterally the apertural margin is shaped as a gently sigmoidal line while the dorsal wall is attached along a small length to the ventral wall of the next theca (Text-fig. 12 and Pl. 3, Fig. 4).

The entire thecal length is here 1.5—1.69 mm while the gently sigmoidal free ventral wall attains a length of 1.32—1.41 mm. The basal width of the thecae ranges from 0.18 to 0.28 mm, that at the aperture being 0.28—0.33 mm.

An analogous type of theca is repeated on the thecal cladium, the entire length of th₁ being here 1.5 mm, that of the free ventral wall 1.4 mm, the basal width is 0.28 mm, and 0.33 mm at the aperture.

The dimensions of the successive thecae are as follows: the entire length 1.58—1.69 mm, the free ventral wall 1.32—1.41 mm, the basal width 0.18—0.22 mm, width at the aperture 0.28—0.30 mm.

In the proximal part of the procladium there are 8 th/cm. in the distal part 9 thecae fit in 1 cm. On the thecal cladium there are 8—9 th/cm.

Remarks. — *C. hamatus* is a form commonly known in the literature, but the descriptions given are based on flattened material not dissolved from the rock. Hence they lack greater precision and are not very useful. Of considerable value is, however, the description of *C. hamatus* presented by Cope (1954), since some of the structural details of thecae on the procladium and thecal cladium he gives have been confirmed on material dissolved from the rock. Hence, this description is, to some extent, representative for flattened forms.

The small differences in dimensions as given in the particular descriptions (Elles & Wood 1916, Bouček 1933, Waterlot 1945, Cope 1954, Berry & Murphy 1975) are of no essential significance for the definition of species, since they may result from intraspecific differences and, either from the state of preservation or the measurement methods.

Cyrtograptus lundgreni Tullberg
(Pl. 2, Figs 1—3, 5—8; Pl. 4, Figs 2, 4; Text-figs 13—17)

1833. *Cyrtograptus lundgreni* Tullberg; *Skanes grapt. II*, p. 36, Pl. III, Figs 8—11.
1899. *C. lundgreni* Perner, *Etudes Grapt. Bohem. III B*, p. 19, tab. XVI, Figs 13—16; tab. XVII, Fig. 16 and Text-figs 23—24.
1900. *C. lundgreni*; Elles & Wood, *Quart. J. Geol. Soc.*, LVI, tab. 24, Fig. 1A—B.

1913. *C. lundgreni;* Elles & Wood, *Monogr. of British Grapt.*, pp. 507—508, tab. 52, Fig. 1a—c, Text-fig. 353a, b.
1933. *C. lundgreni;* Bouček, *Monogr. d. Obersilur. Graptoliten aus der Familie Cyrtograptidae;* pp. 50—61, tab. 4, Figs 4—6, Text-fig. 9a—e.
1965. *C. lundgreni;* Obut & Sobolevskaja, *Grapt. i Strat. Niż. Silura Kotym. massiva*, tab. 20, Figs 1—5.
1968. *C. lundgreni;* Schauer, *Zur Taxionomie u. Strat. der Gattung Cyrtograptus*, p. 39, tab. III, Figs 1—5.
1968. *C. pseudolundgreni;* Schauer, *Zur Taxionomie u. Strat. der Gattung Cyrtograptus*, p. 38, tab. II, Figs 1—3.
1975. *C. lundgreni;* Berry & Murphy, *Univers. of California Publ.*, vol. 110, p. 86—87, Pl. 10, Figs 2—3c.

Material. — A great number of fragments dissolved from the rock from the Wenlockian profile of Zawada *1* (depth 1533.0—1552.7 m). Most rhabdosomes flattened and strongly carbonized, lack of complete specimens. The description is based on separate fragments.

Stratigraphic position. — Cyrtograptus lundgreni Zone from Zawada *1* profile (NE Poland), depth 1533.0—1552.7 m.

Association. — *Cyrtograptus hamatus* (Baily), *C. urbanekii* Teller, *Monograptus testis* Barr., *M. flemingi* (Salter), *Monocl. flumendosae* Gortani.

Diagnosis. — A thin cyrtograptid with the procladium outwardly arched. Thecal cladia unevenly spaced — never more than three — originating from the procladium. The formation of the first thecal cladium is followed by the twisting of the rhabdosome axis at an angle of 180 degrees. Thecae biform. Sicula narrow and short.

Description. — Procladium ventrally outwardly arched. Proximally very narrow (0.28 mm at the apex of sicula), soon expanding to a width of 0.39 mm near th_{10-12} while from th_{15-20} it ranges from 0.57 to 0.62 mm. Distally the width increases to 0.73 mm. After the appearance of the first thecal cladium which usually occurs between th_{15} and th_{20}, the axis of the procladium twists at an angle of 180 degrees. This causes the thecae to be shifted to the concave side of the arch (Pl. 2, Figs 3, 5—8).

The thecal cladium originates from the larger apertural lobe of the procladium theca (Pl. 2, Fig. 2; Pl. 4, Fig. 2). The first thecal cladium appears between th_{15} and th_{20} and after the development of the first theca its basal width is up to 0.4—0.5 mm. This width increases rapidly; near th_2 it is already 0.7—0.8 mm while at th_3 and the next thecae it attains a maximum constant width of 0.9 mm (Text-fig. 13).

Neither the length nor the number of the thecal cladia can be determined on the material available to the writer. As a rule there is only one thecal cladium but in some forms two or three may be present.

Sicula — narrow and very short (1.41 mm) with apex reaching to the base of th_2. Prosicula, 0.69 mm long, occupies nearly half of the sicula. The apertural margin of prosicula distinctly thickened. Vertical supporting threads are present, too.

Metasicula, 0.72 mm long, dorsally terminating in a very short and blunt process. Ventrally there is a virgella exceeding 0.33 mm in length. The metasicular aperture is rather deeply incised, its width is 0.22 mm. The fuselli not crowded, uniformly arranged (Text-fig. 14).

Thecae biform, in the proximal and medial parts of procladium on the external side of the arch (Pl. 2, Figs 1, 2, 6, 7), while after the twist of the procladium axis at an angle of 180 degrees — as a rule above the first thecal cladium — they are shifted to the concave side of the arch.

The first theca of the procladium buds at mid-length of the metasicula (0.33 mm from the prosicular aperture), at the beginning, up to the level of the prosicular

aperture it is rather narrow and uniformly broad. Thereafter it begins gently to expand, becomes triangular and distinctly hooked with the aperture directed downward. It is overlapped by the lobe which prolongates the dorsal wall of the theca,

Cyrtograptus lundgreni Tullberg (Depth 1540.0—1552.7 m)

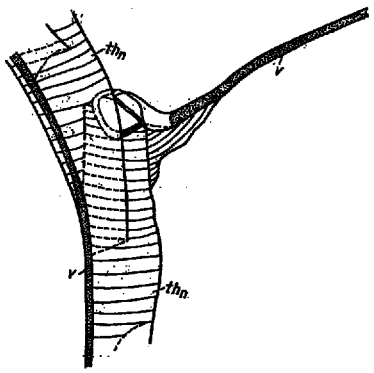

Fig. 13. Budding of th_1 of the thecal cladium

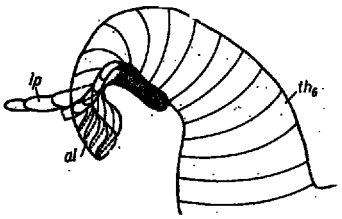

Fig. 14. Sicula with the first theca

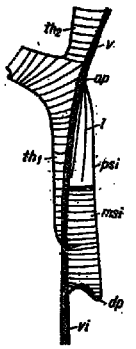

Fig. 15. Th_6 of the procladium

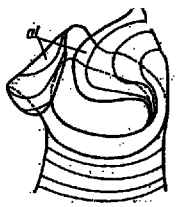

Fig. 16. Distal theca of the procladium

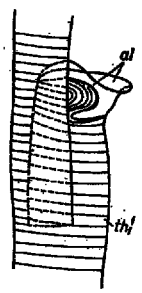

Fig. 17. First theca of the thecal cladium

Explanations as for Figs 2—5

while laterally there occurs a paired apertural process built of macrofuselli. The apertural margin of the theca slightly thickened (Text-fig. 14).

An analogous shape of thecae is observable in the first 10—12 proximal thecae which are isolated from each other. The length of these first thecae (Pl. 2, Fig. 8) is variable and gradually increases from 0.97 to 1.23 mm, similarly as the length of the free ventral wall increases from 0.77 to 0.80 mm (Text-fig. 15).

In the medial part of the procladium, but still before the appearance of the thecal cladium, the structure of thecae becomes simplified. The hooked shape disappears altogether, they straighten out and are attached to each other over a considerable length (Pl. 2, Fig. 7). The lateral processes of the aperture disappear, too being replaced by two asymmetrical apertural lobes which are a prolongation of the

dorsal wall. The left lobe, tongue-like in shape, is smaller, the right one somewhat bigger and turned inside. The aperture is so overlapped by the two thecal lobes that its free area is a mere horse-shoe shaped slit.

The straightening out of thecae occurs very suddenly as it takes place within 5—6 thecae. Simultaneously their entire length increases from 1.69 to 2.0 mm, that of the free ventral wall increasing from 1.0 to 1.27 mm.

The apertures of the elongating thecae first reach just below the base of the next theca but very soon the position of the aperture becomes constant at the level of the base of the next theca. This position is observable both in the distal part of procladium and on the thecal cladium. In the distal part of the procladium the thecae do not differ in their structure from the medial thecae, except in that their length increases to 2.1—2.3 mm and the free ventral wall attains the value of 1.2—1.3 mm (Text-fig. 16). The basal width of thecae is 0.2—0.3 mm, that at the aperture 0.4 mm.

Thecae formed on the thecal cladium do not in any way differ from those observed in the distal part of the procladium (Pl. 4, Fig. 4). Th_4 excepted, they have a constant length of 2.1—2.2 mm, the free ventral wall being up to 1.1 mm. Basal width is 0.27 mm, at the aperture 0.4 mm (Text-fig. 17).

The first theca is, however, characteristic by a markedly greater length of up to 2.9 mm, while the other dimensions remain unchanged. In the proximal part of the procladium there are 10 th/cm, in the distal part 9 thecae fit in 1 cm. In the thecal cladium there are 8—9 th/cm.

Remarks. — The form here described is fairly well known in the literature but its diagnosis is, as a rule, based on flattened material not dissolved from the rock (Elles & Wood 1914); Obut & al. 1965, 1967; Berry & Murphy 1975 and others). Therefore, the available descriptions are somewhat vague and without substantial value for comparative studies. Some of the statements are even accidental and do not coincide with the analyses of the material available to the writer. Neither has any description been so far given of an isolated proximal part with a sicula.

Bouček (1933) postulates that the thecae of *C. landgreni* are initially of the *M. priodon* type, having tiny apertural processes and distally passing into thecae of the dubius type. Regretfully, except for the processes, the remaining features have not been confirmed.

Along with a very general description of the form *C. lundgreni* Schauer (1968) erects a new species, *C. pseudolundgreni*. However, in the writer's opinion this is not reliably justified owing to the lack of distinct differences between these two forms.

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Warsaw, December 1975

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L. TELLER

MORFOLOGIA NIEKTÓRYCH GÓRNO-WENLOCKICH CYRTOGRAPTINAE Z PROFILU ZAWADA 1 (NE POLSKA)

(Streszczenie)

Spośród bogatej, wypreparowanej chemicznie, fauny graptolitowej wenloku z profilu otworu Zawada *1* wybrano i opisano cztery gatunki graptolitów z rodzaju *Cyrtograptus*. Spośród nich jeden gatunek jest nowy.

Ponadto scharakteryzowano litologię i stratygrafię serii sylurskiej osiągniętej w omawianym wierceniu.

Serię sylurską według ustaleń karotażowych nawiercono w otworze Zawada *1* pod czerwonym spągowcem na głębokości 1477,5 m, lecz była ona rdzeniowana aż do spągu (1673,5 m) dopiero od głębokości 1533,3 m. Otwór zakończony został na głębokości 1830,3 m w osadach kambru.

Na głębokości 1673,5 do 1657,8 m nad zielonkawymi wapieniami marglistymi aszgilu nawiercono zwięzłe jasno-beżowe, margliste wapienie zrostkowe z przemazami ilastymi, które zaliczyć należy do dolnego landoweru. W profilu Zawada *1* nie

zawierają one mikroskamieniałości, a chemiczne rozpuszczanie pozwoliło jedynie uzyskać fragmenty dolnosylurskich graptolitów.

Od głębokości 1657,8—1646,7 m występuje czarny łupek ilasty miejscami laminowany z obfitym pirytem i liczną fauną graptolitową, przeławicający się z zielonkawymi wapieniami marglistymi. Fauna graptolitowa poniżej głębokości 1637,0 m reprezentuje zony od Cephalograptus cometa aż do Spirograptus spiralis środkowego i górnego landoweru. Do ważniejszych napotkanych przedstawicieli należą:

Stomatograptus grandis (Suess), *M. priodon* (Bronn.), *M. marri* Perner, *Spirograptus spiralis* (Geinitz), *Rastrites approximatus* Perner, *Demirastrites convolutus* Hisinger, *Monoclimacis vomerinus* (Nichol.), *M.* cf. *crenulatus* (Törnq.), *Petalolitus* sp., *Cephalograptus cometa* (Geinitz).

Na głębokości 1646,7 do 1533,3 m stwierdzono mułowiec jasnoszary wapnisty z liczną fauną graptolitową i miejscami z wkładkami (do 20 cm) jasnoszarych wapieni marglistych. Graptolity występujące od głębokości 1637,0 do 1533,3 m, dokumentują pełny profil osadów wenloku, którego łączna miąższość przekracza 103,3 m. Można przyjąć, że obecne są tutaj wszystkie zony tego piętra, a z ważniejszych gatunków stwierdzono obecność:

Cyrtograptus lundgreni Tullb., *C. radians* Törnq., *C. hamatus* (Baily), *C. murchisoni Carruth.*, *C.* cf. *insectus* Bouček, *C. urbanekii* nov. sp. Teller, *Monograptus testis* (Barr.), *M. flemingi* (Salter), *Monoclimacis vomerinus* (Nichol.), *M. flumendosae* (Gortani), *M. hemipristis* (Meneghini), *Retiolites geinitzianus* Barr.

W partii stropowej serii sylurskiej, z której nie pobrano rdzenia, obecne są zapewne utwory najniższego ludlowu.

PLATE 1

1—3 — *Cyrtograptus radians* Törnquist, borehole Zawada *1*, depth 1555.9—1562.0 m. 1 — Proximal part of procladium with sicula; the first thecal cladium growing up from th_8 and virgula of the second thecal cladium at th_9 (×13); 2 — Proximal part of procladium with three thecal cladia (×7); 3 — Proximal part of procladium with two thecal cladia, the first growing up from th_9 (×8).

4, 9 — *Cyrtograptus hamatus* (Baily), Zawada *1*, 1540.0—1546.5 m. Proximal part of procladium with sicula (×11.5).

5, 8 — *Cyrtograptus urbanekii* nov. sp., Zawada *1*, 1546.5—1552.7 m. 5 — Holotype (×12.5); 8 — Sicula and first theca of the holotype (×26.5).

6 — *C. hamatus* (Baily), Zawada *1*, 1555.9—1562.0 m. Part of the procladium with thecal cladium (×12.5).

7 — *C. urbanekii* nov. sp., Zawada *1*, 1540.0—1546.5 m. Broken up and regenerated procladium or thecal cladium from which grows, in opposite direction, a pseudocladium with two thecae (×12.5).

PLATE 3

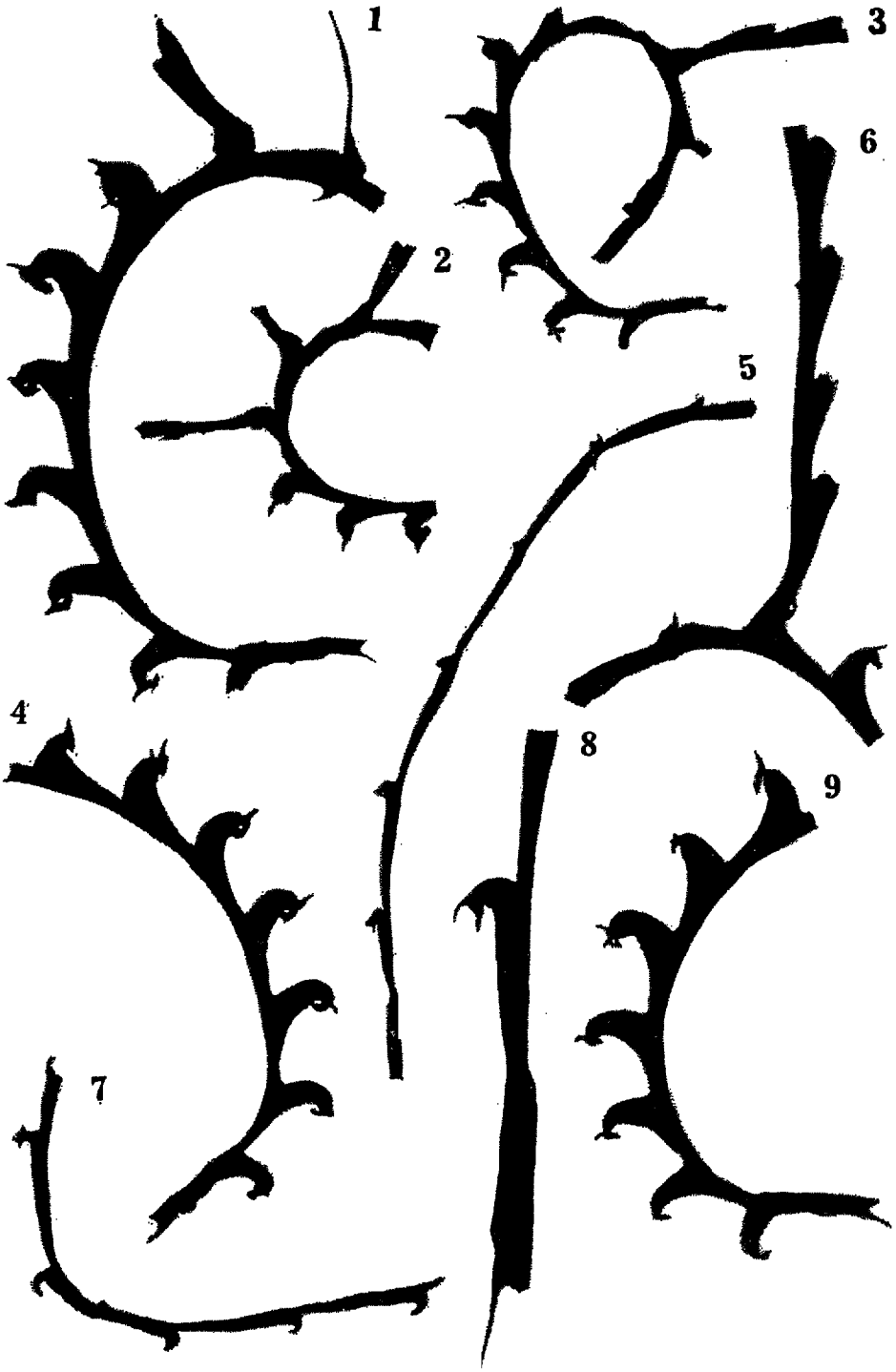
1 — *C. urbanekii* nov. sp., Zawada *1*, 1555.9—1562.0 m. Sicula with visible boundary between the pro- and metasicula and protheca of the first theca (×70).

2, 3 — *C. radians* Törnquist, Zawada *1*, 1555.9—1562.0 m. Enlarged sicula of samples shown in Pl. 1, Figs 1, 3 (×45.5).

4, 5 — *C. hamatus* (Baily), Zawada *1*, 1555.9—1562.0 m. Enlarged fragments of sample shown in Pl. 1, Fig. 6. 4 — Shape of apertural part of theca on the thecal cladium (×65); 5 — The mother theca of thecal cladium (×50).

6 — *C. radians* Törnquist, Zawada *1*, 1555.9—1562.0 m. Shape of th_8 on procladium of sample shown in Pl. 1, Fig. 1 (×80).

7 — *C. urbanekii* nov. sp., Zawada *1*, depth 1540.0—1546.5 m. Enlarged fragment of sample shown in Pl. 1, Fig. 7. Visible regenerated part of the pro- or thecal cladium, structureless membrane and the first theca of pseudocladium (×85).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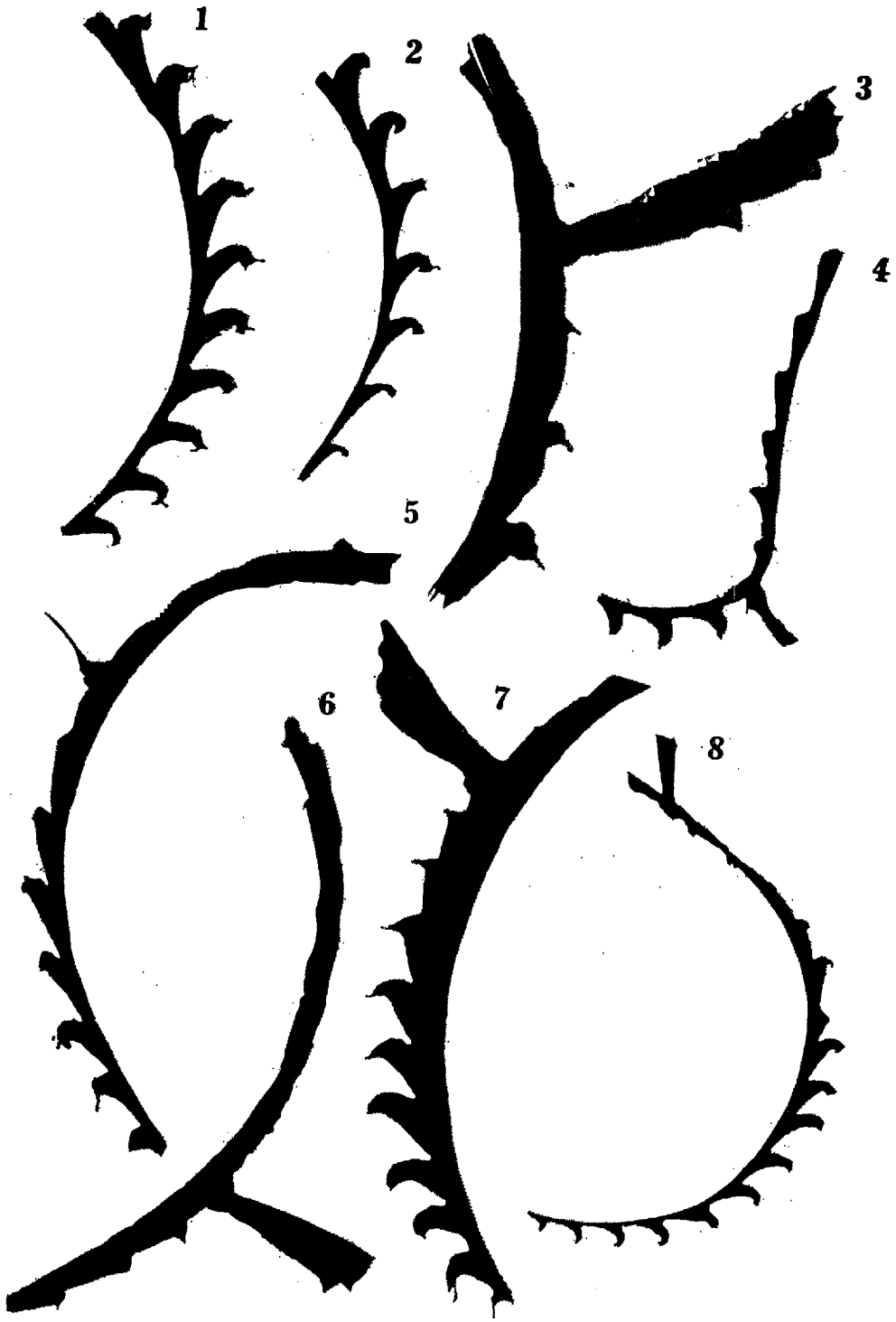

1-3, 5-8 — *Cyrtograptus lundgreni* Tullberg, Zawada *1*, 1546.5—1552.7 m, except for 7 (1540.0—1546.5 m). 1-2 — Proximal parts of procladium without sicula (×7); 3, 6-8 — Procladium with the first thecal cladium. Note torsion of the procladium axis and displacement of the thecae (3 ×13.5, 6-8 ×8); 5 — Procladium with virgula of the first thecal cladium (×9).

4 — *C. hamatus* (Baily), Zawada *1*, 1540.0—1546.5 m. Procladium with thecal cladium. Note torsion of the procladium axis, displacement of thecae and their different shape (×7.5).


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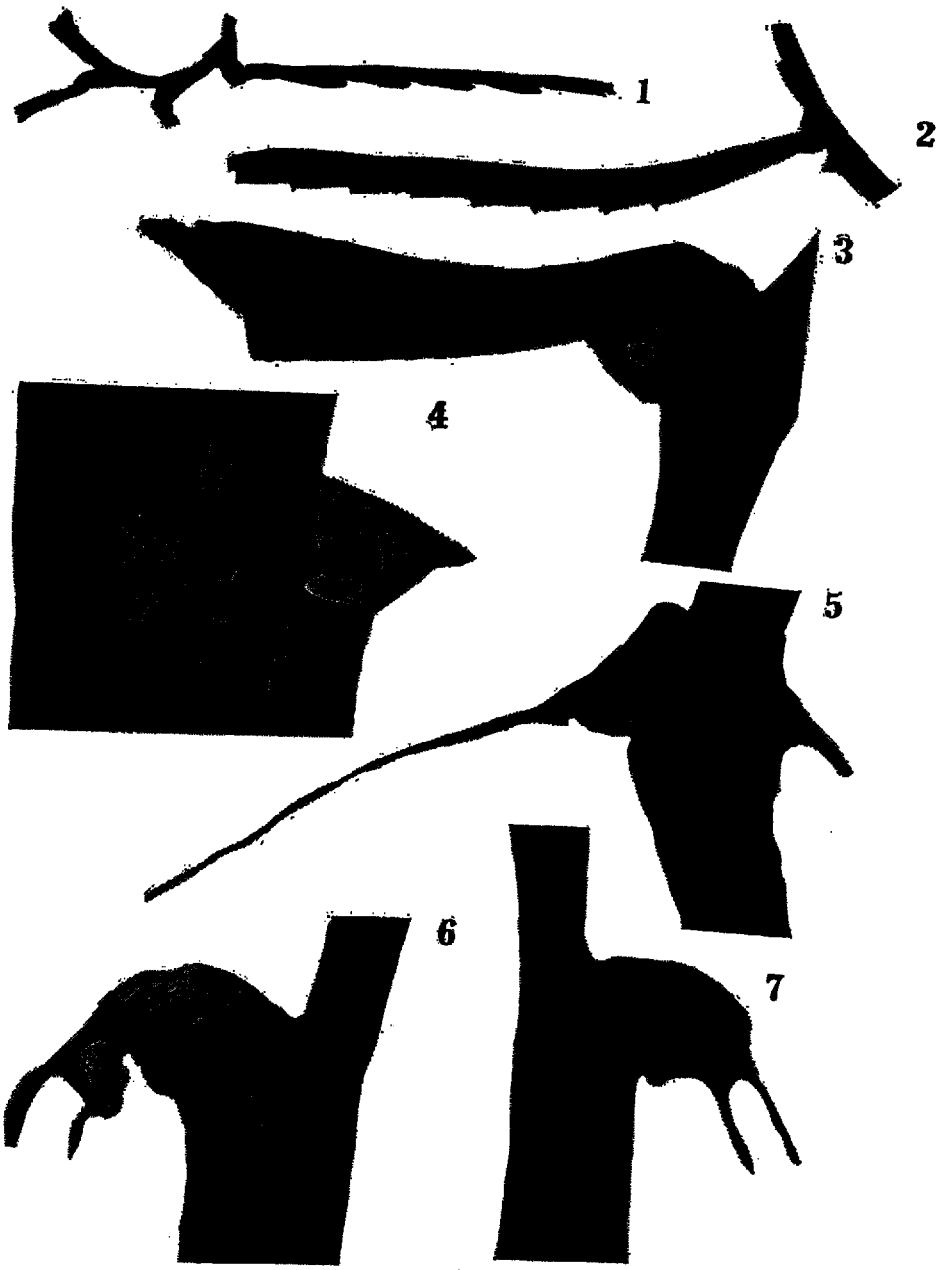

1, 3, 5 — *C. radians* Törnquist, Zawada *1*, 1565.9—1562.0 m. 1 — Part of procladium with three thecal cladia (×7.5); 3, 5 — Enlarged fragments of sample shown in Pl. 1, Fig. 1 (×45).

2, 4 — *C. lundgreni* Tullberg, Zawada *1*. 2 — Fragment of procladium with thecal cladium, 1540.0—1546.5 m (×7.5); 4 — Enlarged fragment of apertural region of the first theca on the thecal cladium. Sample shown in Pl. 2, Fig. 6; 1546.5—1552.7 m (×60).

6-7 — *C. urbanekii* nov. sp., Zawada *1*, 1546.5—1552.7 m. Enlarged fragments of th_1 and th_2 of the holotype shown in Pl. 1, Fig. 5. 6 ×120; 7 ×80.