

First record of *Telephina* (Trilobita) from the Ordovician of northeastern Estonia and its stratigraphical implications

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Abstract. For the first time a telephinid trilobite was recorded from the shallow-water rocks of the North Estonian Confacies Belt in the oil-shale mining area of northeast Estonia. A cranidium of *Telephina* (*Telephops*) *biseriata* (Asklund) was collected from a loose boulder of the kerogenous limestone of the Viivikonna Formation, Kukruse Stage, together with a rich assemblage of other trilobites, bryozoans, ostracods and rare graptolites. In its type area Jämtland, Sweden, *T. biseriata* occurs together with *Pygodus anserinus* and *Hustedograptus teretiusculus* in the Ståltorp Limestone Member of the Andersö Shale Formation, marking the latest Darriwilian. The occurrence in the North Estonian Confacies Belt of *Telephina*, known as a pelagic trilobite inhabiting deeper-water areas, probably reflects a transgression event at this time. Together with *T. biseriata*, other trilobite taxa such as *Remopleurides* and *Lonchodomas*, common in the *Hustedograptus teretiusculus* Biozone in deeper-water areas, arrive in the North Estonian Confacies Belt. Graptolites from the other loose boulders at the same locality have been identified as *Hustedograptus* cf. *uplandicus*, which occur together with a few dendroids.

Key words: Ordovician, Baltoscandia, Viivikonna Formation, Kukruse Stage, trilobites, *Telephina*.

INTRODUCTION

A relatively large cranidium of *Telephina* (*Telephops*) *biseriata* (Asklund, 1936) with a partly preserved test was found when collecting small proetid trilobites during fieldwork in the summer of 2010. It comes from a loose boulder on the tip-heap of the Sompa mine, Kohtla-Järve, where kerogen-rich limestone is mined for oil production. This oil shale is well known from its very abundant faunal assemblage, which includes about fifty trilobite species that have been studied since the beginning of the 19th century. This is the first record of *Telephina* Marek, 1952 from this area, and from Estonia in general.

In Baltoscandia *Telephina* first appears in marls of the lower Darriwilian Helskjer Member (Kunda Regional Stage) in the Mjøsa area of Norway (Nikolaisen 1963; Hansen 2009), and is widely distributed within the late Darriwilian fine-grained rocks. A few records are known from the lower Sandbian, and the latest from the Boda Limestone of latest Katian or possibly Hirnantian age (e.g. Nikolaisen 1963; Ahlberg 1995a, 1995b; Hansen 2009; Pärnaste et al. 2009). Nikolaisen (1963) described a case of explosive evolution of *Telephina* in the dark shales of the Elnes Formation (formerly *Ogygiocaris* Series) of Norway and coeval strata in Scandinavia, and concluded that they were adapted to waters low in oxygen. Altogether at least 15 species have been identified from

the Ordovician of Norway (Nikolaisen 1963; Wandås 1984; Bruton & Høyberget 2006; for synonymy see Ahlberg 1995a; Hansen 2009), many of which occur in contemporaneous beds in different areas of Sweden (Hadding 1913a, 1913b; Thorslund & Asklund 1935; Asklund 1936; Ahlberg 1995a; Månsson 1995). In addition, some rare occurrences are known from drill cores of Latvia and of the Pskov district of western Russia (Männil 1963; Ahlberg 1995b). Following Nikolaisen, Ahlberg (1995a) noted that in Baltica and Laurentia *Telephina* was restricted to the periphery of the continental plates, and so far, there are no known occurrences from nearshore sequences. A new find of this genus in the North Estonian Confacies Belt may reflect a sea-level highstand. However, most of the specimens are preserved in calcareous lenses and interlayers or concretions within the shales (e.g. Bruton & Høyberget 2006), as well as in some thicker carbonate beds such as the Ståltorp Limestone Member of the Andersö Shale in Jämtland (Månsson in Pålsson et al. 2002). Occurrences are also known from limestones of the Killeröd Formation in Scania, southern Sweden (Månsson 1995), and in the Vollen Formation (formerly *Ampyx* Limestone) in Norway (Nikolaisen 1963). Therefore the appearance of *Telephina* in the North Estonian Confacies Belt is not totally unexpected (Fig. 1).

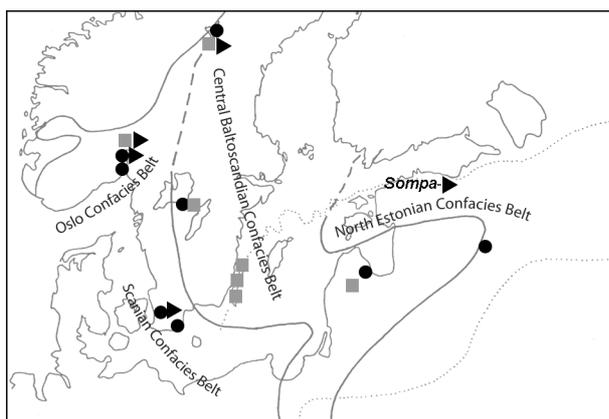


Fig. 1. Map of Baltoscandian confacies belts showing occurrences of *Telephina*. Grey squares indicate occurrences of *Telephina* (*Telephina*); black triangles show species of *Telephina* (*Telephops*) with the anterior glabellar spines situated close to each other, and black circles mark those with the wider space between the anterior glabellar spines.

Material used in this study (trilobites and graptolites) is deposited in the collections of the Institute of Geology at Tallinn University of Technology (repository acronym GIT). The trilobite specimen (not the graptolites) was whitened with magnesium oxide before photographing. The terminology used herein follows that of Whittington & Kelly (1997).

SYSTEMATIC PALAEOLOGY

Order PROETIDA Fortey & Owens, 1975
 Family TELEPHINIDAE Marek, 1952
 Genus *Telephina* Marek, 1952

Type species. *Telephus fractus* Barrande, 1852 from the Katian–Hirnantian (Ashgill) Králův Dvůr Formation, Bohemia, Czech Republic.

Diagnosis. See Nikolaisen (1963), Ahlberg (1995a) and Hansen (2009).

Remarks. A short-lived group of Baltoscandian *Telephina* species characterized by a pair of spines on the frontal part of the glabella was assigned by Nikolaisen (1963) to his subgenus *Telephina* (*Telephops*). Other workers considered that this character is only of specific significance (Tripp 1976; Ahlberg 1995a; Hansen 2009), but we agree with Chatterton et al. (1999), who argued

on the basis of ontogenetic studies that this feature may have a higher value in the taxonomy of these trilobites. The paired glabellar tubercles appear in their early life stages, and these are reduced during the ontogeny (Chatterton et al. 1999). A different case is with the paired spines, developed in the most frontal part of the glabella on *Telephina* (*Telephops*). The possible meraspid stage of one of the Scandinavian telephinids, designated as *Fialoides antiquatus* Hadding, 1913b, shows no tubercles and most probably represents *Telephina* (*Telephina*). The anterior glabellar spines likely are derived from the glabellar tubercles, which are known in the other meraspid telephinids. This group occurs together with spineless forms (Fig. 1). Thus it shows no geographic or lithostratigraphic variety, and we consider *Telephina* (*Telephops*) as a valid taxon.

Subgenus *Telephina* (*Telephops*) Nikolaisen, 1963

Type species. *Telephus granulatus* Angelin, 1854 from Norway (for comments, see Ahlberg 1995a, p. 274).

Diagnosis. See Nikolaisen (1963).

Telephina (*Telephops*) *biseriata* (Asklund, 1936)
 Figure 2

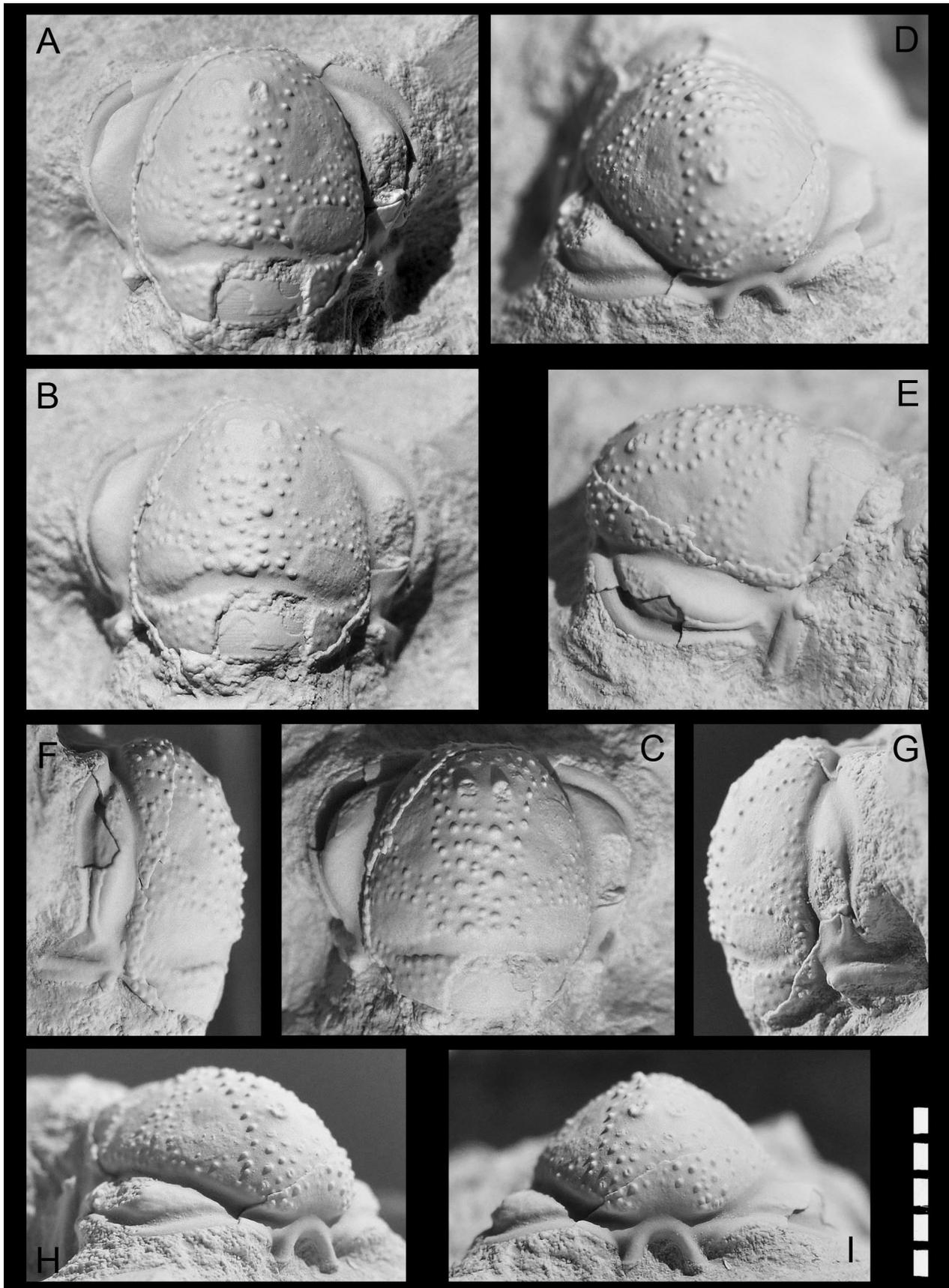
Synonymy. See Ahlberg (1995a, p. 277).

Material. A partly exfoliated cranidium (GIT 360-335). It is preserved in light terracotta-brown kerogenous limestone of the Kukruse Stage from the tip-heap of the Sompa mine, near Kohtla-Järve, northeastern Estonia.

Diagnosis. See Ahlberg (1995a).

Description. Length of cranidium (sag.) about 0.85 times its width, and fixigena narrow (tr.), occupying 18 per cent of the cranidium at its maximum width; anterior border convex in profile, also curving antero-ventrally; glabella highly convex, medially 1.15 times longer than its maximum width at the occipital furrow, and truncate in front. The surface sculpture of glabella including the occipital ring consists of relatively large tubercles, except for three pairs of smooth muscle attachment areas; the posterior one is transversely elongated and situated just in front of S0, occupying about a third of the glabellar width; the middle is kidney-shaped and surrounds a shallow bifurcated lateral glabellar furrow situated mid way from the sagittal line towards the axial furrow; the anterior one is nearly circular, rather small

Fig. 2. *Telephina* (*Telephops*) *biseriata* (Asklund, 1936) in the Kiviõli Member of the Viivikonna Formation, Kukruse Regional Stage. A–I, GIT 360-335. A–C, dorsal views; D, oblique anterior view; E, oblique dorso-lateral view; F, G, lateral views; H, anterolateral view; I, anterior view. All $\times 6$. Scale bar 5 mm.



and positioned close to the axial furrow just in front of the second one; the largest tubercles occur sagittally, and a pair of glabellar spines occurs on the far anterior, close to the mid-line. The lateral glabellar furrow S1 is shallow, diverging symmetrically into short branches at the mid point of palpebral fixigena; S0 prominent, slightly parabolic anteriorly, widest medially, narrowing shortly behind the muscle area, dying out without reaching the axial furrow; L0 relatively long, extending over 27 per cent of the glabellar length, its median part is broken off and the presence or absence of an occipital spine cannot be confirmed. The palpebral fixigena is narrow (tr.), evenly rounded and slightly concave; palpebral furrow rather deep, widest anteriorly; palpebral rim widens slightly anteriorly; a specific pattern of lirae (see Bruton & Høyberget 2006) covers the anterior part of the palpebral fixigena, and the posterior part with the muscular pattern is bounded adaxially by a narrow ridge. The ridge and the palpebral rim run parallel to each other and both slope downwards at the posterior suture of the fixigena, narrowing shortly thereafter. Triangular postocular fixigena very short (exsag.) behind the palpebral area, ending posteriorly in a ridge-like posterior border, which is also narrow transversely, together with the articulating area which is distinctly pointed up to the prominent fulcrum on the posterior border, from where it curves steeply down abaxially at nearly 90 degrees. Posterior border convex dorsally in profile, like the anterior border, but has additional shallow border furrow close to the posterior edge dying out adaxially before reaching the fulcrum.

DISCUSSION

On the basis of the distance between the anterior glabellar spines *Telephina* (*Telephops*) can be subdivided into two groups, one with a narrow space and the other with a wider space. In stratigraphical succession, the former occurs first, in the *Hustedograptus teretiusculus* Biozone or below, and includes *T. biseriata* from the middle Andersö Shale of Jämtland, *Telephina* sp. A *sensu* Ahlberg (1995a) from the Almelund Shale (formerly lower *Dicellograptus* Shale) at Röstånga, Scania in Sweden, and *T. invisitata* Nikolaisen, 1963 and *T. aff. granulata* (Angelin, 1854) *sensu* Hansen (2009) from the Elnes Formation (formerly *Ogygiocaris* Shale) in the Oslo, Hadeland and Mjøsa regions, Norway. Of these, the last species incorporates two juvenile cranidia more closely resembling *T. invisitata* than *T. granulata*.

The second group appears in the *Nemagraptus gracilis* Biozone and is represented by *T. granulata* (Angelin, 1854) from the Vollen Formation (formerly *Ampyx* Limestone) in the Oslo Region, Norway, the upper

Dalby Limestone in Västergötland, Sweden, and the upper Andersö Shale in Jämtland, Sweden. It also includes *T. armata* Nikolaisen, 1963 from the Vollen Formation in Asker, Norway. The geographical range of *T. granulata* extends farther east to the Livonian Tongue area, where it appears in the Blidene drill core, western Latvia, and the Lopatovo well in western Russia (Männil 1963; Ahlberg 1995b). The wide space between the anterior glabellar tubercles is also common in post-Darriwilian *Telephina* outside Baltica, for example in *T. bicornis* (Ulrich, 1930) from the Whitesburg Limestone of Virginia and *T. cf. bicornis* from the Brickwork's Quarry Shales Member of the Knockerk Formation in the Grangegeeth area, eastern Ireland (see Romano & Owen 1993). This feature might prove to be a good marker for biostratigraphical correlation, and in recognizing the Darriwilian–Sandbian boundary.

In our specimen the anterior glabellar spines are situated close to each other, as in a specimen of *T. biseriata* from the middle Andersö Shale (middle–upper *H. teretiusculus* Biozone) on Andersön, central Storsjön area, Jämtland, Sweden (see Ahlberg 1995a, pl. 6: 11, 12). However, the glabellar furrows are less pronounced in the Estonian specimen, but this is similar to other Swedish specimens of *T. biseriata*, including the holotype (Ahlberg 1995a, pl. 6: 9, 13). The glabellar tubercles are coarser in the Estonian specimen and in this respect, it resembles *T. aff. biseriata* (Ahlberg 1995a, pl. 6: 14) from a dark grey limestone in the middle Andersö Shale (probably the upper *H. teretiusculus* Biozone) on the northwestern shore of Andersön. Unfortunately, the latter is too fragmentary for detailed comparison. *Telephina aff. biseriata* also resembles our specimen in its proportionally wider glabella, but differs in the width of the palpebral lobes. In the shape of the glabella, its anterior truncation and in the size of tubercles our specimen also resembles *T. aff. granulata* from the Killeröd Formation (upper *H. teretiusculus* Biozone) at Röd mölla and Killeröd, southeast Scania. This is the only representative of the ‘wide’ group determined from the beds equivalent to part of the upper *H. teretiusculus* Biozone (Bergström 1973; Ahlberg 1995a). Of the three known specimens, the two smaller have the prominent glabellar spines rather close adaxially, resembling the older species (e.g. *T. biseriata*), but in the largest specimen these spines are farther apart. Perhaps this combination of the anterior spines moving apart during the late holaspid period also shows the phylogenetic sequence in the *biseriata*–*granulata* lineage. These three specimens differ from our specimen in having very shallow glabellar furrows located closer to the sagittal line.

In their biostratigraphical and palaeoecological study on graptolites, trilobites and conodonts of the Andersö

Shale in Jämtland, Pålsson et al. (2002) showed parallel the ranges of these groups. They also established a new lithostratigraphical unit, the Ståltorp Limestone Member. This is a dark-coloured, rather pure, and richly fossiliferous bedded limestone, overlying the Lower Andersö Shale Member. Previously this unit was informally called the ‘*Telephina biseriata* beds’ (Thorslund 1960), or simply ‘*biseriata* limestone’ (Karis 1982). *Telephina biseriata* and *T. aff. biseriata* co-occur in the Ståltorp Limestone (Månsson in Pålsson et al. 2002, p. 45, fig. 10), which is assigned to the lower part of the *Pygodus anserinus* Biozone (Bergström in Pålsson et al. 2002, p. 47, fig. 12), and tentatively to the upper part of the *H. teretiusculus* Biozone (Pålsson in Pålsson et al. 2002, p. 41, fig. 7). *Pygodus anserinus* has not been recorded from the oil-shale mining area in northeastern Estonia but it occurs rarely to the south in drill cores from the upper part of the Uhaku Stage (Viira et al. 2006; Hints et al. 2007; Viira 2008). Representatives of the younger *Amorphognathus tvaerensis* Biozone are numerous in northern and southern Estonia, except in Kohtla, which is close to Sompa. In Kohtla this conodont species appears in the first limestone interbed A/B at about 30 cm from the base of the Kukruse Stage, and is very rare until bed G in the upper part of the stage (Viira et al. 2006). Elsewhere, Viira (2008, p. 33) points out an interval without any of these index species at the boundary of the Uhaku and Kukruse stages. The age of this ‘barren’ interval is obscure. It seems that there is a potential for correlation within Baltoscandia based on the distribution of trilobite genera *Telephina*, *Remopleurides* Portlock, 1843 and *Lonchodomas* Angelin, 1854, represented in both areas and stages.

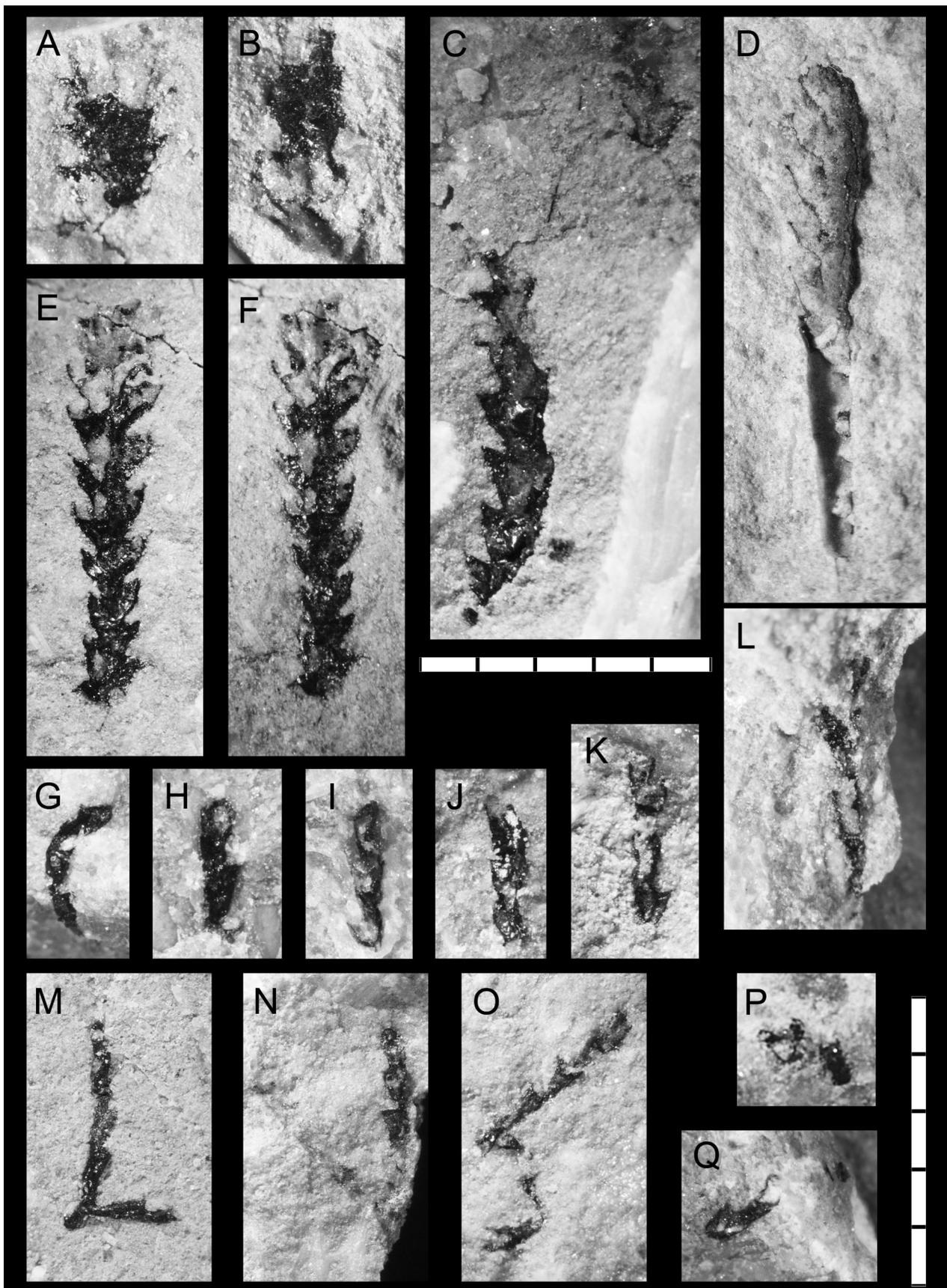
Graptolites are scarce in the North Estonian carbonate succession. Some fragmentary graptolites (Fig. 3P, Q), which derive from the same piece of rock as the telephinid trilobite described above, resemble *Dicranograptus irregularis* Hadding (in Pålsson et al. 2002, p. 40, fig. 6), but are too poorly preserved for precise identification. An assemblage of graptolites (Fig. 3A–F) from other loose boulders at the same locality includes more complete material identified probably as *Hustedograptus* cf. *uplandicus* (Wiman, 1895). This species co-occurs with *Laufeldochitina stentor* (Eisenack, 1937) in the Dreimani Formation in the Aizpute core, western Latvia, i.e. the Livonian Basin (Männil 1976, fig. 2). The others (Fig. 3G–O) resemble *Dendrograptus rigidus* Bulman, 1936, which is known from somewhat older beds of the Engervik Member of the Elnes Formation in the Oslo Region (Maletz & Egenhoff 2004), and also *Dendrograptus? balticus* Wiman, 1895. The latter was collected from the South Bothnian district together with *H. uplandicus* (Wiman 1895). However, these are not

recorded from the ‘*biseriata* limestone’ in Jämtland (Pålsson et al. 2002) or from the Almelund Shale in Scania, and so direct correlation with the Viivikonna Formation on the basis of these graptolites is not possible. In Jämtland *Nemagraptus gracilis* (Hall, 1847), the index graptolite for the lower boundary of the Sandbian, appears above the Ståltorp Limestone Member. Some recent finds of *N. gracilis* from Estonian and Latvian sections are summarized by Nölvak and Goldman (2004, 2007). They show that all these specimens of *N. gracilis* come from the upper part of the Viivikonna Formation of the Kukruse Regional Stage, dating it as Sandbian. In general, the Kukruse Stage has been considered to be roughly coeval with the *gracilis* Biozone, and consequently the boundary between the Middle and Upper Ordovician has been drawn mainly at the boundary between the Uhaku and Kukruse regional stages. Recently, *N. gracilis* has been found in the upper part of the Kõrgekallas Formation of the Uhaku Stage in the Männamaa drill core, Hiiumaa, western Estonia (Nölvak 2008), bringing the lower boundary of the Sandbian downwards in Estonia. The exact level of the base of the Upper Ordovician in Estonia is nevertheless debatable (see discussions in Nölvak & Goldman 2004; Viira et al. 2006; Hints et al. 2007).

CONCLUSIONS

Telephina (Telephops) biseriata is common in the Ståltorp Limestone Member of the Andersö Shale Formation in Jämtland, where it co-occurs with conodonts of the lower part of the *P. anserinus* Biozone as well as with graptolites of the upper part of the *H. teretiusculus* Biozone. The record of *T. biseriata* in the kerogenous limestone of the Viivikonna Formation, Kukruse Regional Stage, in the vicinity of Kohtla-Järve suggests that the lower part of this formation may be contemporaneous with the ‘*biseriata* limestone’ of the *H. teretiusculus* Biozone in Jämtland. The presence of *Hustedograptus* cf. *uplandicus* at the same locality as *T. biseriata* at Sompa, however, is insufficient to prove or disprove this suggestion. Thus, the lowermost part of the Viivikonna Formation in northeastern Estonia may possibly belong to the uppermost Darriwilian, or also to the Sandbian, if there is a shift in time in occurrences of *T. biseriata* in Estonia compared to the Jämtland area.

The appearance of a pelagic trilobite *Telephina biseriata* (Asklund), previously known as a deep-water inhabitant (Fortey 1975), in the North Estonian Confacies Belt, may reflect the peak of a major sea-level highstand event embracing the late Darriwilian–early Sandbian (Haq & Schutter 2008).



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Fig. 3. Graptolites from the Viivikonna Formation, Kukruse Regional Stage of the Sompma mine, Kohtla-Järve, northeastern Estonia. **A–F**, *Hustedograptus* cf. *uplandicus* (Wiman). A, GIT 360-345-1; B, GIT 360-345-2; C, GIT 360-346-1, -2; D, GIT 360-347; E, F, GIT 360-345-3. **G–Q**, *Dendrograptus*? sp. G, GIT 360-338; H, GIT 360-339; I, GIT 360-340; J, GIT 360-341; K, GIT 360-342; L, GIT 360-343; M–O, GIT 360-344-1, -2, -3; P, GIT 360-336; Q, GIT 360-337 (P, Q, from the same piece of rock as the trilobite *Telephina* (*Telephops*) *biseriata*). All $\times 10$. Scale bars 5 mm.

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Telephina (Trilobita) leid Kirde-Eesti Ordoviitsiumist ja selle stratigraafiline tähendus

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Kukuruse lademe seni teadaolevale viiekümnele trilobiidi liigile lisandus *Telephina (Telephops) biseriata* (Asklund). Selle perekonna esindajad on senini teada olnud vaid sügavamaveelistest faatsiestest Norra, Rootsi ja Läti vastavates piirkondades. Uus leid Kohtla-Järvelt Sompast on esimene kaldalähedasest Põhja-Eesti fatsiaalvööndist. Rootsis Jämtlandi regioonis esineb see liik Ståltorpi lubjakivi kihistikus Andersö kiltade vahel koos *Pygodus anserinus*'e konodontitsoonile ja *Hustedograptus teretiusculus*'e graptoliiditsoonile iseloomuliku fossiilikooslusega. Viimased markeerivad Darriwili globaalse lademe ülemist osa. Kirde-Eesti *T. biseriata* peakilp esineb lahtisel kivimpalal koos mittemääratava dendroidi fragmendiga ja ei võimalda täpsemat biotsonaalset määrangut. Samast leiukohast, kuid samuti määramata tasemest on pärit graptoliit *Hustedograptus cf. uplandicus*, mida on korreleeritud Sandbi lademe *Nemagraptus gracilis*'e tsooniga. *N. gracilis* leiti hiljuti Hiiumaa puuraugust Kõrgessaare kihistust, mida on peetud Viivikonna kihistust vanemaks, ja seega joonistub piir globaalsete lademete Darriwili ning Sandbi vahel Uhaku regionaalse lademe sisse. Uus *T. biseriata* leid põlevkivi levilas viitab võimalusele, et see liik esineb Kirde-Eestis hiljem kui Kesk-Rootsis Jämtlandi piirkonnas, või ka võimalusele, et Viivikonna kihistu alumine osa Kirde-Eestis võib lokaalselt olla Hilis-Darriwili vanusega.