Silurian graptolite biostratigraphy of the Röstånga-1 drill core, Scania – a standard for southern Scandinavia

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Abstract

The Röstånga-1 core from west-central Scania provides the most complete succession of the Sandbian (Upper Ordovician) through lower Telychian (Silurian, Llandovery) strata of southern Scandinavia. The Hirnantian is identified in the Kallholn Formation by the presence of a *Metabolograptus persculptus Biozone* fauna. The *Akidograptus ascensus*, *Parakidograptus acuminatus, Cystograptus vesiculosus* and *Monograptus revolutus* biozones can be differentiated in the Rhuddanian. Following a considerable gap (*Demirastrites triangulatus* Biozone to a level within the *Pribylograptus leptotheca* Biozone), the succession resumes. The Aeronian also includes the *Lituigraptus convolutus* and *Stimulograptus sedgwickii* biozones. The *Stimulograptus halli* Biozone appears to be missing, but the Telychian *Spirograptus guerichi* to *Streptograptus crispus* biozones have been recognized.

Introduction

Scania (Skåne) has long been a focus for research into the Ordovician and Silurian graptolite biostratigraphy of southern Scandinavia and especially of Sweden as it provides the most complete successions available for the palaeocontinent of Baltica throughout this interval. The Sandbian Stage of the Upper Ordovician Series has, for instance, its Global Boundary Stratotype Section and Point in the Fågelsång area east of Lund in south-central Scania (Bergström et al. 2000; Bergström & Ahlberg 2004). A number of drill cores pierce the Palaeozoic succession of the region, providing additional information to that provided by the generally poor to moderate outcrops. As little work has been undertaken since the early investigations by Törnquist and Tullberg in the late 19th century (e.g. Tullberg 1882, 1883; Törnquist 1893, 1897), the Silurian graptolitic strata of Scania are, unfortunately, less well known than might be expected and new research is urgently needed.

The Röstånga-1 core from west-central Scania (Bergström et al. 1999), drilled in 1997, provides the most complete succession of the lower Upper Ordovician (Sandbian) through lower Silurian (Llandovery, Telychian) strata of southern Scandinavia. The drilling was stopped at a depth of 132.59m and penetrated a seemingly continuous lithological succession with little tectonic disturbance. The sedimentary rocks have a dip of c. 35° and the stratigraphical thickness of the sedimentary column was estimated to be about 96m (Bergström et al. 1999). The core diameter is 71mm (between 0 and 40.13m) and 52mm (between 40.13 and 132.59 m), thus providing ample sedimentological and palaeontological information for a general analysis. The drill core has provided important information on the Upper Ordovician–lower Silurian biostratigraphy of Scania and serves as an important reference standard for this interval in southern

Scandinavia. The lowermost part of the core comprises the upper part of the Sandbian Sularp Shale (?*Nemagraptus gracilis to Climacograptus bicornis* biozones), in which numerous K-bentonite beds were recorded (Bergström et al. 1999). The base of the Sularp Shale, the Fågelsång Phosphorite Bed, and the base of the *N. gracilis* Biozone which is c. 1.4m below (the base of the Sandbian Stage), was not reached. Above the Sularp Shale, the Skagen Formation, Mossen Shale, Fjäcka Shale, Lindegård Mudstone and lower Kallholn Shale were differentiated in the Ordovician interval (öet al. 1999). Graptolites from the *Pleurograptus linearis* and *Dicellograptus complanatus* biozones have been identified and support the estimated datings of the Katian portion of the core (Pålsson 2002).

The Upper Ordovician (Katian–Hirnantian) Lindegård Mudstone grades into the Kallholn Formation, the base of Mudstone grades into the Kallholn Formation, the base of which is placed at 58.50m and can be referred to the Hirnantian *Metabolograptus persculptus* Biozone (Koren' et al. 2003, fig. 2). The overlying, largely lower Silurian succession was previously referred to the Rastrites Shale and Retiolites Shale in southern Scandinavia, but Bergström & Bergström (1996) used the term Kallholn Formation for this interval. The sedimentology of the succession has never been described in detail and, unfortunately, a comparison with the Kallholn Formation of Dalarna (Llandovery: upper Rhuddanian to Telychian) is not possible at the moment.

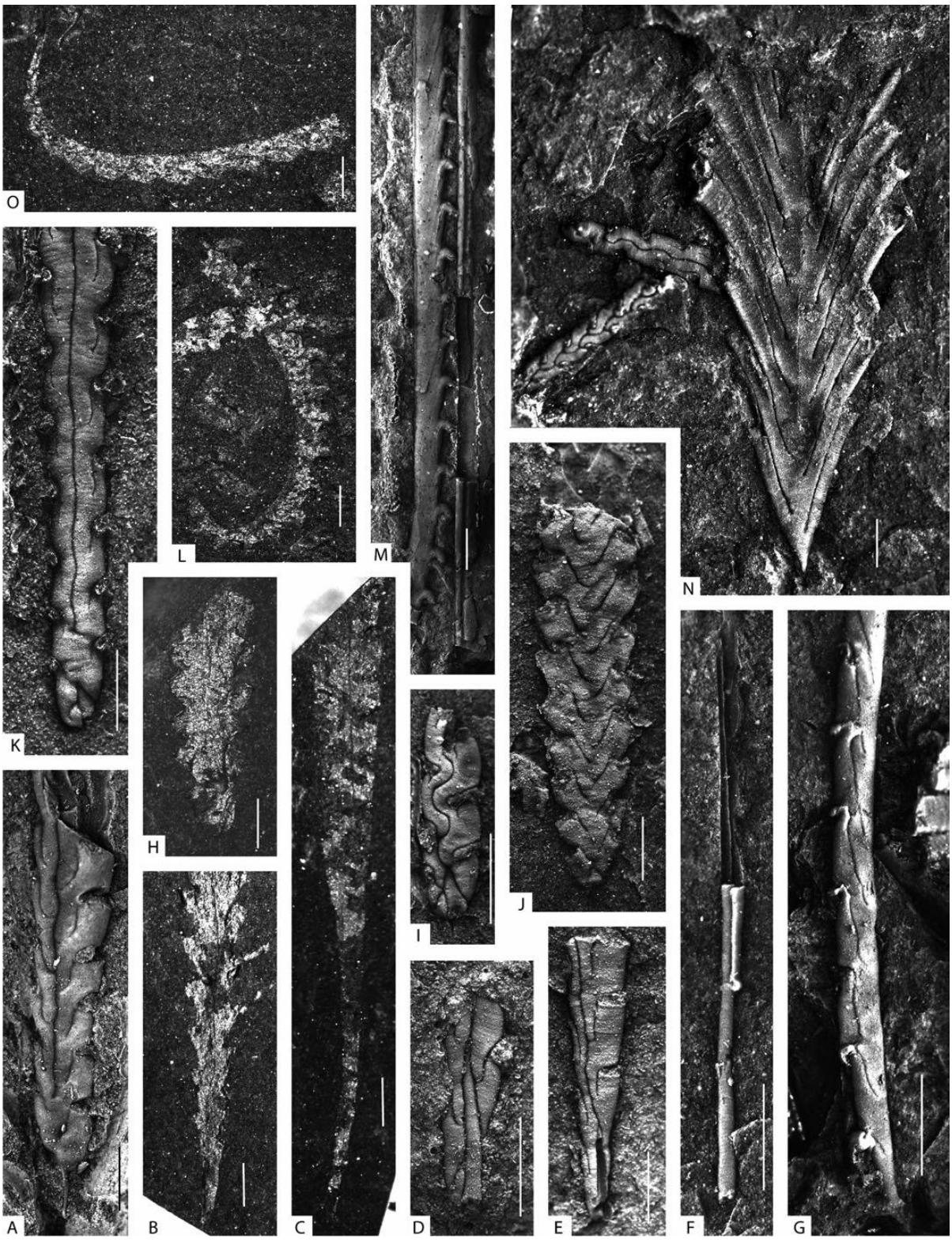

Fig. 1. Representative graptolites from the Ro¨sta°nga-1 drill core. All illustrated specimens are housed at the Department of Geology, Lund University, Sweden (prefixed LO). **A.** *Metabolograptus parvulus*, reverse view, ro 58.50 m, LO 11851t. **B.** *Parakidograptus acuminatus*, flattened, ro 48.70–48.60 m, LO 11852t. **C.** *Dimorphograptus extenuatus*, flattened, ro 44.75–44.60 m, LO 11853t. **D.** *Normalograptus* sp. indet. Obverse view, ro 35.50–35.40 m, LO 11854t. **E.** *Rhaphidograptus toernquisti*, obverse view, ro 35.50–35.40 m, LO 11855t. **F.** *Huttagraptus. acinaces?*, juvenile, note origin of th1, ro 35.50–35.40 m, LO 11856t. **G.** *Pernerograptus argutus*, stipe fragment, ro 33.65–33.55 m, LO 11857t. **H.** *Korenograptus illustris*, ro 49.2–49.1 m, LO 11867t. **I.** *Metaclimacograptus* sp., obverse view, ro 38.80–38.70 m, LO 11858t. **J.** *Rivagraptus bellulus*, obverse view, ro 33.65–33.55 m, LO 11859t. **K.** *Pseudoglyptograptus vas*, obverse view, ro 35.40–35.30 m, LO 11860t. **L.** *Campograptus clingani*, flattened, ro 34.30–34.15 m, LO 11861t. **M.** *Pernerograptus? argenteus*, fragment, ro 35.20–35.10 m, LO 11862t. **N.** *Petalolithus folium* (LO 11863t), reverse view, associated with *Pseudoglyptograptus vas* (LO 11864t) and *Metaclimacograptus undulatus* (LO 11865t), ro 35.40–35.30 m. **O.** *Monograptus inopinus*, flattened, ro 34.00–33.90 m, LO 11866t. Scale bar indicates 1mm in each photo.

The mudstones of the Lindegård and Kallholn Formations in the Röstånga-1 drill core include a variety of lithologies, predominantly black to dark-brown, reddish and greenish mudstone and shale with intercalations of 1–15-mm-thick siltstone layers in certain intervals. Lamination, cross-bedding and bioturbation are common, except in some of the finer sedimentary rock types. The upper part of the Kallholn Formation is dominated by dark-to-light greenish shale with lamination; coarser layers are usually lighter in colour. Some bioturbation is visible, often enhanced by pyrite crystals outlining the burrows. Fossils are largely restricted to graptolites, but a few phosphatic and calcitic brachiopods and even trilobite fragments have also been encountered. Beds crowded with current-oriented graptolites are common in the lower, darker part of the Kallholn Formation, where graptolites are often preserved in full relief, filled with pyrite.

This study provides a preliminary overview on the graptolite succession of the drill core, based on initial identification of the graptolite specimens. A complete documentation of the biostratigraphic ranges of all taxa will require a more detailed study of the available material. Especially graptolite faunas of the Aeronian and Telychian intervals have been updated considerably from Bergström et al. (1999), showing also possible (previously unknown) gaps in the succession. Illustrations of key index taxa for the biostratigraphy have been provided. The lithology is shown in Bergström et al. (1999, fig. 2), where also the metrage for the boundary levels is provided, based on the original measurements of the drill core, not the re-calculated thickness of the stratigraphic column.

Hirnantian Stage (Upper Ordovician)

The base of the Hirnantian cannot be determined as faunas are lacking in large parts of the interval. The first appearance of the graptolite *M. persculptus* at 58.50m is taken as the base of the local *M. persculptus* Biozone.

M. persculptus Biozone and post-persculptus interval (58.50–52.70 m)

The *M. persculptus* Biozone can be recognized by the presence of the index species. Koren' et al. (2003) illustrated the fauna. Graptolite assemblages from 58.50 to 55.78m include *Metabolograptus parvulus* (Fig. 1A) and in the upper part *Normalograptus* sp. A single specimen of *Sudburigraptus* sp. was also found in the interval. Strata from 55.78 to 52.70m contain a slightly more diverse assemblage including *Normalograptus angustus, Normalograptus normalis, Normalograptus premedius* and *Avitograptus avitus*. The specimens are flattened and often poorly preserved in silty, dark-to-reddish or greenish shale. Species differentiation is difficult, especially for those specimens preserved in scalariform view. Koren' et al. (2003) differentiated the fauna as the 'Normalograptus (now Avitograptus) avitus s.s. fauna' and discussed the interval as a *postpersculptus* interval, possibly of Silurian age.

Rhuddanian Stage (Silurian, Llandovery)

The base of the Rhuddanian (Llandovery) is difficult to determine and may be placed at 52.70 m, i.e. at the first occurrence of *Akidograptus ascensus* (Koren' et al. 2003). However, it is commonly difficult to establish the exact ranges of many graptolite species based on the limited material from the drill core. The post-*persculptus* interval, in which index species are not present, can be of either latest Ordovician or earliest Silurian age.

A. *ascensus* Biozone (52.70–50.50 m)

The fauna includes A. *ascensus*, *N. normalis* and *N. angustus*. The preservation of the graptolites is poor, as the specimens are generally completely flattened and preserved in a silty reddish to greenish shale.

Parakidograptus acuminatus Biozone (50.50–46.60 m)

The base of the *Parakidograptus acuminatus* Biozone is taken at the first occurrence of the eponymous species (Fig. 1B) at 50.50m. Further faunal elements include *A. avitus*?, *N. angustus, Normalograptus balticus, Normalograptus ajjeri, N. normalis, Normalograptus rectangularis* and *Korenograptus illustris* (Fig. 1H). All graptolites are flattened and poorly preserved, not providing details of their astogeny, and identification is often difficult.

Cystograptus vesiculosus Biozone (46.60–37.30 m)

Koren' (unpublished report) differentiated a lower *Cystograptus vesiculosus* Biozone (46.60–42.70 m; the *extenuatus–toernquisti* Subzone) and an upper C. *vesiculosus* Biozone (42.70–37.30 m; the acinaces Subzone) in this interval. The rich fauna includes C. vesiculosus, Dimorphograptus extenuatus (Fig. 1C), *Rhaphidograptus toernquisti* (very common), *Metaclimacograptus undulatus, Metaclimacograptus* sp. (Fig. 1I), *Glyptograptus tamariscus?, Dimorphograptus elongatus, Dimorphograptus erectus, Atavograptus atavus* and *Huttagraptus praestrachani*. The specimens are preserved as flattened films or in partial to full relief, filled with pyrite.

Monograptus revolutus Biozone (37.30–35.40 m; = *Coronograptus cyphus* Biozone)

The rich fauna of this interval includes several normalograptids (*N. normalis, Normalograptus medius*), *Metaclimacograptus hughesi, M. undulatus, Glyptograptus* sp., *R. toernquisti* (Fig. 1E), *Dimorphograptus confertus, Coronograptus cyphus, Huttagraptus acinaces?* (Fig. 1F) and *Pribylograptus* sp. Many specimens are preserved in partial to full relief, providing information on the construction of the colonies (e.g. *Normalograptus* sp. indet., Fig. 1D).

Aeronian Stage (Silurian, Llandovery)

A considerable gap is present in the lower Aeronian, comprising the *Demirastrites triangulatus* Biozone to a level within the *Pribylograptus leptotheca* Biozone.

P. leptotheca and *Lituigraptus convolutus* biozones (35.40–31.05 m)

The rich fauna of this interval includes, among others, the index species *Lituigraptus convolutus, Campograptus clingani* (Fig. 1L), *Campograptus lobiferus, Torquigraptus decipiens, Monoclimacis crenularis, Monograptus inopinus* (Fig. 1O), *Cephalograptus cometa, Cephalograptus cometa extrema, Petalolithus minor, Petalolithus folium* (Fig. 1N), *Rivagraptus bellulus* (Fig. 1J), *Pseudoglyptograptus vas* (Fig. 1K, 1N), *Clinoclimacograptus retroversus, M. undulatus* (Fig. 1N), *Pernerograptus? argenteus* (Fig. 1M) and *Pribylograptus argutus* (Fig. 1G).

The interval may be differentiated into the *P. leptotheca* Biozone (see Štorch 1998) and the *L. convolutus* Biozone (cf. Bjerreskov 1975; = *cometa* Biozone of Waern 1960; *convolutus* Biozone of Štorch 1998). The preservation of the material ranges from flattened to full relief, filled by pyrite.

Stimulograptus sedgwickii Biozone (31.05–28.45 m)

Stimulograptus sedgwickii appears at 31.05m, defining the base of the biozone. The fauna includes *Normalograptus* sp., *M. undulatus, C. retroversus, Petalolithus praecedens, C. cometa extrema, Pseudoretiolites perlatus, Pristiograptus* sp., *Monograptus capis, Monograptus urceolus, Torquigraptus* sp. and *Rastrites* sp. The graptolites are flattened, but a few partial relief specimens exist at certain levels.

Telychian Stage (Silurian, Llandovery)

The *Stimulograptus halli* Biozone is not recognized, indicating a possible gap in the biostratigraphical succession.

Spirograptus guerichi Biozone (28.45–24.12 m; = lower runcinatus Biozone of Waern 1960)

The fauna includes *Normalograptus sp.*, *G. tamariscus* grp., *Glyptograptus elegans, Parapetalolithus hispanicus, Pristiograptus* sp., *Monograptus marri, S. halli?*, *Spirograptus guerichi, Torquigraptus planus* and *Rastrites linnaei*. Graptolites are flattened and usually fragmented, poorly preserved.

Spirograptus turriculatus Biozone (24.12–21.70 m; = upper *runcinatus* Biozone of Waern 1960)

This zone is differentiated into three subzones. The lower subzone (24.12–23.90m) is dominated by *Streptograptus plumosus*; the middle subzone (23.90–22.80 m) is dominated by *M. marri* and *Pristiograptus bjerringus* and the upper subzone (22.80–21.70m) is dominated by *Streptograptus exiguus*. The fauna is poorly preserved and generally the specimens are flattened. A single layer includes the relief specimens of *S. plumosus*, filled with pyrite.

Streptograptus crispus Biozone (21.70–11.16 m)

Koren' (unpublished report) differentiated three subzones: a lower subzone dominated by *M. marri* and *Monograptus galaensis* (21.70–20.70 m), a middle subzone dominated by *Glyptograptus nebula* and *M. galaensis* (20.70–12.48 m) and an upper subzone, dominated by *Cochlograptus veles* and *S. exiguus*.

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