ISOS-14 Field Guide
The Ordovician of Estonia

Edited by Olle Hints and Ursula Toom

14th International Symposium on the Ordovician System, Estonia, July 19-21, 2023
Pre-conference Field Excursion: The Ordovician of Estonia, July 15-18, 2023

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Stop 8: Reinu quarry

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Location: Latitude 59.08768°N, longitude 24.74044°E; Rapla County, central northern Estonia.
Stratigraphy: Latest Katian to Rhuddanian; Pirgu to Juuru regional stages, Adila, Ärina, Varbola and Tamsalu Fm.
Status: Active quarry with high walls – be careful; hammering and fossil collecting are welcome!
More information: https://geoloogia.info/en/locality/16317

The Reinu quarry is located in northern Estonia, 40 km south of Tallinn. The early Silurian limestone of the Varbola Formation, Juuru Regional Stage, has been quarried for crushed stone production since 2007. Today the quarry is operated by the infrastructure construction and maintenance company TREV-2 Grupp. The limestone aggregates from the Reinu quarry are used mainly in road construction.

The locality has been visited by geologists since the first bedrocks were quarried, and it has served as an excellent and fossiliferous outcrop for the Varbola Formation (Einasto et al. 2007). A number of studies have been published on the material from the Reinu succession, notably on important palaeontological finds (Ausich et al. 2020; Wright & Toom 2017; Jeon et al. 2022), but also on chemostratigraphy (Gul et al. 2021). The Ordovician–Silurian boundary interval was first exposed in the quarry in 2020 within a small rounded excavation used for water drainage and pumping. In 2022, Ordovician rocks were opened on a larger scale, and they started contributing to the quarry's production. Since then, the topmost Pirgu (latest Katian) and the entire Porkuni (Hirnantian) regional stages have been accessible in the Reinu quarry. This is now the second outcrop of the Ordovician–Silurian boundary interval in Estonia, the other being the Neitla quarry (Männik & Nõlvak 2023). Hirnantian rocks are well known in a few additional sites, notably the old Porkuni quarry (Hints et al. 2000, Hints & Männik 2014).

Studies on Hirnantian strata in the Reinu quarry are currently underway, with only some preliminary results on microfossils and chemostratigraphy published (Hints & Tonarova 2023; Meidla et al. 2023b). The main units identified in the quarry are briefly characterised and discussed below.

(1) The **Adila Formation** (0.3 m; Pirgu Regional Stage, Latest Katian) consists of gray wackestones with several pyritsed discontinuity surfaces. It is the lowermost stratigraphic unit exposed only in the deepest part of the quarry. The formation contains organic-walled microfossil assemblage typical of the Pirgu Regional Stage in Estonia, including rare *Spinachitina coronata*, *Cyathochitina campanulaeformis*, *C. kuckersiana*, and *Belonechitina micracantha*. However, no specific zonal chitinozoans were found in the few samples studied. Additionally abundant scolecodonts, melanosclerites and foraminiferans (*Blastammina* sp.) were found.

Fig. 8.1. Overview of the Reinu quarry, showing Hirnantian reefs (Ärina Formation, Porkuni Regional Stage) in the lower escarpment and overlying limestones of the Varbola Formation (Hirnantian to Rhuddanian, Juuru Regional Stage). Photo: Olle Hints, 2022.

Fig. 8.2. Ordovician-Silurian boundary beds in the Reinu quarry. Hand points to the Koigi Member. Photo: Olle Hints, 2022.

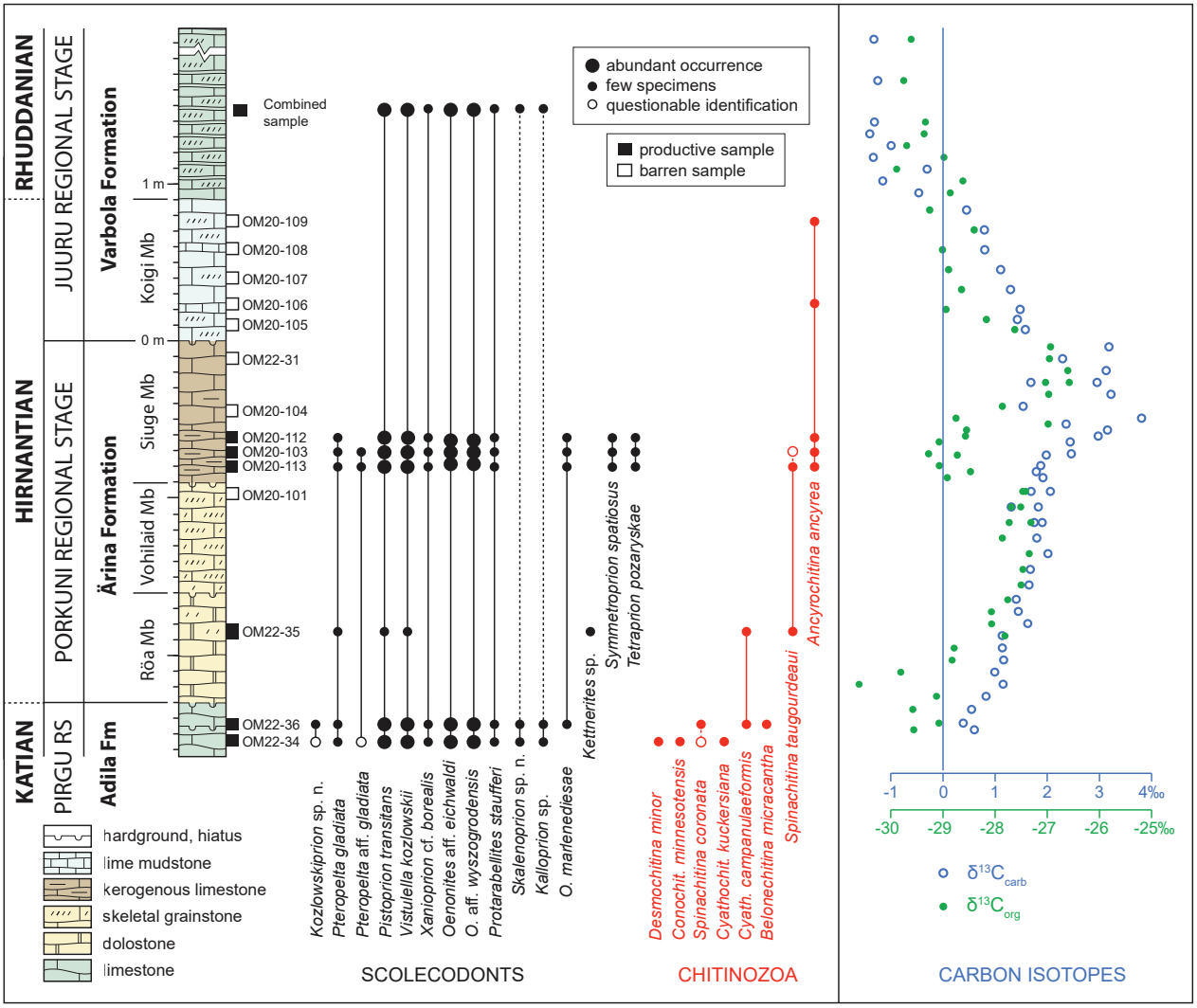

Fig. 8.3. Ordovician-Silurian boundary beds in the Reinu quarry. Distribution of selected scolecodonts is modified from Hints & Tonarova (2023), chitinozoan data by Jaak Nõlvak (unpublished), carbon isotopes from Meidla et al. (2023). Note that the isotope data points are adjusted to fit the boundaries between lithological units, due to the fact that thickness of individual beds varies between the sampling sites within the quarry.

Fig. 8.4. Dolomitised Hirnantian reef the Reinu quarry. The reefal limestone is usually assigned into the Tõrevere Member of the Ärina Formation. Here the reefs are laterally replaced by the kerogenous Siuge Member in distance of few meters. Photo: Olle Hints, 2022.

(2) The **Ärina Formation** (c. 2.5 m; Porkuni Regional Stage, Hirnantian) consists of various shallow-marine carbonates. The formation is distributed in northern and central Estonia and considered to be primarily early Hirnantian in age, bound by stratigraphic gaps (Meidla et al. 2023a, 2023b). It is commonly divided into the dolostone (**Röa** Member), skeletal grainstone (**Vohilaid** Member), kerogenous limestone (**Siuge** Member) and, in places, dolomitised reef limestone members (**Tõrevere** Member). Ainsaar et al. (2015) showed that the Vohilaid, Siuge and Tõrevere units are reef-related lithotypes rather than true members. In the Reinu quarry, all these units can be identified (Fig. 8.2, 8.3, 8.4, 8.5), but their lateral distribution and thickenss varies between sites, particularly due to organic buildups and uneven erosion during the Hirnantian. A single reef body c. 20 m in diameter was exposed in 2022 (Fig. 8.4) showing a gradual lateral transition from the dolomitised reef limestone (Tõrevere Member) into the kerogenous limestone of the Siuge Member (Fig. 8.1). Shelly fossils are common in the Vohilaid and Siuge members (Fig. 8.7). The Siuge Member is characterised also by abundant benthic microfossil assemblage. The most abundant Ordovician polychaete fauna from Baltoscandia was recently reported from the Siuge Member in the Reinu quarry, with well over 5000 scolecodonts per kg of rock (Hints & Tonarova 2023). Ostracods show similarly rich fauna, study of which is currently in progress. The most kerogenous part of the Siuge Member (sample OM20-113) contains the zonal chitinozoan *Spinachitina taugourdeaui*, confirming the early Hirnantian age of the unit (Kaljo et al. 2008). *S. taugourdeaui* was also identified from the Röa Member (Fig. 8.3); thus, the entire Ärina Formation in the Reinu quarry corresponds to the S. *taugourdeaui* Zone.

(3) The **Varbola Formation** (ca 11 m, Juuru Regional Stage, Hirnantian–Rhuddanian) is represented mainly by the alternation of packstones/grainstones and marl beds. The formation contains abundant tabulate corals, stromatoporoids, rugosans, brachiopods, echinoderms and other shelly fossils (Fig. 8.6). Microfossil samples have revealed an abundance of benthic forms, notably scolecodonts. However, chitinozoans and conodonts and very rare and of very low diversity indicating strong impact of the Hirnantian extinction to these groups.

The lowermost part of the formation, the **Koigi Member**, is usually represented by lime mudstones, but in the Reinu quarry, the grainstones overlying the Siuge / Tõrevere lithotypes are also assigned to the Koigi Member. Fig. 8.5 shows the lower boundary of the unit and succession of three rock varieties: (1) brown kerogenous Siuge wackestone, (2) 5-cm-thick grainstone bed, overlain by (3) fine-grained mudstone unit, typical of the Koigi Member. In places, the basal part of the Koigi Member contains a conglomerate with pebbles several cm in size and large fragments of corals and stromatoporoids.

Conventionally, the Ordovician–Silurian boundary has been drawn below the Varbola Formation (and Koigi Member). However, carbon isotope chemostratigraphy, has shown that the Koigi Member represents the falling limb of the Hirnantian Carbon Isotope Excursion. This pattern is also visible in the Reinu succession (Fig. 8.3), where the highest $\delta^{13}C$ values are recorded in the Siuge Member, and the overlying Koigi strata show a gradual decline in $\delta^{13}C$. Biostratigraphic evidence to identify the base of the Silurian is limited in the Reinu quarry. Most likely, the Koigi Member is of late Hirnantian age, whereas the main part of the Varbola formation belongs

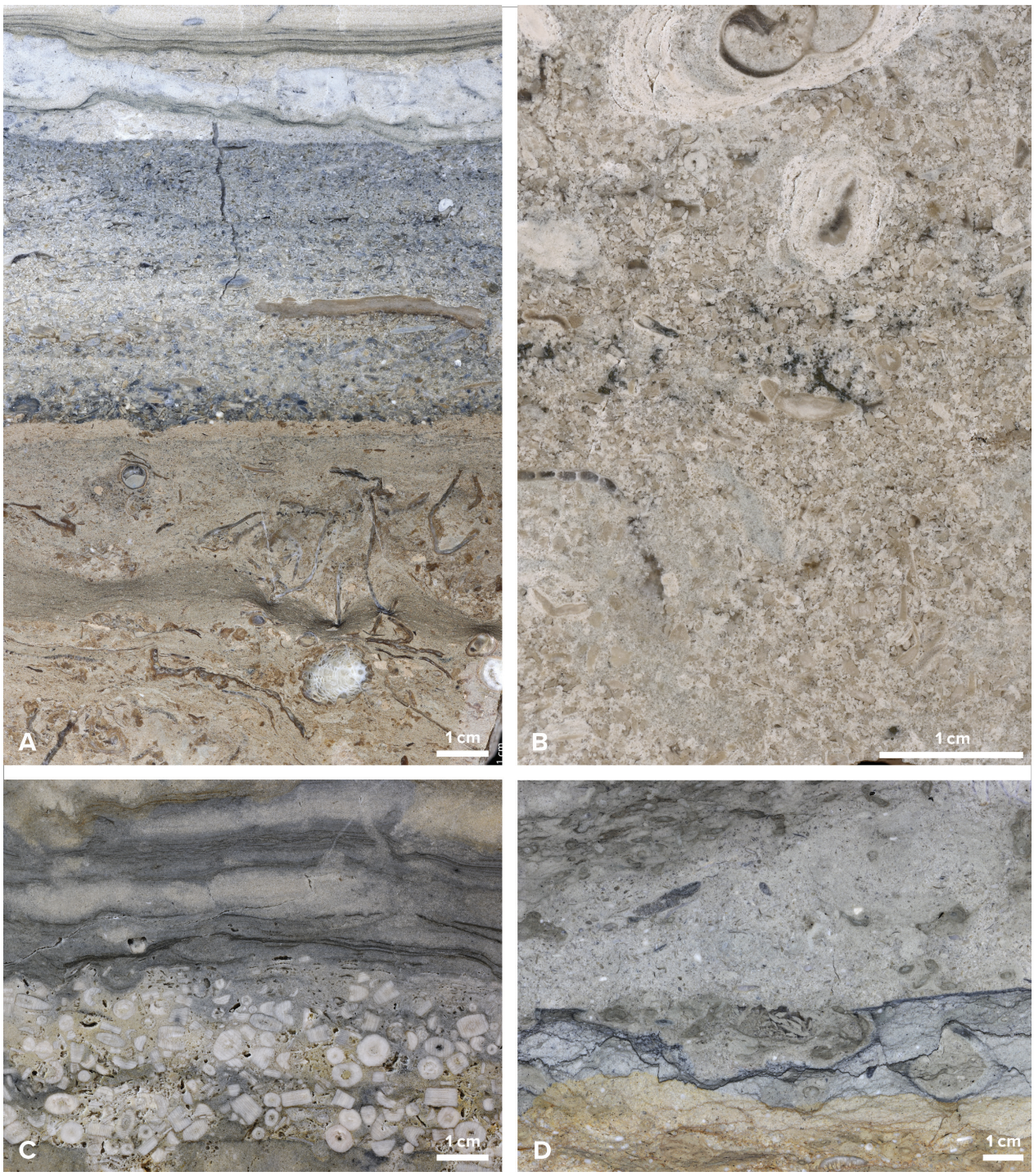

Fig. 8.5. Examples of latest Katian and Hirnantian rocks from the Reinu quarry. **A** – Boundary between kerogenous Siuge Member of the Ärina Formation and grainstone and carbonate mudstone of the Koigi Member, Varbola Formation. **B** – Grainstone of the Vohilaid Member, Ärina Formation. Note the oncolithic overgrowths on some shells. **C** – Dolostone with abundant echinoderm ossicles, Röa Member, Ärina Formation. **D** – Wackestone with a pyritised discontinuity surface, Adila Formation, Pirgu Regional Stage, latest Katian. Sample from the collection of TalTech Department of Geology.

to the Rhuddanian (Gul et al. 2021; Meidla et al. 2023a). Here we correlate the Ordovician–Silurian boundary with the upper boundary of the Koigi Member.

(4) The **Tamsalu Formation** (Juuru Regional Stage, Rhuddanian) overlying the Varbola Formation has a thickness of less than a metre. It consists of Borealis-limestone – essentially a coquina of brachiopod *Borealis borealis borealis* (Fig. 8.6N) containing in places also abundant corals and stromatoporoids. This rock unit is characterised by very high CaO content and is therefore, a valuable resource for the chemical industry. It is quarried in several localities in central Estonia, notably in the Karinu and Võhmuta quarries (Ainsaar 2004).

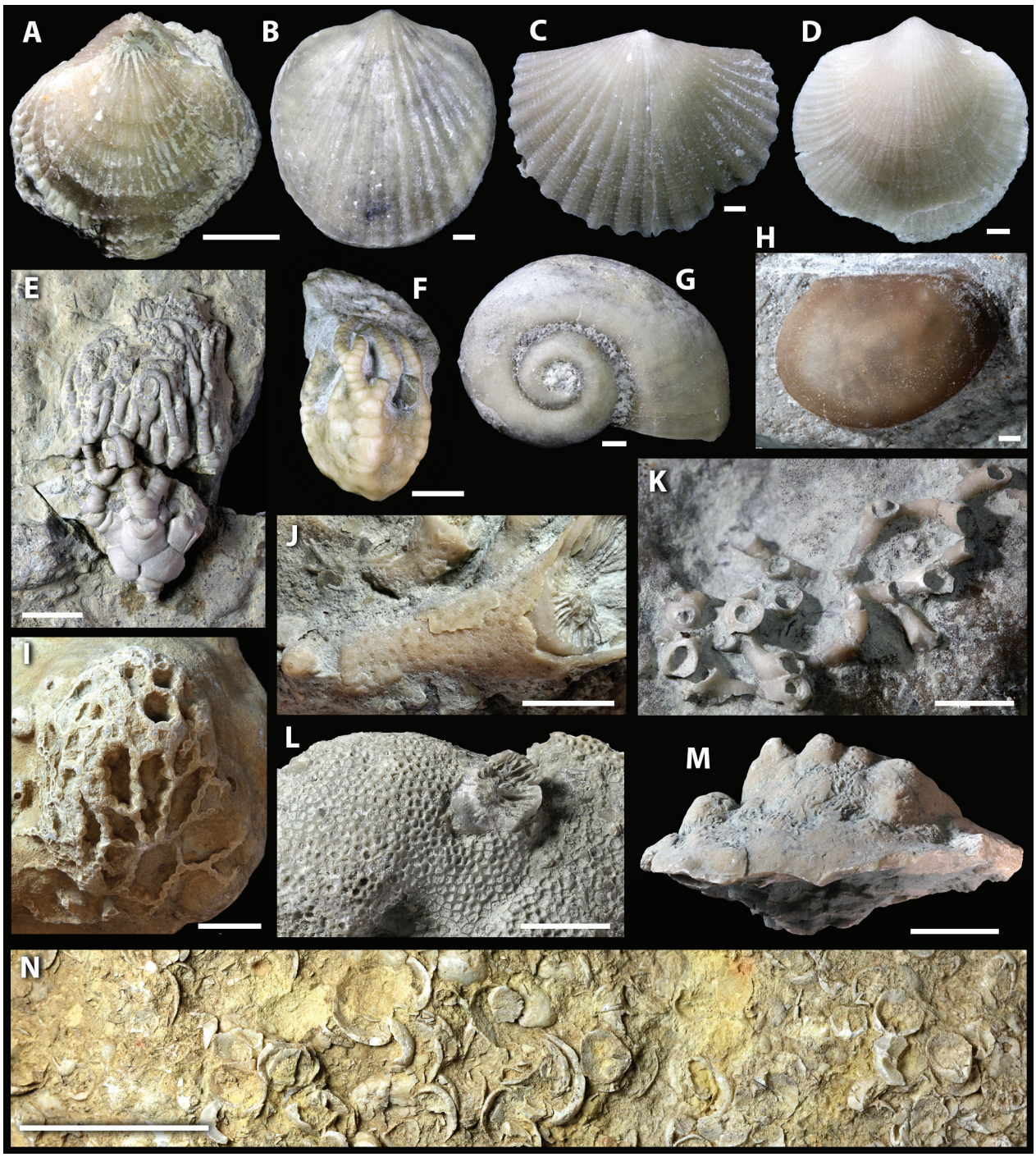

Fig. 8.6. Selected fossils from the Reinu quarry of the Varbola and Tamsalu formations (Rhuddanian). Scale bars: M, N – 5 cm; E, I, L – 1 cm; A, F, J, K – 5 mm; B–D, G, H – 1 mm. **A–D** – brachiopods from the Varbola Formation; **A** – *Sypharatrypa hillistensis*, GIT 554-2500; **B** – *Zygospiraella*, GIT 835-1781; **C** – *Hesperorthis hillistensis*, GIT 855-848; **D** – *Onniella trigona*, GIT 554-2501. **E–F** – crinoids from the Varbola Formation; **E** – *Euspirocrinus hintsae*, GIT 405-256; **F** – *Paerticrinus arvosus*, GIT 405-255. **G** – gastropod from the Varbola Formation, *Naticonema*, GIT 535-161. **H** – leperditicopid from the Varbola Formation, GIT 368-329. **I–L** – corals from the Varbola Formation; **I** – halysitid encrusting stromatoporoid, GIT 666-49-1; **J** – heliolitid encrusting rugose coral *Streptelasma*, GIT 393-75; **K** – auloporid encrusting stromatoporoid, **L** – endobiotic rugose coral *Streptelasma* in *Paleofavosites balticus*, GIT 666-20. **M** – stromatoporoid with bioeroded surface, Varbola Formation, GIT 362-505. **N** – *Borealis borealis borealis* coquina, Tamsalu Formation, GIT 623-1095.

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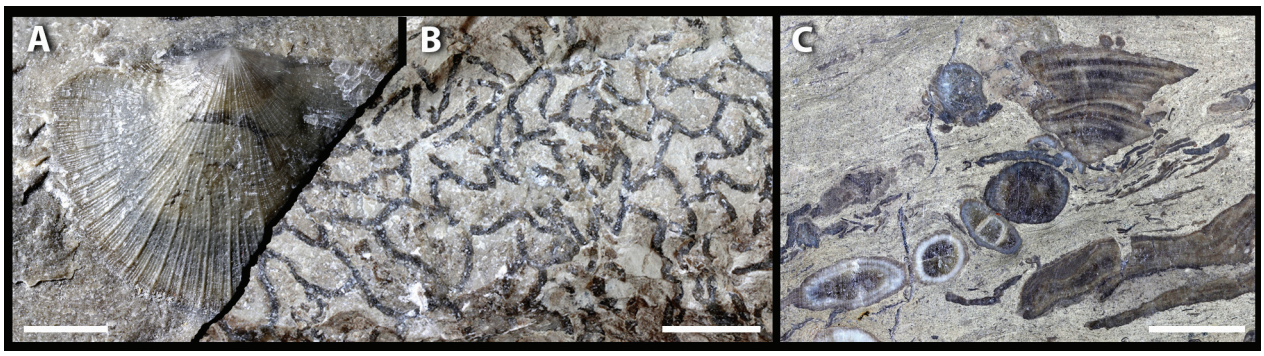

Fig. 8.7. Selected fossils from the Reinu quarry, Ärina Formation (Hirnantian, Ordovician). Scale bars: B, C – 1 cm; A – 5 mm. **A** – brachiopod *Eostropheodonta* GIT 674-698. **B** – tabulate coral *Catenipora*, GIT 734-239. **C** – stromatoporoids and rugose corals, GIT 748-25.

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