Stop 7: Rummu quarry

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Location: Latitude 59°13´42,8˝N, longitude 24°13´49,5˝E; Harju County, Estonia.
Stratigraphy: Latest Sandbian, Keila Regional Stage, Vasalemma Formation.
Status: Abandoned quarry. Sampling and fossil collecting are welcome.
More information: https://geoloogia.info/en/locality/10177

The following text is updated and slightly modified from Kröger & Toom (2023).

The Rummu quarry is an abandoned quarry located c. 30 km south-west of Tallinn, near Keila, Harju County. The large quarry is largely filled with water. On the eastern and northern margins parts of the former quarry wall expose upper-most sections of the Vasalemma Formation with partly beautifully weathered patch reefs.

History

The echinoderm limestone of the Vasalemma Formation has been quarried for centuries and is known in the region as the "Vasalemma Marble". The limestone was described and named in a stratigraphical context by Eichwald (1854) and Schmidt (1881). The names "Hemicosmitenkalk" (Eichwald 1854) and "cystoid limestone" (Männil 1960) refer to the rock-building abundance of echinoderm intraclasts (mainly of the genus *Hemicosmites*, Rhombifera). Within the massive echinoderm limestone beds, echinoderm-bryozoan-receptaculitid reefs are abundant (Fig. 7.1). Together, the echinoderm grainstone and the reefs form the "Wasalemm'sche Schicht" of Schmidt (1881), which is synonymous with the Vasalemma Formation of subsequent authors (e.g., Männil & Rõõmusoks 1984; Hints & Miidel 2008). In Schmidt's system, the Vasalemma Formation was designated as D3, the topmost layer of sequence D, and thus formed the stage above the "Kegel'sche Schicht" (Keila Regional Stage, D2). In a series of field guides, Linda Hints, and her colleagues (Hints 1990, 1996; Hints *et al*. 2004; Kröger *et al*. 2014b) published several drill core sections and outcrop details. A comprehensive review and reappraisal of the stratigraphy and sedimentology of the formation was published by Kröger and co-authors (Kröger *et al*. 2014b, 2014c). Today, the Vasalemma Formation is stratigraphically placed within the Keila Regional Stage, being of late Sandbian age (Meidla *et al*. 2023).

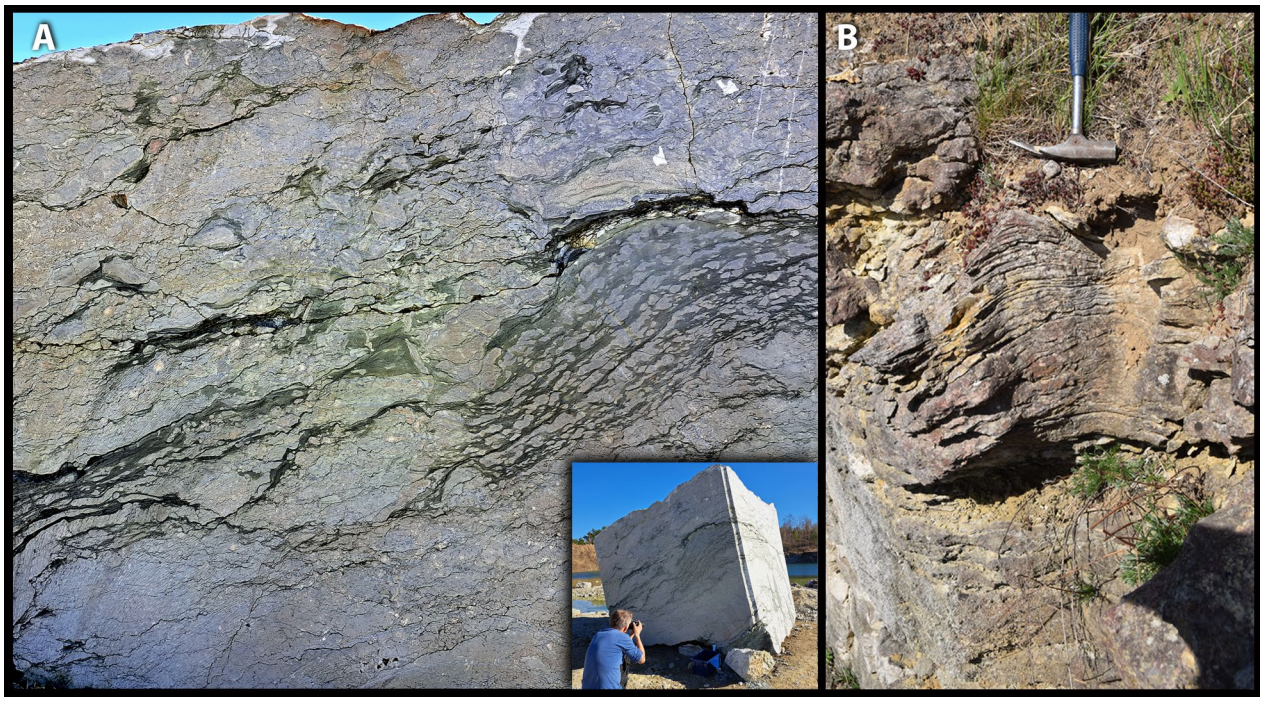

Fig. 7.1. Rummu quarry, Vasalemma Formation (Katian), **A** – block of limestone with reef's body. Photo: Ursula Toom; **B** – large crust of stromatoporoid. Photo: Björn Kröger.

The Rummu quarry was opened in the late 1930s to ex-

cavate limestone , including “Vasalemma marble”. The latter is a specific kind of limestone with its structure and texture resembling that of marble. During the Soviet era, until the 1990s, excavation was performed as hard labour by Murru and Rummu prisoners, who excavated and processed limestone from the water-drained quarry. When the pumping of water ceased, the quarry quickly filled with groundwater, forming a lake, and immersing some of the utility buildings and machinery. With the closure of the Rummu quarry, the area became a featured location for nature photography, hiking, rafting, scuba diving, as a summer spot, musical and sports events, and as a filming location for its unique layout (https://en.wikipedia.org/wiki/Rummu_quarry).

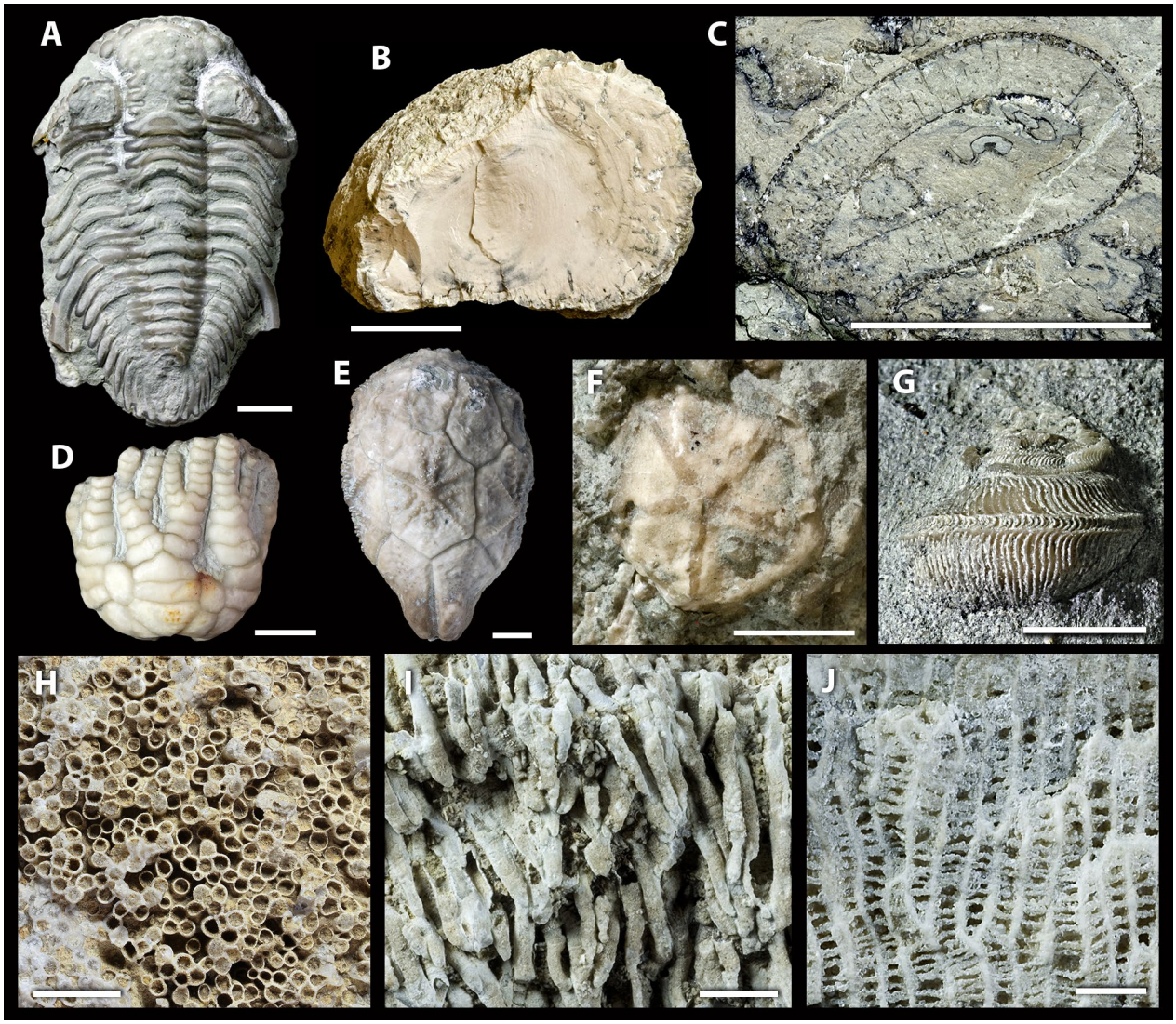

Fig. 7.2. Selected fossils from the Vasalemma Formation (Katian), Vasalemma quarry. Scale bars: H, I – 1 cm; A– G, J – 5 mm. **A** – trilobite *Atractopyge kutorgae* (Schmidt), TUG 1393-1. **B** – *Solenopora* sp., GIT 339-1043. **C** – retceptaculitid Receptaculites poelmi Miagkova, GIT 413-166. **D** – crinoid *Tintinnabulicrinus estoniensis* Wright & Toom, GIT 653-3. **E** – blastozoans *Hemicosmites extraneus* Eichwald, GIT 633-206. **F** – edrioasteroid *Cyathocystis rhizopora* Schmidt, GIT 643-11-1. **G** – gastropod *Brachytomaria baltica* (Verneuil), GIT 222-114. H, I, J – tabulate corals; **H, I** – *Eoflecheria orvikui* (Sokolov), H –GIT 94-10, I – GIT 180-94; **J** – *Saffordophyllum tulaensis* (Sokolov), GIT 94-10.

Stratigraphy

The Vasalemma Formation is a partly discontinuity-bounded unit. The lower and the upper boundaries are diachronous. From the combined drill core and outcrop data, it is known that in the southern part of the Vasalemma quarry, 5 km north-east of the Rummu quarry (see e.g. Kröger & Toom 2023), the base is marked by a prominent hardground on top of the Pääsküla Member, Kahula Formation (Kröger et al. 2014b, 2014c). In other places, the base is less than a few meters above this hardground, within the overlying Saue Member of the Kahula Formation (Kröger *et al*. 2014a). Laterally the echinoderm limestone of the Vasalemma Formation grades into the skeletal wacke- to packstone lithologies of the Saue and Lehtmetsa members of the Kahula Formation. This gradual lateral change is exposed along a kilometre-long quarry wall of the Vasalemma quarry.

The top of the formation is formed by a distinct hardground surface on top of the reefs, which locally

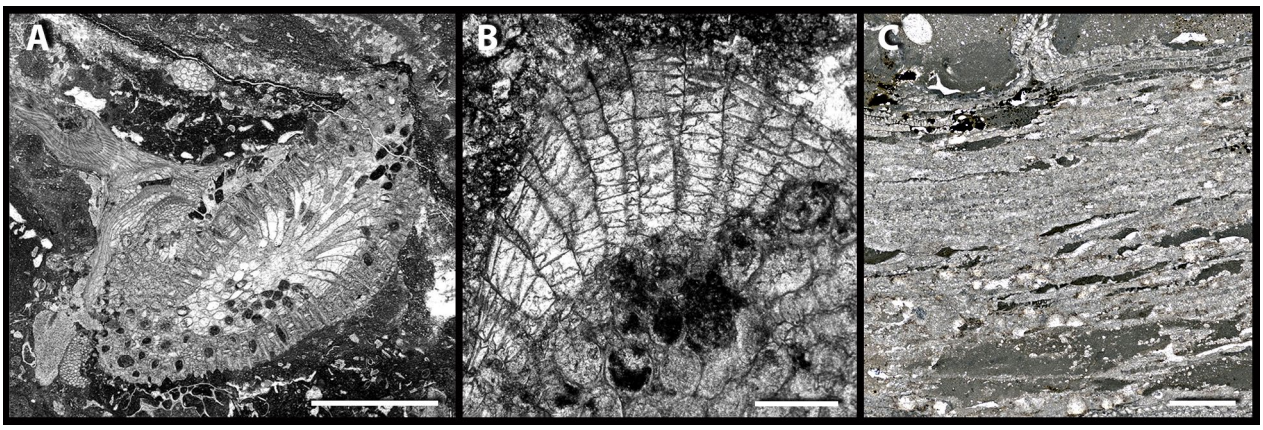

Fig. 7.3. Selected thin sections of bryozoa and stromatoporoid, Vasalemma Formation (Katian), Rummu quarry. Scale bars A – 0.5 mm, B, C – 5mm. **A** – *Orbignyella germana* Bassler; **B** – *Dittopora colliculata* (Eichwald); **C** – *Cystistroma sakuense* Nestor.

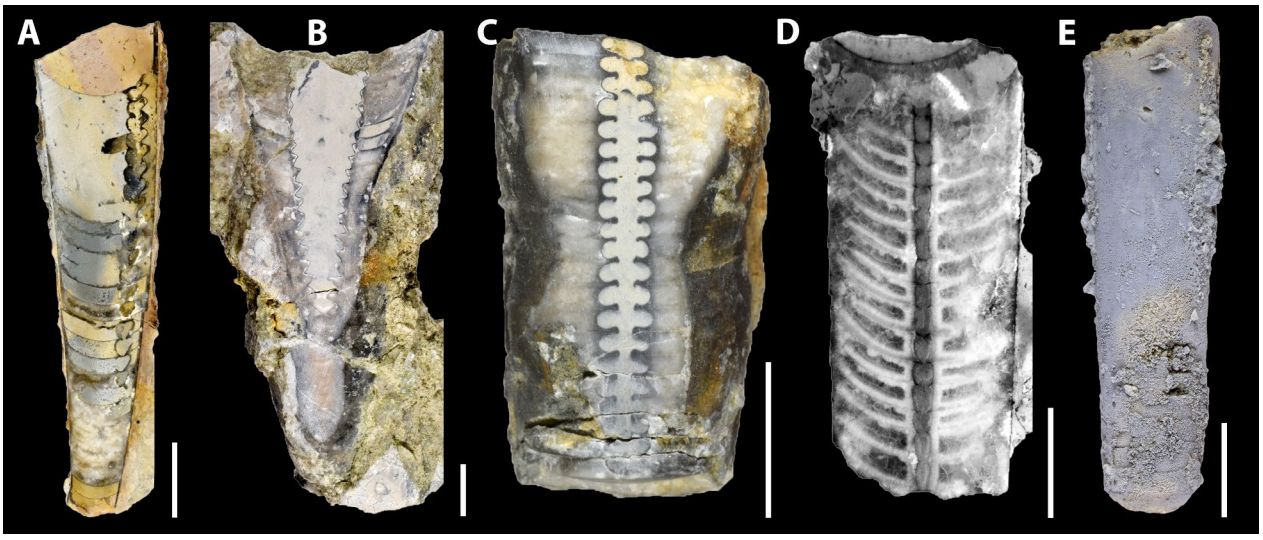

Fig. 7.4. New cephalopods taxa from the Rummu quarry described by Kröger & Aubrechtová (2018), Vasalemma Formation (Katian). All scale bars 1 cm. **A** – *Hoeloceras muroni*, TUG 1709-6; **B** – *Rummoceras rummuensis*, TUG 1709-31; **C** – *Hemibeloitoceras arduum*, TUG 1612-13; **D** – *Isorthoceras cavi*, TUG 1585-41; **E** – *Isorthoceras padisense*, TUG 1585-18b.

also represents a (partially subaerial) erosional surface, which cuts into the reefs and the echinoderm limestone. This upper surface is overlain by the argillaceous sediments of the Hirmuse Formation, Oandu Regional Stage, or locally by yellowish micritic limestone of the Rägavere Formation (Kröger *et al*. 2014a, 2014c).

The conodont zonation in the Upper Ordovician is mainly based on the evolutionary lineage of *Amorphognathus*. However, only a few unidentifiable fragments of *Amorphognathus* were found in the Vasalemma Formation. Previous studies have shown that there is an interval corresponding to the upper Haljala and Keila, but probably also to the lowermost Oandu regional stages in Estonia, where *Amorphognathus* is extremely rare or missing. Tentatively, this interval was assigned to the *Amorphognathus tvaerensis* conodont zone (Männik 2017) or, based on the recently revised conodont zonation, to the (upper part) of the *Baltoniodus alobatus* conodont zone (Paiste et al. 2023). $\delta^{13}C_{carb}$ data from drill cores of the Vasalemma Formation record the rising limb of the upper Sandbian Guttenberg Isotopic Carbon Excursion (GICE; see e.g., Meidla *et al*. 2023) and a sharp drop of values at its upper discontinuity, indicating that the main interval of the GICE is younger than the formation (Fig. 6.2; Kröger *et al*. 2014a, 2014c).

Geological setting and sedimentology

The Vasalemma Formation occurs along a c. 20 km E–W stretched belt with an N–S extension of c. 5 km. Toward the north, it is partly limited by an erosional front. The formation has a thickness of up to 15 m and consists mainly of a massive echinoderm grainstone with, in its central areas, concentrations of patch reefs. The echinoderm limestone is a massively bedded grainstone, almost completely composed of *Hemicosmites* ossicles held together by syntaxial cement. Ripple waves and crossbedding are widespread features within the echinoderm limestone. The reefs are up to c. 10 m thick and up to 50 m wide, and their cores are formed by a matrix-rich boundstone (50–80% matrix), with abundant echinoderms, bryozoans, and receptaculitids as

main skeletal components and abundant fenestral fabric (Kröger *et al*. 2014a) (Fig. 7.1). The reefs of the Rummu quarry are comparatively strongly dominated by bryozoans and edrioasteroids (Kröger *et al*. 2023a). Associated with the reef cores are commonly pockets, preserving locally restricted siliciclastic (marl, silt) and microbial limestone facies. In the north-eastern part of the Vasalemma quarry, the base of the formation forms the top hardground of the Pääskula Member, which here exposes a rippled surface and which is partly highly bioeroded with borings of *Trypanites sozialis*. The ripple-marks have a mean wavelength of c. 0.4 m and an NE/SW direction (Hints & Miidel 2008). In the Vasalemma quarry, the top of the Vasalemma Formation is formed by an iron (pyrite) impregnated and bioeroded hardground and erosional surface, which is locally covered by a conglomerate with highly rounded, pyrite-impregnated clasts from the Vasalemma Formation. In the eastern part of the Rummu quarry herringbone cross-bedding and gravitational cements in the uppermost sections of the echinoderm limestone indicate a very shallow, intertidal depositional environment, and subaerial exposure (Kröger *at al*. 2014a).

Sea level and paleoclimate

The top Vasalemma discontinuity reflects a major regional sea level drop (corresponding to the base of the depositional sequence VIII of Dronov *et al*. 2011, the Lower Wesenberg Sequence of Dronov 2017, and the Frognerkilen Lowstand Event of Nielsen 2011). This discontinuity and its associated facies and faunal change mark a massive change in the regional sedimentation regime and faunal composition during the late Keila to Rakvere time that has been termed Mid-Caradoc Event (Meidla *et al*. 1999) or Middle Caradoc Facies and Faunal Turnover (Ainsaar *et al*. 2004). The interval has been interpreted as related to climate change and associated changes in ocean circulation (Ainsaar *et al*. 2004). Oxygen isotope data suggest that the Mid-Caradoc Event (late Haljala-Keila stage) was an interval of global cooling that climaxed during the Frognerkilen Lowstand Event (Männik *et al*. 2021).

Fauna and flora

The Vasalemma Formation contains extraordinarily rich and abundant fauna. Dozens of species of bryozoans were described from the Vasalemma Formation by Bassler (1911), Männil (1959), Modzalevskaya (1953), Pushkin (1990) and Gorjunova & Lavrentjeva (1993). A thorough revision of the bryozoan fauna is still needed. Hemispherical and massive species of bryozoans are less abundant in the reefs of the Rummu quarry compared with that of the Vasalemma quarry (Kröger *et al.* 2023a). Results from a statistical analysis of the bryozoan fauna indicate that the extraordinarily high bryozoan richness reflects high small-scale (within reef) heterogeneities in lithology and original bryozoan habitat (Kröger *et al*. 2023a). The echinoderm fauna is strongly dominated by *Hemicosmites*, but locally edrioasteroids (*Cyathocystis*, Rozhnov 2004), rare solutans (Rozhnov & Jeffries 1996), asteroids (Blake & Rozhnov 2007) and crinoids (Ausich *et al*. 2015; Rozhnov 1990, 2012; Wright & Toom 2019) are worth mentioning. The reefs of the Vasalemma Formation contain rugose corals, such as *Lambelasma carinatum* which are among the oldest of the region. Retseptaculitids are common; *Receptaculites poelmi* from the Vasalemma Formation has been described by Miagkova (1981). The chaetetid sponge *Solenopora* is locally common within the reefs. Bryozoans, echinoderms, receptaculitids and *Solenopora* form complex, partly densely intergrown assemblages (Vinn *et al*. 2018). Locally, the uppermost sections of the reefs contain large colonies of tabulate corals *Eofletcheria orvikui*, *Saffordophyllum tualensis* and *S. grande* (Klaamann 1975); also crusts of stromatoporoids such as *Cystistroma sakuense* occur (Fig. 7.3). The reefs contain rich macrofauna with monoplacophorans (*Pilinia* sp.) and gastropods (*Brachytomaria baltica* and *Cyclonema lineatum*). The trilobites of the Vasalemma Formation have not been systematically studied, but the most common representatives include *Asaphus*, *Chasmops*, *Stenopareia* and *Toxochasmops*. Kröger & Aubrechtová (2018) described a rich cephalopod fauna from the Vasalemma Formation that included five new taxa from the Rummu quarry (*Hemibeloitoceras arduum, Isorthoceras padisense, I. vexilli, Orthonybyoceras isakari, Rummoceras rummuensis*; Fig. 7.4). Cephalopods, trilobites and echinoderms occur frequently as concentrations in pockets associated with the reefs. Dense cornulitid infestations of the reef and echinoderm-limestone on the capping hardground surface are remarkable (Vinn & Toom 2015). Brachiopods *Estlandia pyron silicificata*, *Bassettella alata*, Saukrodictya, *Horderleyella kegelensis*, and *Apatorthis* sp. occur mainly in the argillaceous interlayers of the lower half of the Vasalemma Formation. Three taxa of well-preserved noncalcified dasyclad algae have been discovered from an algal-Lagerstätte within dolomitic mudstone layers associated with the reefs (Kröger et al. 2023b).

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