

Evolution of a Katian tropical hardground

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A succession of shallow-marine carbonates characterises the Middle and Upper Ordovician of Estonia (Baltica). In northern Estonia, the boundary between the Nabala and Vormsi regional stages (and Saunja and Kõrgessaare formations) is marked by a prominent discontinuity surface, which has been interpreted as a paleo-karst horizon. The stable isotopic curve in the boundary beds shows the characteristic change for the Saunja Excursion and has been correlated with the Waynesville Excursion in North America.

Historically, the boundary has been exposed in several outcrops like Turvaste, Kohila, Saunja and Aulepa. Currently, in the new large Sutlema Quarry, tropical carbonates of the Saunja and Kõrgessaare formations (middle Katian) are exposed. For several years, it has been possible to collect samples and examine the flat, slightly wavy, hardground that marks the boundary between these formations.

The lithology of the uppermost part of the Saunja Formation and its fossil content is suggestive of restricted conditions, similar to a lagoonal depositional environment. It is characterised by higher salinity and the presence of microbial communities, which was also confirmed by the occurrence of specific biomarkers. Remnants of microbial mats were also observed in thin sections of the Saunja Formation, in the form of filamentous, carbonaceous structures. The hardground was thick and formed rapidly. Some borings from the surface demonstrate elevated openings, proving that the formation of the hard surface was rapid. The cementation process was enhanced by warm tropical water and microbial mats. The surface was partially cracked before its full lithification. These cracks are deep and filled with sediments. The hardground is heavily bored, and the bioerosional ichnofauna of the hardground is abundant, consisting of shallow *Trypanites sozialis*, elongated *Trypanites weisei*, winding and undulating *Trypanites* isp., algal bioerosional traces, and fine shallow grooves. Also occurring are large sub-surface U-shaped trace fossils with variable diameters, similar to *Balanoglossites triadicus*. The epizoans of the hardground include small-sized typical marine fauna like cornulitids, crinoids, bryozoans, brachiopods, and tabulate corals. Some hardground samples demonstrate shallow regular pits with smooth walls. These structures cannot be assigned as bioerosional trace fossils. They are most likely solution pits, which are surface features that form on horizontal surfaces under subaerial conditions.

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