

KNOWN AND UNKNOWN METEORITE IMPACT EVENTS, AS RECORDED IN THE EPICONTINENTAL LOWER PALAEOZOIC SEDIMENTARY SEQUENCE OF THE BALTIC REGION. V. Puura¹, L. Ainsaar¹, M. Eriksson², T. Flodén², K. Kirsimäe¹, A. Kleesment³, M. Konsa³ & K. Suuroja⁴, ¹Institute of Geology, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia, e-mails: Väino.Puura puura@ut.ee; Kalle.Kirsimäe arps@ut.ee, ²Department of Geology and Geochemistry, Stockholm University, 106 91 Stockholm, Sweden, e-mails: Tom.Flodén tom@geo.su.se, ³Institute of Geology at Tallinn Technical University, Estonia Ave 7, 10143 Tallinn, Estonia, e-mails: Anne.Kleesment kleesmen@gi.ee, Mare.Konsa mare@gi.ee, ⁴Geological Survey of Estonia, Kadaka Ave 80/82, 12618 Tallinn, Estonia, e-mail: Kalle.Suuroja k.suuroja@egk.ee.

In ancient sedimentary deposits, the survival of impact-related cosmic material with different characteristic signatures depends on the rate of diagenetic and metamorphic changes. In the Baltic Palaeozoic sedimentary basin, and especially in its northern part, the deposits have never been loaded under a cover more than 1 km thick. The groundwaters that have percolated the sedimentary sequence have been of considerably unaggressive nature. Thus, the mineralogical and geochemical evidences of past impacts, namely their signatures in the sediments, have survived remarkably well. However, the Palaeozoic sedimentary sequence of the Baltic region is dissected by a number of sedimentary breaks and erosional unconformities. Impacts during those intermedia might be recorded by some secondary signatures only.

The variety of signatures caused by impacts of nebular bodies into the regional environment of the Baltic Early Palaeozoic sedimentary basin is considerably large (Fig. 1).

Cosmic material has been found in the form of small meteorites, small particles and spherules, and as an admixture of indicative Platina-Group-Elements (PGE) in cosmic material and impacted target rocks (Fig 1, column I).

Structural forms in layered formations caused by, or related to, impacts are **craters but also surrounding and distant impact deformations** (Fig. 1, column II). The deformations consist of faults, folds, fractures, and mainly clastic sedimentary and injection dikes. **Specific sharp asperities in the seafloor depositional environment**, namely anticlines, synclines, flexures, homoclines etc., may also be attributed to impact events.

Due to impact-related **modifications of the depositional environment**, specific facies zonations, which resulted in local sedimentary breaks and the erosion of pre-existing layers, occurred around the crater sites (Fig. 1, column III).

Post-impact compaction of the secular crater sediments caused synclinal downwarping of the respective layers (Fig. 1, column IV). Compaction of the impact-deformed, and impact-rarefacted, formations surrounding the crater caused fracturing and uneven layering of the subsequent post-impact sediments.

Influx of impact ejecta, as well as crater- and ejecta-provenanced material, forms distinctive clastic-enriched layers in the sediments surrounding the craters (Fig. 1, column V). Primary impact ejecta is typical for

the surroundings of the crater rim. In the distant area, redeposited material derived from the ejecta, and from uplifted crater elements, occurs. Clastic admixtures, mainly sand and gravel, derived from the erosion of crater rims that were subjected to post-impact syndepositional erosion, may occur **in deposits that formed during tens of million years after the impact**. Even in the distant areas well sorted sands may form interlayers at different post-impact levels. Findings of impact metamorphic signatures in minerals of ejected and redeposited material may be highly indicative.

Erosional **re-exposition** of crater structures after thin burial under sediments may form sources of **crater-derived** clastic sediments (Fig. 1, column VI). Many previously buried craters are re-exposed under the recent sediments at the present earth surface.

Craters, as well as surrounding primary impact-induced, and secondary crater-derived, elements in the sedimentary sequences can be identified or at least indicated using **geophysical techniques**. Marine seismic profiling, gravity- and magnetic surveys, among other methods, are most informative.

Structures and lithologies out of the ordinary which are found in the sedimentary sequence of a region, as well as other findings which point directly towards suspected impact structures, may be either of primary or of secondary origin. Thus, the dating and nature of these layers would be of a special value for identification of possible events. Research of different impact- and crater-related signatures in a geological sequence mutually enriches the perspectives in finding new craters as well as for the interpretation of the complex environmental consequences of the meteorite explosions and the craters formed by them. At present, the multiple reflection of the Kärddla and Neugrund impacts, and their respective structures in the geological record, is rather well distinguished. On the other side, findings of cosmic material in the Upper Vendian of north-eastern Estonia (the Viru-Roela borehole), in the Lower Cambrian of Ruhnu Island in south-western Estonia (the Ruhnu borehole at 500 m depth), in the Upper Silurian, Pridolian, in the Baltic Sea southeast of Gotland Island, and other places, may predict the discovery of new impact structures in the region. Recording of specific geophysical signatures may furthermore lead to new discoveries, or deeper structural studies of known impact structures as e.g. the Tvären, Hummeln, Neugrund and Ivar craters.

