



Comparative geological analyses of the two nearby early Palaeozoic marine impact structures (Kärdla and Neugrund, Estonia) in Baltic region

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This paper discusses geology and post-impact development of the two nearby (distance ca 60 km) well-preserved marine impact structures – Kärdla and Neugrund (Estonia). The above structures are located in the eastern Baltic Sea, at the edge of the East European Platform, near the boundary of the Baltic Shield. The Kärdla impact structure is located on the north-eastern coast of Hiiumaa Island (58°58'N, 22°46'E) and the Neugrund impact structure – in the mouth of Gulf of Finland (59°20'N, 23°31'E).

Both Kärdla and Neugrund impact structures were formed in the early Palaeozoic (about 455 Ma and 535 Ma, respectively) in a shallow (100–200 m) sea not far (ca 100 km) from the shore. Both targets had quite similar sequence, consisting of three layers: water, sedimentary siliciclastic rocks (ca 100 m), and crystalline metamorphic rocks. However, in Kärdla the sedimentary cover was somewhat thicker (up to 140 m), with a thin (ca 15 m) limestone bed on the top.

The Kärdla structure was discovered somewhat accidentally in 1967 when drilling of an artesian well (its impact origin was proved 14 years later in 1980), but the existence of the Neugrund structure was predicted. The hypothesis that an impact structure may occur in the surroundings of the Neugrund Bank was suggested in 1995, a crater-like structure was discovered in 1997 and its impact origin was finally proved three years later in 1998.

The Kärdla impact structure is completely buried and its outlines are difficult to follow, while some structures (ring-ridges) of the Neugrund structure crop out directly on

the seabed. However, the impact-related deposits inside the crater proper are not exposed, neither are they penetrated by drill holes, only the ejecta layer and some distal disturbances are opened by some wells. Majority of the information has been obtained by continuous seismic profiling, sonar profiling and sampling by diving methods. In the area of the Kärddla structure during 30 years (1967–1997) more than 250 wells have been drilled and various geophysical studies (gravimetry, magnetometry, continuous seismic profiling) have been carried out.

Both Kärddla and Neugrund impact structures are complex. The rim-to-rim diameter of the Kärddla structure is 4 km, the crater proper is more than 500 m deep and ca 3 km in diameter, with ca 130 m high uplifted central peak. The crater is surrounded by an elliptical ring fault 12–15 km in diameter. The Neugrund structure has a crater proper ca 5 km in diameter, which is surrounded by three ring-ridges 6, 8 and 12 km in diameter. A slightly elliptical ring fault 20–21 km in diameter separates the zone of strongly disturbed target rocks from the area where these are mostly intact.

In the Kärddla case the 0.01–3.5 m thick ejecta layer of silt- and sandstones lies in a radius of ca 50-km in a succession of Ordovician limestones and is therefore well observable. In the Neugrund case the ejecta layer (mostly sand) lies in the section of Lower-Cambrian siliciclastic rocks (silt- and sandstones) and is therefore difficult to follow and can be established only by findings of PDFs in minerals.

Huge ejected megablocks of fractured and brecciated crystalline target rocks are found in the surroundings of both impact structures. Sidescan sonar observations have revealed numerous huge (diameter 50–100 m) megablocks on the seabed around the Neugrund structure.