Cambrian Deimena Regional Stage sandstones – the oldest and most prospective geothermal reservoir in the Baltic Basin

Alla Shogenova[1*], Kazbulat Shogenov[1], Saulius Sliaupa[2], Rasa Sliaupiene[2], Argo Jõeleht[3] and Aleksandrs Zajacs[4]

[1] Department of Geology, Tallinn University of Technology, Ehitajate tee 5, 19086, Tallinn, Estonia
[2] Nature Research Center, Institute of Geology and Geography, Akademijos 2, LT-08412 Vilnius, Lithuania
[3] Department of Geology, Institute of Ecology and Earth Sciences, University of Tartu, Ravila 14a, 50411 Tartu, Estonia
[4] Institute or Sustainable Building Materials and Engineering Systems, Riga Technical University, Kipsalas str. 6a - 535LV-1048, Riga, Latvia
[*] Corresponding author, alla.shogenova@taltech.ee

In the present study, the geological and geothermal data were collected from various sources from Estonia, Latvia, and Lithuania. As the major result, the geothermal and structural maps of the Cambrian reservoir were compiled. The common database incorporates porosity, gas permeability and heat-flow density, temperature (T), geothermal gradient, and thermal conductivity (TC) records collected from industrial and project reports. The most prospective areas for geothermal energy exploitation were defined and characterised. Estonia, Latvia, and Lithuania are in the eastern part of the Baltic Sedimentary Basin (BSB), a 700 km long and 500 km wide synclinal structure dipping to the southwest. The Ediacaran (formerly Vendian) comprises an important part of the underlying geothermal aquifer. These siliciclastic deposits overlie the Precambrian basement. The Ediacaran-earliest Cambrian hydrogeological complex is distributed in the eastern part of the Baltic region and is attributed to the western periphery of the Moscow sedimentary basin. The oldest Valdai Series is documented in SE Lithuania. The younger Valdai Series is distinguished in Lithuania, Latvia, and Estonia. The Ediacaran clastic sediments up to 120–130 m thick are distributed in Estonia and Latvia and reach 180 m in NE Lithuania. The thickness of the Cambrian terrigenous succession attains 150 m in W Lithuania. The top of the Cambrian succession of the periphery of the basin dips from +100 m (N Estonia) to -50 m (E Lithuania) to -2150 m) in W Lithuania. The Dominopol and Ljuboml RSs are composed of fine-grained sandstones and siltstones, reaching 110 m on Saaremaa Island. Due to the low reservoir properties, this aquifer is considered a low-quality geothermal aquifer. The first major maximum transgression in the BSB took place the Cambrian Age 4 and Wuliuan, which compose the major Deimena RS sandstone reservoir. The main part of the Cambrian Stage 4 consists of shales with subordinate sandstones and is classified as an aquitard. The rocks in the eastern part of Lithuania and Latvia are attributed to the Cirma and Lakajai Fms. The shallow marine sandstones are composed of fine-grained quartz arenites cemented by minor carbonate and clay cement in the shallow basin periphery. The quartz cementation controls the reservoir quality of deep-buried sandstone. The TC is measured at only 2.2 W/m K in shallow sandstones and exceeds 6.7 W/m K in strongly cemented sandstone. The porosity of the Cambrian sandstones is as high as 22–34 %, and permeability attains 500–2300 mD in the shallow part of the BSB and decreases to only 5–10 % and <1 to 100–200 mD in the W Lithuanian E periphery, the T of the Cambrian basin is measured 7–10 °C (Estonia, E Latvia, S Lithuania). The T of Latvian geothermal anomalies attain 55–62 °C (Liepaja and Jelgava anomalies) and reaches 80–95 °C in the W Lithuania anomaly.

The most prospective geothermal resources are defined in the Deimena RSt sandstones in Lithuania and Latvia and the Cambrian–Ediacaran aquifer in Estonia. The 40–60 m thick Cambrian reservoir sandstones with good reservoir properties (porosity 15–22 %, temperature 35–65 °C) have the highest prospects in the central Lithuania and central and westernmost Latvia. The W Lithuanian anomaly sandstones show poor reservoir properties related to a high temperature (up to 95 °C) controlled quartz cementation. The Cambrian–Ediacaran aquifer located at the shallow burial depth in Estonia shows low T, but good reservoir properties.

Keywords: Cambrian, Ediacaran, Wuliuan, porosity, permeability, temperature.