

THE GEOTHERMAL POTENTIAL OF THE LOW-ENTHALPY GEOTHERMAL AQUIFERS OF LATVIA

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GEOLOGICAL FRAMEWORK

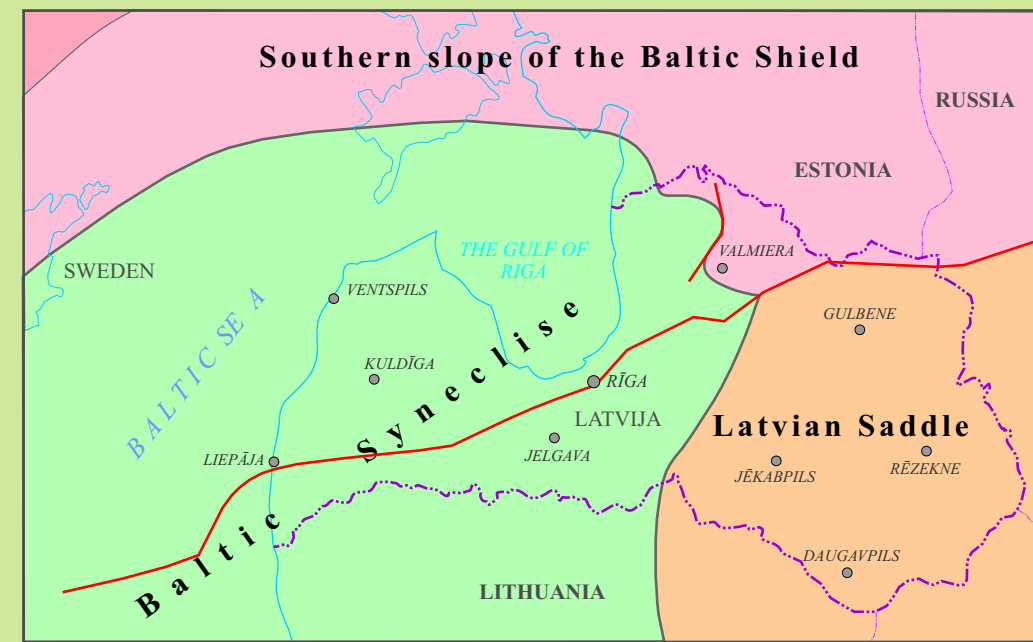


Figure 1. Tectonic setting

Latvia is situated in the territory of the East European Platform, where the Baltic Syncline, the Latvian Saddle and the southern slope of the Baltic Shield are singled out in the top crystalline basement and lower part of the sedimentary cover as interregional structures (Fig.1). Elements characteristic of ancient platforms, are singled out in the geological section of the Latvian territory – dislocated block-type crystalline basement overlain by the sedimentary cover of varying composition (Fig. 2).

The sedimentary cover is represented by the Vendian, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic and Jurassic deposits. Its thickness varies from 300-600 m in north-eastern Latvia to 1,900 m in its south-western part.

The sedimentary cover is subdivided into the Baikalian, Caledonian, Hercynian and Alpine structural complexes.

The **Baikalian** complex was identified only in the eastern Latvia and in a small area in the north-west. They consist of the Vendian and oldest Cambrian terrigenous rocks. The thickness of the complex reaches 30 m in the north-west, in eastern Latvia – 300 m.

Deposits of the **Caledonian** complex occur all over Latvia. It incorporates the Cambrian, the Ordovician, the Silurian and the Lower Devonian successions, the thickness of which varies from 60 m in north-eastern Latvia to 1,000 m in the south-western areas. The complex is characterised by a varying structure, with different structural components, including numerous faults and ramparts, as well as by local highs.

The **Hercynian** complex incorporates all the Devonian and Carboniferous deposits, which discordantly overlie variously eroded formations of the Caledonian complex. The complex, the thickness of which varies from 110 m in the northern part to 900 m in the south-west of Latvia, is characterised by gently sloping and slightly dislocated tectonic elements.

The **Alpine** complex consists of the Permian, Triassic and Jurassic deposits, up to 130 m thick. They occur only in the south-western areas, where they overlie the rocks of the Hercynian complex.

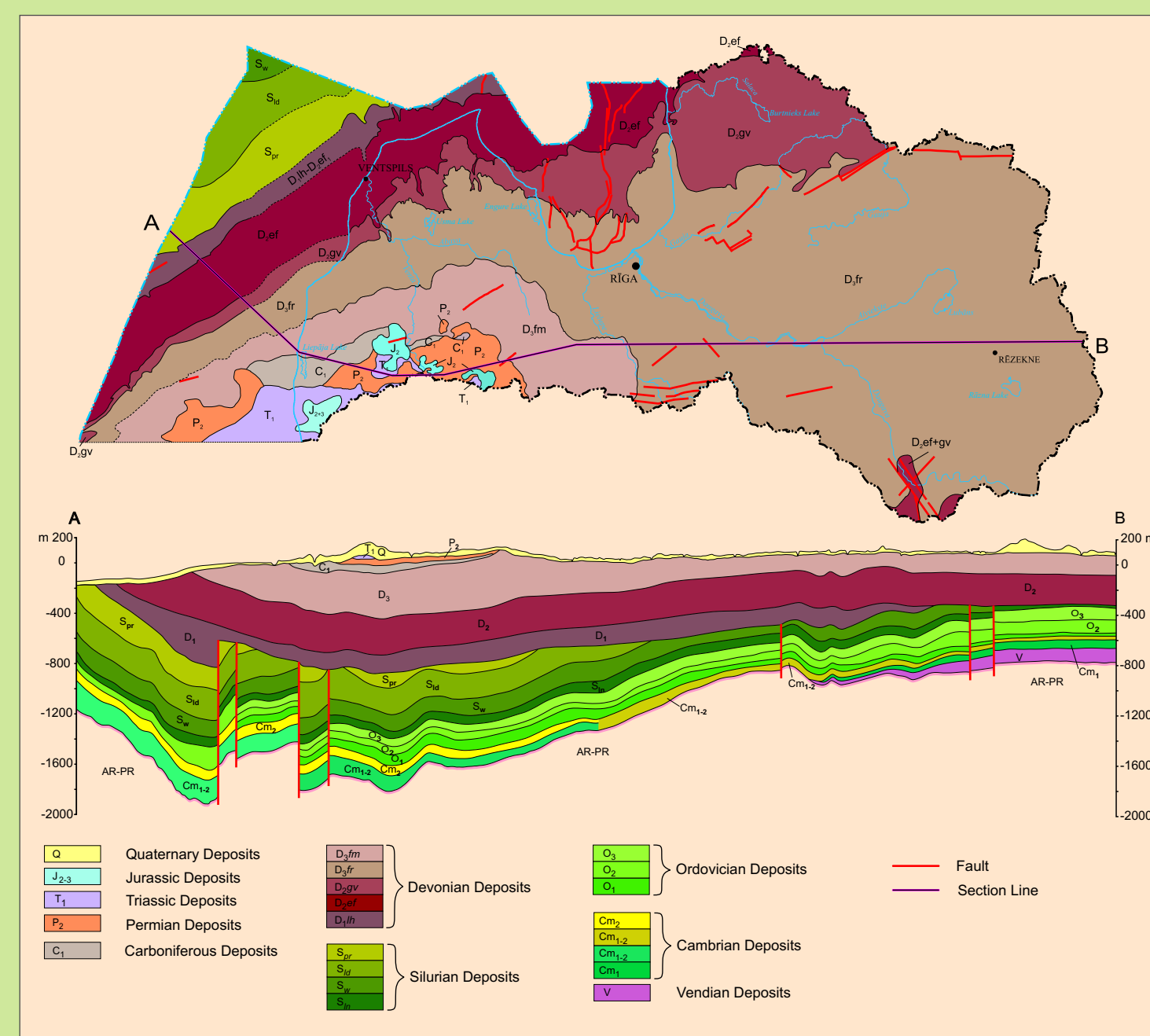


Figure 2. Geological map and section

DATA OF TEMPERATURE MEASUREMENTS IN WELLS



Figure 3. Map of temperatures measured in wells

The well temperature regime was extensively studied in Latvia during the 2nd half of the 20th century.

The State Geological Fund has 133 original thermogram records from 121 wells (Fig.3).

After the evaluation of the quality of 133 logs and generalisation of the logging conditions, the following conclusions can be made:

1. In 39 wells, temperature logging was conducted as far as the top Basement.
2. In 76 wells, Cambrian deposits were studied using temperature logging;
3. In 108 wells, temperature log data characterise the groundwater of the L.- M. Devonian complex;

THE POTENTIAL GEOTHERMAL AQUIFERS

The prospects for the practical use of geothermal water in Latvia are related to the **Cambrian** and **Lower-Middle Devonian** aquifers composed of sandstone and siltstone with subordinate shale.

The Cambrian aquifer complex is associated with the Caledonian Complex. Two aquifers are singled out within it in south-western Latvia. The lower one corresponds to the sandstone member of the Ventava Formation (Lower Cambrian), 5 to 30 m thick, while the upper one – to the predominantly sandy deposits of the Mid-Cambrian Deimena Formation (Cm2dm), 40 to 83 m thick (Fig.4). Towards the east, sandy and clayey-silty deposits of the Ventava, Tebra and Deimena Formations are gradually replaced by predominantly sandy deposits of the Cirma Member (Cm1-2cr). The thickness of the Cirma Member sandstone in the central Latvia varies from 22 to 40 m (Fig.5). The deposits of the Cambrian aquifer complex are generally overlain by the Ordovician and Silurian deposits, 380 to 760 m thick. The Ordovician and Silurian carbonate-clayey formations are represented by tight deposits with low porosity, which form a regional aquiclude for the Cambrian reservoirs.

The deposits of The Hercynian complex overlie the deposits of the Caledonian Complex with an angular and stratigraphic disconformity. Several aquifer complexes are singled out within it: Pärnu-Kemeri, Arukūla-Amata etc. From the point of view of utilisation of geothermal water, only the Pärnu-Kemeri aquifer complex is of interest, its total thickness varying from 140 to 215 m. The deposits of that complex are generally overlain by the tight clayey-carbonate deposits of the Middle Devonian Narva Formation, 110 to 210 m thick. The temperature of the formation water of the aquifer complexes, which overlie the Narva clay, rarely exceeds 20-25 °C.

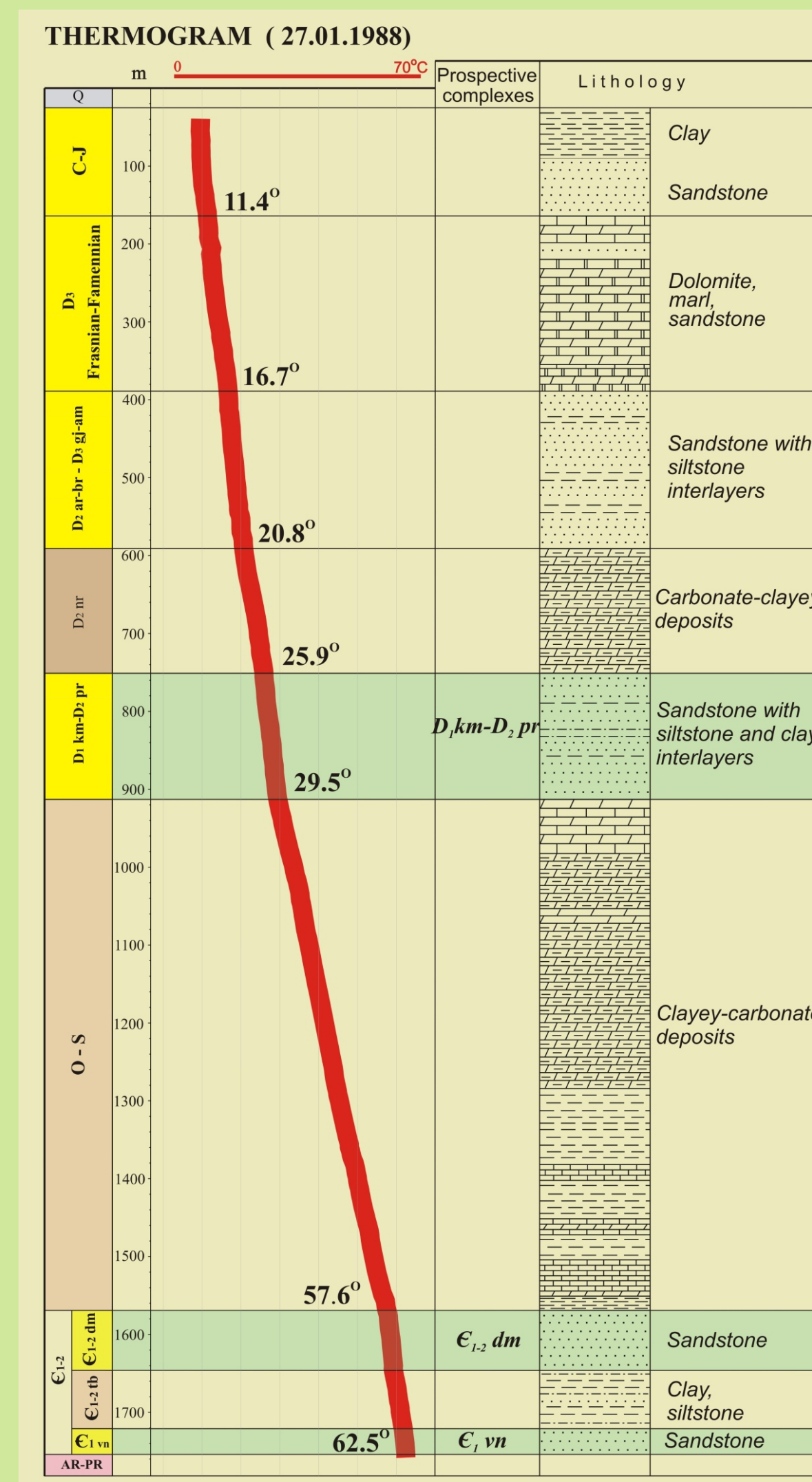


Fig.4. Thermogramm for well Pape-23. South-Western geothermal zone.

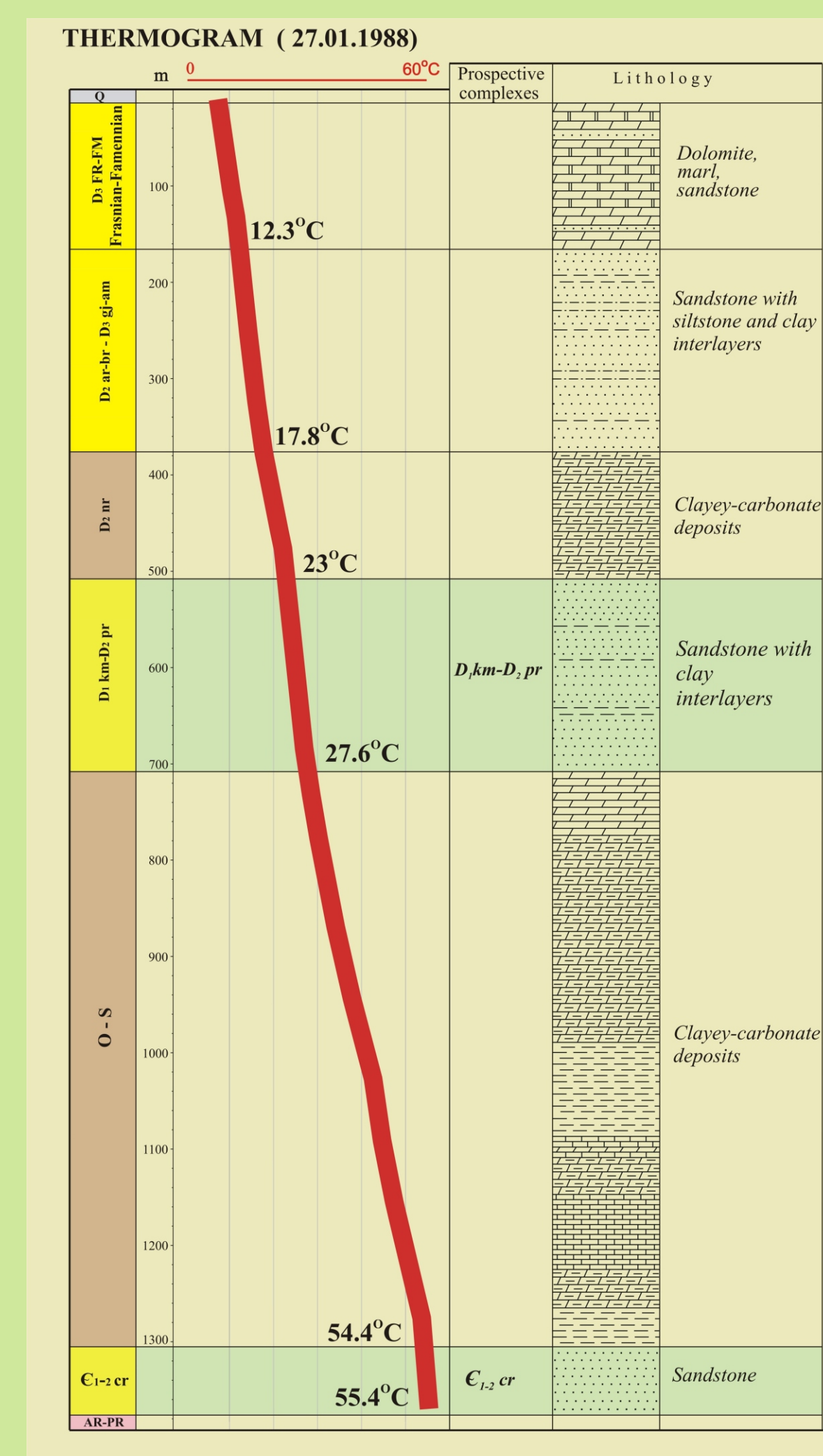


Fig.5. Thermogramm for well Vircava-5. Central geothermal zone.

TEMPERATURES IN THE CAMBRIAN AQUIFER COMPLEX

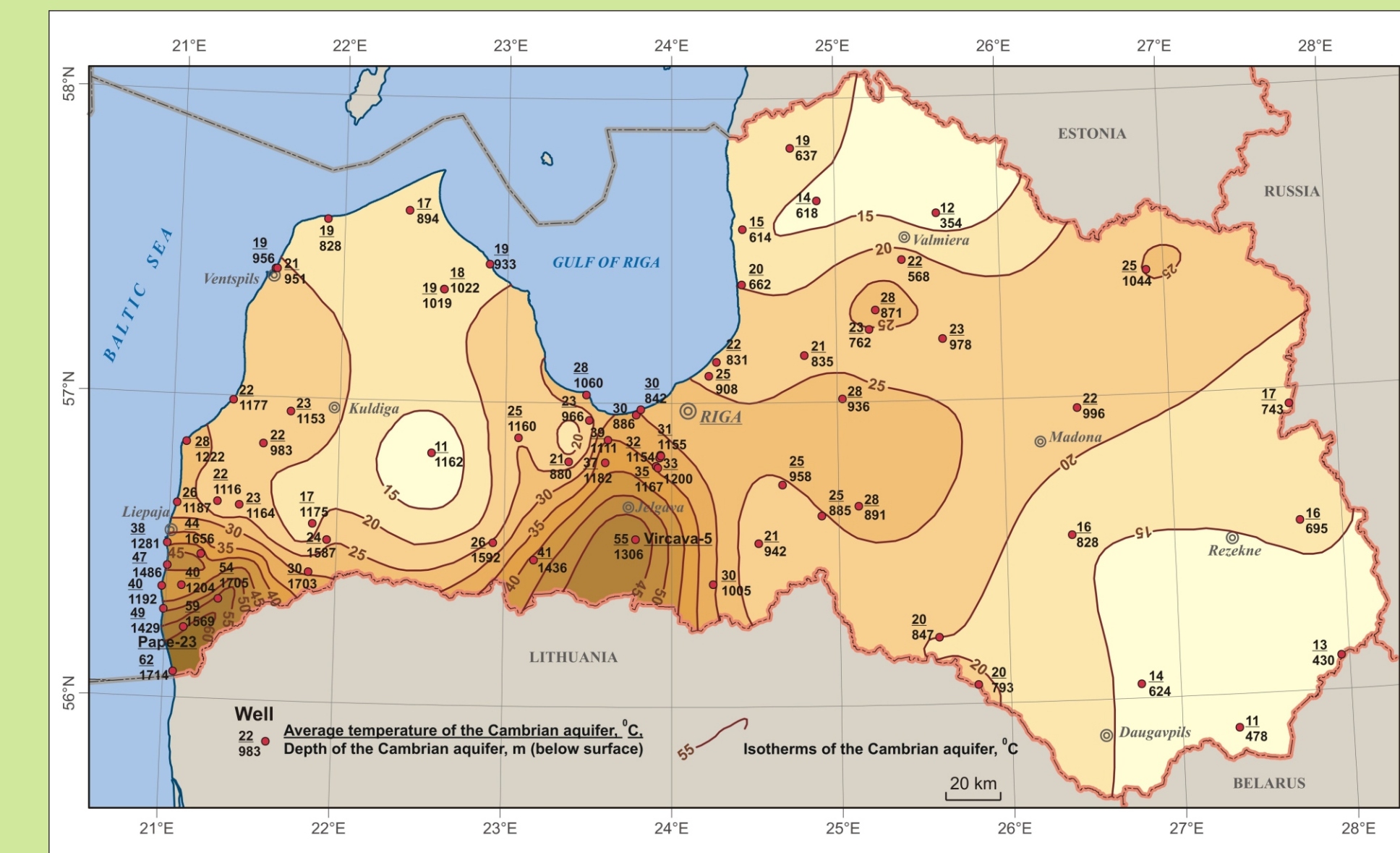


Fig.6. Map of average temperatures in the Cambrian aquifer (Deimena & Cirma aquifers)

During the preparation of the map of average temperatures of the Cambrian groundwater complex, temperature measurement data from 75 wells were used.

The water temperature within the Cambrian complex varies from 11 °C (Kraslava-104 well) to 62 °C (Nidasciems-45 well).

Two hydrothermal zones with heightened temperatures were singled out in the Cambrian aquifer complex – The South-western and The Central geothermal zones.

The **South-western geothermal zone**, stretching to the south and south-east from Liepāja.

The Cambrian temperature in that zone at the depth 1,192 – 1,714 m reaches 38°C – 62°C.

The total reservoir (Deimena formation) thickness varies from 63 to 86 m, the effective thickness - from 47 to 56 m. The average open porosity of the sandstone comprises 14%. The average permeability reaches 87 mD. Mineralization of groundwater – up to 111-135 g/l.

The **Central geothermal zone** stretches from Jurmala to the Lithuanian border.

In its southern part, the temperature of groundwater of the Cambrian reservoir at the depth 1,100 – 1,436 m is 33°C – 55°C.

The effective reservoir (Cirma Member) thickness varies from 14 to 39 m. The average open porosity of the sandstone comprises 21%. The average permeability reaches 460 mD. Mineralization of groundwater – up to 116-126 g/l.

TEMPERATURES IN THE LOWER-MIDDLE DEVONIAN AQUIFER COMPLEX

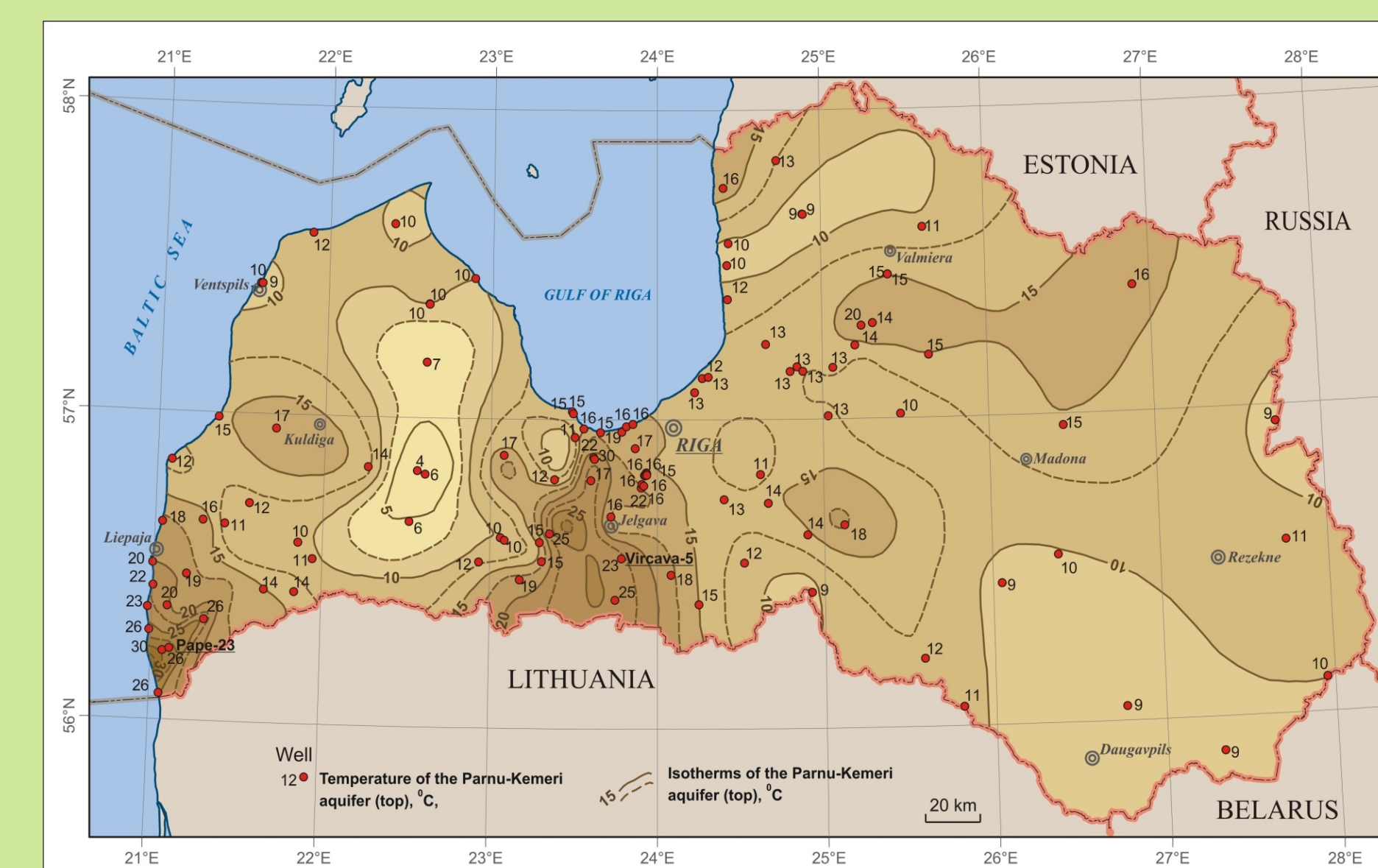


Fig.7. Map of temperatures in the Pärnu-Kemeri aquifer.

During the preparation of the map of average temperatures of the complex, temperature measurement data from 108 wells were used.

Regionally, the temperature distribution in the L.-M. Devonian groundwater complex is similar to that of the Cambrian groundwater complex.

In most of the Latvian territory, such temperatures vary with the limits of 7.5 – 20°C. In the central part of western Latvia, a zone with minimal temperatures (4-7°C) was singled out.

As in the deeper aquifers, the zone of heightened temperatures in the L.-M. Devonian groundwater complex is situated in SW and central Latvia.

In the **South-western geothermal zone**, the temperature at the depth 600 – 775 m reaches 20°C – 30°C.

The effective reservoir thickness varies from 70 to 120 m.

The average open porosity of the sandstone comprises 24%.

The average permeability reaches 590 mD.

Mineralization of groundwater – up to 10-70 g/l.

In the **Central geothermal zone**, the temperature at the depth 400 – 584 m is 20 °C – 30°C.

The effective reservoir thickness varies from 88 to 140 m.

The average open porosity of the sandstone comprises 27%.

The average permeability reaches 760 mD.

Mineralization of groundwater – up to 20 g/l.

The total evaluated energy resources of the Cambrian complex for the 6,572 km² area (temperature > 30°C) comprise 46,000 * 10¹⁵ J /2/. The resources of the L. Devonian aquifer for the 1,000 km² area (temperature > 25°C), based on E. Eihmanis' data, comprise 5.4 * 10¹⁸ J /1/.

- References
1. Eihmanis E., 2000. Incorporation of geothermal heat sources in Latvian heat supply systems; Proc. World Geothermal Congress 2000, Kyushu-Tohoku, Japan, pp. 169-174.
 2. Levins I., Levina N., Gavena I., 1998. Latvian groundwater resources. Ed. I. Dzīlna, Rīga, SGS, p. 24 (in Latvian).

