THERMAL STATE AND HYDROLOGY OF THE BYELORUSSIA AND ADJECENT AREAS

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Tectonic Position.

The territory of Byelorussia is located in Western Part of the Pre-Cambrian East-European Platform (EEP) in limits of the Russian Plate /1/. The considered region represents junction of tectonic structures of different age and origin. The Mazury-Beylorussian Anteclise (MBA) is the main positive structure of the territory, surrounded by depressions. Its Western edge stretches to the Poland. Sedimentary cover thickness amounts to 500 m, but it does not exceed 100 m for the Central Byelorussian Massif. The Paleozoic Pripyat Trough, which was actively formed during late Devonian-Triassic time, adjonis to it in South-West. Its crystalline basement is subdivided in blocks, lowered to different depts, by system of faults. Two regional halite layers are blanketing its territory. Their total thickness reaches 2-3 km, the Bragin-Loev Saddle joins the Pripyat Trough to the Dnieper-Donetz Depression, separating the Ukrainian Shield and the Voronezh Anteclise.

The Polesye Saddle joing the Pripyat Trough to another Paleozoic structure Podlyasie-Brest Depression, stretching in West to the EEP margin. The main its part is on the territory of Poland. From East the Orsha Depression adjoins the MBA. It was formed during the final stage development of the Volyn-Orsha-Krestsy Paleodepression, which separated the old Baltic and Sarmatian shields. The platform cover thickness reaches here 1400-1600 m in the Mogilev and Vitebsk synclinal bowls.

The Baltic Syneclise lies in the North-West direction from the MBA in the extreme West of the Russian Plate. Its basement is Pre-Paleozoic, and deepest part reaches 5-6 km outside the considered territory.

In the South, North, and East the MBA joins through the Polesye, Zhlobin and Latvian saddles correspondingly to the Ukrainian and Baltic shields, and Voronezh Anteclise. The Moscow Syneclise lies in the North-East direction from the Orsha Depression.

Heat Flow Density Pattern.

The most number of heat flow density determinations were fulfiled in the Pripyat-Dnieper-Donetz Aulacogen (PDA), USSR part of the Mazury-Byelorussian Anteclise, and the Baltic Syneclise. Not numerous heat flow data were received for other tectonic structures. The depths of boreholes geothermally studied exceed 1000 m. For the Baltic Syneclise and Podlyasie-Brest Depression, and only in limits of the PDA it reaches 3-4 km. Several hundred meters deep boreholes were used for this purpose in the last territory.

The background values of heat flow density are 30-40 mW/m^2. The highest geothermal gradients and heat flow density up to 80-90 mW/m^2 /2/ were observed in the Baltic Syneclise and correspond to the West-Lithuanian Massif. In direction to the East-Lithuanian Zone and the East-Latvian Massif it is decreasing to 40-50 mW/m^2 /3/. The zone of high heat flow has North-East to South-West stretching along the line between Riga and Kaliningrad cities. For the Inchukalns Folded Zone it exceeds again 50 mW/m^2 .

The Podlyasie-Brest Depression is studied nonuniformly in geothermal respect. The positive heat flow anomaly in its central part is marked by 50mW/m^2 isoline, oriented in West direction to the Teisseyre-Tornquist Line, having tendency to increase to the margin of the EEP.

In general the Orsha Depression is a cold structure and is characterizing by low heat flow values about 30-35 mW/m^2, which increases to 40-45 mW/m^2 in directions to the Moscow Syneclise, Voronezh Anteclise, the Pripyat Trough, and the Baltic Syneclise.

The contrast pattern of terrestrial temperature field exists in the Pripyat Trough /4/. Heat flow density determinations, based on instrumental measurements showed the evident increasing of geothermal gradients in the same deposits in the north-east direction. Thereafter the North zone of the trough was studied in details /5/ and Shatilki-Pervomaisk positive anomaly was established, where heat flow density exceeds 70 mW/m^2. Local values above 90 mW/m^2 were observed in salt domes. This anomaly is closely adjoin to the North Pripyat Depression Fault and is elongated parallel to it. But in central and South parts it decreases to 40-45 mW/m^2 and is below 40 mW/m^2 for the Northern part of the Ukrainian Shield. Similar values 33-50 mW/m^2 correspond to the North part of the Dnieper-Donetz Depression.

The results for the USSR part of the Mazury-Byelorussian Anteclize exibit low values of heat flow density about 25-35 mW/m^2. Only in the West-Byelorussian Folded System of basement it increases to 45-48 mW/m^2 /6/. Rather like situation exists in the Western parts of the Voronezh Anteclise and the Moscow Syneclise, but the network density of observations here is rather sparse. Finally, heat flow density increases up to 50-60 mW/m^2 to the North of the Orsha Depression in southernmost part of the Baltic Shield, where the Leningrad-Novgorod-Pskov positive anomaly is outlined mainly taking into account temperature measurements in shallow boreholes.

Thermal waters.

The watershed between the Black and the Baltic seas are passing through the territiry under consideration. The Baltic, the Moscow, the Pripyat and the Podlyasie-Brest artesian basins, and the Byelorussia-Lithuanian and the Voronezh artesian domes are distinguished in this territory. In the limits of latter cold fresh waters, or ground-water having low content of dissolved minerals, are widely spreaded. The zone of fresh water for the MBA reaches the depth of 300-400 m.

Thermal waters are contained in deep sedimentary basins. In the South and Central parts of the Baltic Syneclise they are related mainly to Devonian and Ordovician deposits /7/. The Devonian water-bearing complex contains warm Sodium-Chlorid waters, having salt content 30-80 g.p.l. Water-bearing rocks are sands, sandstones, and dolomitic marls. The Ordovician complex contains brines, having salinity 40-200 g.p.l. Their concentration increases accordingly to the deepening of aquifers. The chemical composition of brines is changing from Sodium-Chlorid to Sodium-Potassium-Chlorid in the depth 2 km. An aquifer temperature varies from 20 to 70-80 °C.

The brines with temperature 30-35 °C and salinity 90-140 g.p.l. are found in the West part of the Moscow Syneclise at depths 500-900 m. Their temperature increase to 40-45 °C in aquifers of the Ordovician-Proterozoic sediments, existing at depths 700-1000 m. There are several water-bearing complexes in the Pripyat Trough. The Sub-Salt (terrigenous and carbonaceous) and the Inter-Salt complexes contain highly concentrated brines. The sources of dissolved chemicals are two Devonian halite layers. Above-Salt Devonian, Carboniferous, and Permian-Triassic complexes are also saturated with saline waters and low-concentrated brines. Only aquifers, related to the Mesozoic-Cenozoic deposits contain fresh ground-water. Impermeable rocks, represented by regionally developed two salt strata, clays, and clay marls separate individual aquifers.

The thickness of Sub-Salt Terrigenous Complex changes from 130-140 to 250-300 m. It lies at the depth 1300-3400 m and deepens up to 4500-6000 m for some blocks of the basement (Elsk Graben, Malodusha-Chervonaya Sloboda Stage). The temperature of these brines varies from 30-50 to 70-80 °C, except for the North-East part of the Trough, where it reaches 90-105 °C. The main composition of these brines is Potassium-Sodium-Chlorid with dissolved chemicals content from 170 to 453 g.p.l.

The Sub-Salt Carbonaceous Complex beds at the depths 890 m in the West part and more than 3000-5000 m for some deep-seated blocks. This complex contains the same type of brines, having salinity from 110 to 400 g.p.l. and increased content of some microelements, such as Iodine, Bromine, Ammonium, etc. The temperature varies here in range from 25-30 °C in the West to 80-90 °C in the North-East parts of the trough.

The salinity of the Inter-Salt water-bearing complex brines reaches 380-390 g.p.l. at the temperature changing in wide range from 25 to 90 °C, but this aquifer does not play a significant role from the point of thermal energy extraction.

Above-Salt water-bearing complex contains waters, temperature of which is below 50 °C and may be utilized mainly by means of Heat Pumps application. In this upper part of geologic section it was found a noticeable influence of ground-water movement on the variation of heat flow density with the intervals of depth, chosen for observations.

The basement surface temperature in the Podlyasie-Brest Depression on the USSR territory is below 35 °C at the depth 1.8 km. It increases in the West direction on the Poland territory, where a depth of the basement position reaches 5 km. The salinity of ground-water and brines varies from 10-12 to 180 (hole Tluszcz) g.p.l.

A ground-water in the limits of the Dnieper-Donetz Depression has average temperature about 80 °C for the Devonian deposits. But in some localities, where depth to the basement surface is 6-8 km, it increases to 120-150 °C. The chemical composition of these brines is minly Sodium-Chlorid with mineraliza-

tion about 290-310 g.p.l.

Conclusion.

The terrestrial temperature field in the Western part of the Pre-Cambrian East-European Platform on the territory of Byelorussia and adjacent areas is nonuniform. At the background of low heat flow density values 20-40 mW/m^2, the positive anomalies are clearly distinguished, where 70-80 mW/m^2 values are observed in the area of the Baltic Syneclise and the Pripyat Trough. The upper part of platform sedimentary cover is subjected noticeably to distortion of observed heat flow density values mainly due to ground-water movement.

The most favourable areas from the point of geothermal energy, thermal waters and brines utilization are deep sedimentary basins: the Central part of the Baltic Syneclise, the Pripyat Trough, and the Dnieper-Donetz Depression. Their practical recovery requires a combine approach application including extraction of dissolved chemicals from brines and reihjection of waste waters in the same underground reservoirs.

Waters of Above-Salt deposits of the Pripyat Trough and some aquifers of the USSR part of the Podlyasie-Brest Depression, as well as the Moscow and the Baltic syneclises are low-enthalpy ones. Their utilization is possible mainly by means of Heat Pump technique application.

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