THERMAL STRUCTURE OF LITHOSPHERE OF SIBERIAN PLATFORM

Duchkov,A.D., Sokolova,L.S.

Institute of Geophysics SB RAS, University Ave., 3, Novosibirsk 630090, Russia

The old (Precambrian) Siberian Platform occupies the central part of Northern Asia. The present-day state of geothermal investigation permits the elucidation of only the most general regularities in heat flow (q) and temperature (T) distributions (Duchkov,1991; Temperature...,1994). The heat flow is a basic parameter characterizing the modern tectonics activity of the lithosphere blocks. The heat flow estimations were carried out by a generally accepted method which implies the separate determinations of a geothermal gradient (g) and the thermal conductivity of rocks (λ), $q = \lambda * g$. The temperature measurements were mainly taken in boreholes with average depth of 2.0-2.5 km. In calculating g- and q-values the effects of relief and surface temperature changes were taken into account when necessary. The sharp fall in temperature in Northern Hemisphere in the Holocene led to formation of permafrost (Balobaev, 1991). These create additional problems for geothermal studies. In compiling the q-map of Siberian Platform we used experimental data of varying accuracy. These data are sufficient to point out the features in q-distribution of 15-20 mW/m². The basic geothermal parameters for Siberian Platform and neighbour regions are in the Table.

Table. Mean values of geothermic parameters

Area	Heat flow, mW/m²	Temperature, °C						Thickness of lithosphere, km
		0.5 km	1 km	2 km	3 km	5 km	Moho boundary	
Siberian Platform	38	8	15	30	47	82	300	more 200
West-Siberian Plate	53	12	29	60	92	140	480	180
Verkhoyano-Kolymsk	66						630	140

The Siberian Platform is characterized by lower heat flow with mean value of 38 mW/m² (more 200 values from 15 to 67 mW/m²) The northern part of the Siberian Platform occupies the vast Anabar crystalline Massif. In geothermal plan Anabar Massif is the area with the coldest crust and the lowest heat flow, ranging from 15 to 25 mW/m². The area of low heat flow on the Siberian Platform is considerably wider than the area of the Anabar Massif The Nepa-Botuoba Arch extend into it. Here q does not generally exceed 20 mW/m². This situation could account for the long-term passivity of this lithospheric blocks, the great thickness of the rocks with high thermal conductivity and low radiogenic heat production (crystalline, carbonaceous, salt deposits), and intensive surface cooling over an extended period of time (hundreds of million years). Low q-values are associated with penetration of negative temperatures (permafrost) into the Earth interior, in some locations - to a depth of 1.0-1.5 km. Yakut Kimberlite Province is situated in the limits of that large area of low heat flow. Low q is also typical for Enisey Shield and Enisey-Turukhansk Folded Dislocations which separate Siberian Platform from West-Siberian Plate. A considerable part of the Platform is occupied by Mesozoic depression structures. In the geothermal plan only the Vilyuy and Tunguska synclines are studied. Heat flow increases here to 40-50 mW/m². High q (40-70 mW/m²) is also typical for southern part of Siberian Platform, occupied the Irkutsk Amphitheater and the Aldan Shield. This q-increase in limits of analyzed parts of Siberian Platform should evidently be connected with its latest Meso-Cenozoic tectonic activity. The greatest q- and T-variations are found in the western (with West-Siberian Plate) and in the eastern (with Verkhoyano-Kolymsk Area) boundaries of the Siberian Platform. Crossing their we observe the increase of the heat flow by more than twice.

Thus, within the limits of the Siberian Platform, two heat flow levels are established. In the northern (except Enisey-Khatanga and Tunguska depressions) and central areas the q-level is about 20, and in the south and in the depressions it is about 40-50 mW/m².

The temperature distribution in Siberian Platform interior is studied in boreholes up to the depths of 2-3 km. At the more depths the prognostic T-values are mainly used. Within the limits of the lithosphere the temperature field may be described by stationary heat conduction equation at the first approximation. The regional estimations of T may be carried out by the solution of one-dimensional stationary heat conduction equation with real initial and boundary conditions (Duchkov and Sokolova,1994). Many investigators set lithosphere limits at the depth at which the melting of mantle substance begins. This definition allows us to use the geothermal data to estimate the thickness of the lithosphere: the intersection of calculated isotherms with the solidus curve marks the bottom of the lithosphere.

The temperature field of Siberian Platform lithosphere is characterized by the T-distributions at the depths of 0.5, 1, 2, 3 и 5 км, by schematic maps of tne Moho boundary temperature (T_M) and of the lithosphere thickness (H_L) (see Table).

The analysis of these distributions shows that in the north part of Siberian Platform the temperature is negative everywhere The cooling influence of permafrost is the cause of such deep freezing. At the depth of 1 km the rock temperature is generally everywhere positive and only on north-east the zones with negative temperature are observed. At the depth of 2 km the mean temperature of rocks (T_2) reaches 30°C, however in Western Yakutiya the lower T_2-values are observed. At the depth of 2 km the permafrost influence is considerably weakened and the T_2-field begins to correspond with heat flow. At the depths of 3 and 5 km the rock temperature is determined by the heat flow on the whole (Temperature...,1994).

T_M-estimations show that the Moho boundary is not isothermal and its temperature can be significantly changed (see Table). For the ancient Siberian Platform the low T_M-values (250-350°C) are typical. This is the coldest region in Northern Asia. All other regions surrounding the Platform have higher crustal temperature.

A large zone of thick lithosphere (over 200 km) comprising the Siberian Platform is identified in the central part of Siberia. In many regions of Platform the base of the lithosphere can't be detected by means of the geothermal data as the heat flow is too low for the solidus curve to intersect the suitable geotherms. Thickening of the lithosphere occurs to the Tunguska and Vilyuy synclines, Irkutsk Amphitheater and Aldan Shield. The maximum H_L-values are typical for Western Yakutiya and Enisey Shield. So, the large lithosphere block (practically all the Siberian Platform) are in fact interlocked with the underlying layer of the upper mantle, i.e. serving as "anchors" braking the movement of the Asian lithospheric plate during in Meso-Cenozoic time.

Geothermal data show that central part of Siberian Platform (Western Yakutiya),where the Yakut Kimberlit Province is located, is marked out by anomaly features of the thermal field of lithosphere. So, the anomalous low heat flows and temperatures of the upper layer of Earth's crust and the most thickness of permafrost are typical for this area. The temperature of Moho boundary is lower than 300-350°C and the lithosphere thickness is significantly enlarged (more than 200-250 km) here. Such thermal parameters are also typical for the other Kimberlite Province. Revealed anomalies of thermal field are the regional geothermal indications of Kimberlite Volcanism areas.

The researches was supported by Russian Fund of Fundamental Investigations (grant No.94-05-16543).

Literature

Duchkov A.D.(1991). Review of Siberian heat flow data. In: Terrestrial heat flow and the lithosphere structure. V.Cermak and L.Rybach (Eds.), Springer-Verlag, Berlin-Heidelberg, p.426.

Temperature, permafrost and radiogenic heat production in the Earth's crust of Northern Asia (1994). A.D.Duchkov, V.T.Balobaev, B.V.Volod'ko et al. OIGGiG SB RAS: Novosibirsk, 141 pp. (in Russian).

Balobaev V.T. (1991). Geothermy of permafrost of lithosphere of Northern Asia. Novosibirsk: Nauka, 194 pp. (in Russian).

Duchkov A.D. and Sokolova L.S. (1994). Thermal structure of Siberian Lithosphere. In: Terrestrial heat flow and geothermal energy in Asia. M.L.Gupta and M.Yamano (Eds.). Oxford and IBH Publ. Co. New Delhi, India, p.281.