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GEOPHYSICS

The First Heat Flow Measurements on the Novaya Zemlya Archipelago

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Abstract—This paper reports the heat flow calculations that were made on the basis of the temperature measurements in the boreholes at the Pavlovskoye deposit (Novaya Zemlya), the definition of the thermal conductivity of the rocks sampled from the boreholes, and the estimation of the radiogenic thermal generation in the drilling interval. This gives the first heat flow measurements in the archipelago. The structure of the heat flow in the Novaya Zemlya archipelago is compared with other fold belts of northern Asia.

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The needs of the national economy and the exhaustion of resources in the developed areas objectively predetermine the increase in the exploration works in the Arctic zone of the Russian Federation. At present, the Arctic region of Russia has become a freestanding subject of the government policy in terms of subsoil use. The main reserves of the most important mineral resources, which are crucial for the development of the Russian economy, are concentrated in this region. The Polar Marine Geosurvey Expedition together with VNIIOkeangeologia (A.P. Kalenich, I.D. Glass, L.G. Pavlov, G.I. Ivanov, et al.) generally estimated the mineral resources of the Novaya Zemlya archipelago and determined the largest, as of today, resource sites: the Rogachev–Taina manganese ore area and the Bezymyannyi ore polymetallic cluster. This has led to increased interest from the Russian and foreign mining industry in the archipelago.

The exploration works, including drilling of several boreholes, started 15 years ago at the Pavlovskoye lead–zinc deposit of the Bezymyannyi polymetallic cluster. The deposit is situated in the northwestern part of Southern Island of the Novaya Zemlya archipelago in the basin of the Bezymyannaya River, 16–18 km to the west of its inflow into the Barents Sea (Bezymyannaya Guba) (Fig. 1).

The area studied is situated in the junction zone of the largest rupture structures of the Pai-Khoi–Novaya Zemlya province—Glavnyi Novaya Zemlya and Baidara faults. The deposit occurs in the carbonate Lower Devonian Gribova Formation, which composes the southeastern flank of the large Bezymyanskaya anticline gently dipping to the south and southeast at angles of 25°–45° [1].

Three structurally isolated ore occurrences—Tsentral'naya, Vostochnaya, and Pravoberezhnaya—were established within the deposit. These occurrences are composed of lenslike and bandlike ore bodies lying inside the rock beds of the ore-hosting formation. The inner composition of the ore bodies is characterized by the heterogeneous distribution of the ore mineral aggregates of various generations and stages with disseminated, veinlet, brecciated, and massive textures. The structure of the ore bodies is compounded by quartz–carbonate veins with different orientation, brecciated joints, boudinage, and cleavage of the country rocks and ores.

The structural–geological heterogeneity of the sequence constituents determined the existence of contrast thermophysical complexes. This fact should be taken into account in terms of quantity in studying the thermal conditions and the thermal history of the deposit.

The thermophysical properties of rocks are always considered as the most important parametric data for geothermal study and the simulation of sedimentary basins and fold belts when estimating deep temperatures and the heat flow density. The forecast of rock temperatures is essential to solve the various tasks related to the use of natural resources, to estimate the phase state of the various geospheres, to determine the

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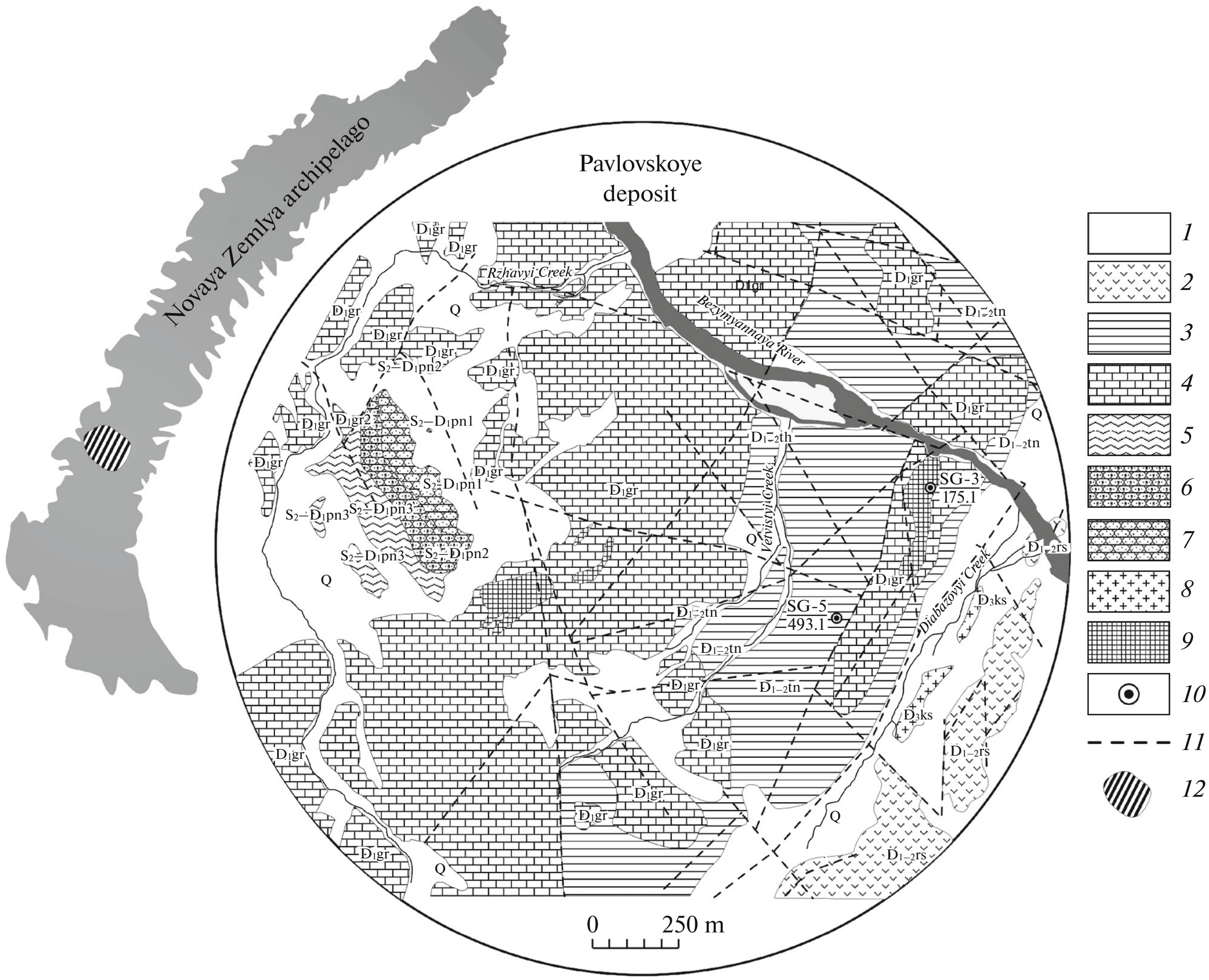

Fig. 1. Layout of the Pavlovskoye deposit and Bezymyannyi ore polymetallic cluster. (*1*) Quartenary deposits poorly defined (Q); (*2*) Reiskaya Formation (D_{1-2}rs). Basalt, tuff; (*3*) Taininskaya Formation (D_{1-2}tn). Claystone, clayey limestone, siltstone; (*4*) Gribovskaya Formation poorly defined (D_1gr). Clayey and dolomitic limestone, sedimentary breccia; (*5*) Pan'kovskaya Formation (S_2–D_1pn3). Upper member. Phyllitic schist, quartz sandstone; (*6*) Pan'kovskaya Formation (S_2–D_1pn2). Middle member. Quartz sandstone, siltstone; (*7*) Pan'kovskaya Formation (S_2–D_1pn1). Lower member. Quartz sandstone; (*8*) Dolerite dikes (D_3ks); (*9*) Exposure of ore bodies; (*10*) Borehole mouths; (*11*) Rapture dislocations; (*12*) Bezymyannyi ore polymetallic cluster.

hydrogeological features of the subsoil, to stratify the lithological sequence, and to define the potential of the deep heat as an alternative power source.

The technical means, which provide mass measurements of the thermal conductivity of the rock and ore samples [2, 3], made it possible to start detailed geothermal studies of various geological sites including ore deposits.

The coefficient of the thermal conductivity of rocks was determined on the core samples by the Optical Scanning Method with the use of the new unit TC14, which was elaborated and constructed in the laboratory of heat and mass transfer of the Geological Institute, Russian Academy of Sciences, Moscow [2].

The samples were taken from two boreholes SG-5 (493.1 m depth) and SG-3 (175.0 m depth). The general selection was 165 samples.

The Devonian claystone and limestone with large inclusions of metasomatic rocks were exposed by drilling. They are characterized by sporadic dissemination of veinlets of ore minerals—galena, sphalerite, and pyrite.

The analysis of k_{max}, k_{mean}, and k_{min} shows that it is these structural thermophysical complexes with contrast thermal conductivity that are distinguished in the sequence on the basis of their thermophysical qualities. These are represented by claystone (the thermal conductivity ranges from 1.18 to 3.50 W m^{-1} K^{-1}), limestone (the thermal conductivity ranges from