

RADIOGENIC COMPONENT THERMAL FIELD OF THE CAUCASIAN REGION

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Abstract

Results of research thermal field of the Caucasus are given in this work. Radiogenic component of the heat flow was calculated for all studied territory. Values of mantle components of heat flows for folded systems, for intermountain depression (the Georgian block) and for the Black and Caspian seas are estimated. Deep temperatures at the bottom of a sedimentary complex, Conrad and Moho borders. Maps of distribution of a heat flows and deep temperatures are created.

The research of thermal model of the Earth represents the big interest because the internal heat of the Earth plays the basic role in the history of its development, define its tectonic, seismic and volcanic activity. The physical state of matter in the Earth substantially depends on the temperature. The internal heat of the Earth has significant influence on other physical fields - electric, magnetic, thermal, a seismic velocity field and others and also plays the important role in processes of rock formation and minerals' deposits, and in particular oil and gas deposits. The main problems in the study of the thermal regime of the earth are to determinate the geothermal flow, the geothermal gradient and the calculation of deep temperatures. The heat flow carries the information about the processes occurring in the depths associated with the release of the energy or absorption. Unfortunately, the experimental data on the heat flow is very small, because these measurements are mainly carried out in the existing wells, the number of which is not enough to create an accurate picture of the flow distribution across the surface of the Earth. There is a lack of data, especially for the seas and oceans. We decided to fill up this lack of data on the heat flow with theoretical calculations of the flows for the considered region. We understand that the data obtained in this way give the average picture of the distribution of the flows, excluding their anomalous values.

Influence of tectonic processes on a thermal field is shown up doubly. On the one hand, at the same time with strengthening of tectonic activity changes the structure of a lithosphere, therefore there is a redistribution of sources of heat and change of processes of transfer of heat , distribution of temperatures and heat flows, that leads to emergence of zones of the raised and lowered flows. On the other hand, during the periods of tectonic activity from a subsoil arrives additional thermal energy, that leads to increase in crust of temperatures and heat flows. Connection between a thermal state and dynamic of a subsoil is shown first of all in compliance of zones of the maximum tectonic activity and zones of tension of crust and also zones of the increased values heat flows and vigorous magmatic activity. Owing to uneven distribution of heat flows and deep temperatures in Earth there are horizontal temperature gradients therefore thermoelastic tension is created. After achievement of

limit values of this tension there can be a gap and an earthquake. Therefore one of the main objectives of an assessment of seismic danger of seismic active regions is studying of a thermal field of the region and allocation of its abnormal zones. Identification of temperature anomalies in the crust can serve as a proof of the presence of thermal stresses, which should be considered in the future when assessing the seismic activity of the region.

In the presented work the results of studying of a heat flow distribution and calculations of temperatures of the Crust of the tectonically and seismic active Caucasian region are given. The distribution of a heat flow is made on the basis of the experimental data and also on the basis of the calculated flow values.

Temperature calculation was performed by solving the heat equation. Study region was covered with equal-step grid and in its node bedding depths of boundary surfaces are known. The temperature calculations were performed at the nodes of the lattice at the bottom of the sedimentary complex, and at the border of Conrad and Moho. The calculations take into account the dependence of the coefficient of thermal conductivity of rocks on temperature.

The calculation of deep temperatures in the crust associated with the availability of data on the heat flows in places temperature calculation. Experimental data about heat flows are insufficient for calculation of temperatures in all considered region. We have carried out calculations of the heat flow in the Caucasian region for definition of deep temperatures in the given work. The geothermal flow represents the sum of mantle and radiogenic components, it is distributed unevenly across all studied territory. Local anomalies are created by following factors: presence of rocks and ores of the raised radioactivity, exothermic and endothermic processes in oil-and-gas bearing horizons, a coal deposit, modern volcanism and tectonic movements, circulation of the underground waters, different sizes of the heat conductivity of rocks.

The calculations of a mantle component of radiogenic heat flow were performed on the basis of a deep structure of the investigated region. We used block parameterization with sloped dividing boundary surfaces. Bedding depth of boundary surfaces at any point is computed by linear interpolation of quantities which exists at surrounding grid nodes. We consider the following three-layer medium as the initial model of the Earth crust structure: I – sedimentary, II- granite, III- basalt layers [1] and cover the investigated region with an equal-step grid and its node bedding depths of boundary surfaces are known. In contrast to flat-parallel medium, in our case boundary surfaces are inclined, which reflects real medium comparatively precisely. If we express the initial model of medium structure in geographical information systems (GIS, Arc View) as tomograms, we'll receive such picture (Fig.1).

The average value of radiogenic thermal emission (radiogenic heat sources density) for a sedimentary layer have been taken equal to $1,25 \mu\text{Wt}/\text{m}^3$, for a granite layer $1,6 \mu\text{Wt}/\text{m}^3$, and for basalt – $0,4 \mu\text{Wt}/\text{m}^3$. Radiogenic component of the flow was calculated by the formula:

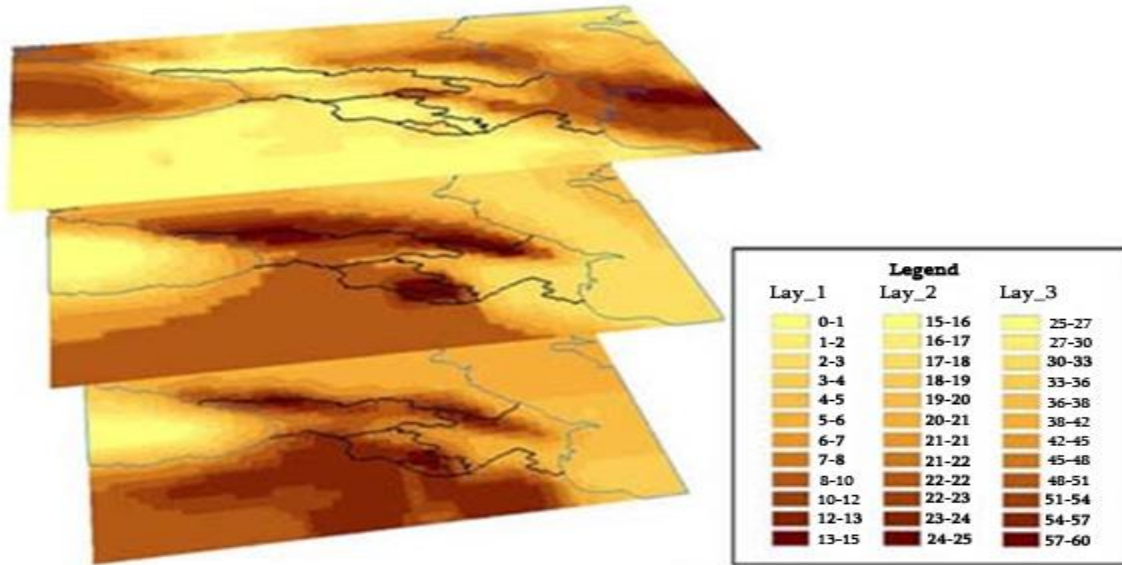
$$Q_1 = A_1H_1 + A_2H_2 + A_3H_3, (1)$$

where A_1, A_2 и A_3 - radiogenic heat source density for a sedimentary layer, for a granite layer and for basalt respectively; H_1, H_2 and H_3 – thicknesses of the layers.

The estimation of mantle component a heat flow q_m for the main structures of the Caucasus is carried out ($q_m = q - Q_1$, where q - heat flow). The average size of a mantle component of geothermal flow by our calculations is equal to: for the Black Sea $20 \text{ mWt}/\text{m}^2$, for folded systems $25 \text{ mWt}/\text{m}^2$, for intermountain depression (the Georgian block) $15 \text{ mWt}/\text{m}^2$, for the Caspian Sea $15 \text{ mWt}/\text{m}^2$. The temperature distribution in the Crust was obtained by solving three-layered model of the stationary heat equation

$$\frac{d}{dz} \left\{ A_i(T_i) \frac{dT_i}{dz} \right\} = -A_i, (2)$$

where Λ_i - thermal conductivity, A_i - radiogenic heat sources density T_i - the temperature, i - denotes the number of layer.



.Fig.1 Distribution of depths (km) of the sedimentary complex, granit and basalt layers in tree – layered model.

We considered the temperature dependence of the value Λ_i . The problem is solved in consideration of the dependence of thermal conductivity on the temperature, of our previous experiments [2]

$$\Lambda_i = \frac{1}{\rho_{0i} + \alpha_i T_i} \quad (3)$$

where $\rho_{0i} (m^{\circ}C/Wt)$ and $\alpha_i (m/Wt)$ were obtained experimentally by us for different rocks [2]. ρ_{0i} - thermal resistance of the rocks at 20⁰C, and α_i - the tangent angle of inclination $\rho_i(T)$ function to the axis of abscissa.

The boundary conditions on the Earth's surface, on the bottom of the sedimentary complex and on the border of Conrad represented as follows; on the Earth's surface we consider temperature as zero and heat flow corresponding to the flow in calculating points. On the bottom of the sedimentary complex and on the border of Conrad we consider continuity of the temperature and heat flow. Calculation of deep temperatures for the Caucasian region was held earlier [3],[4],[5],[6] with the available experimental data heat flows. In the present paper the calculation of temperatures in Caucasian region was conducted using experimental [5] and calculated by us heat flow using the formula (1), by other words, in points where there is no experimental data, we used the calculated values of the heat flow. Similar researches are performed by us for the Black Sea region[7].

The results obtained are presented in form of maps on figures 2,3,4,5. Fig.2 presents distribution of heat flow, fig. 3-5 depict maps of distribution deep temperatures at the bottom of the sedimentary complex, and on the border5 of Conrad and Moho.

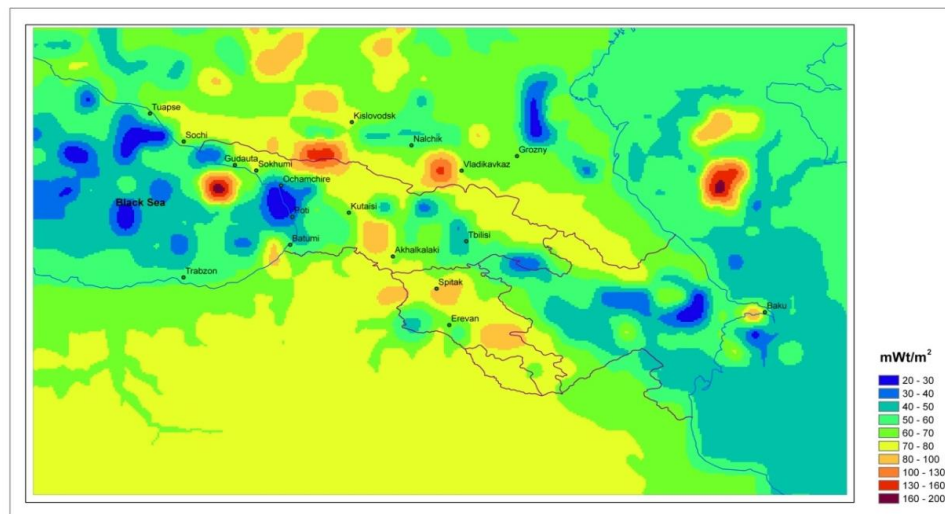


Fig.2 Distribution of the heat flow.

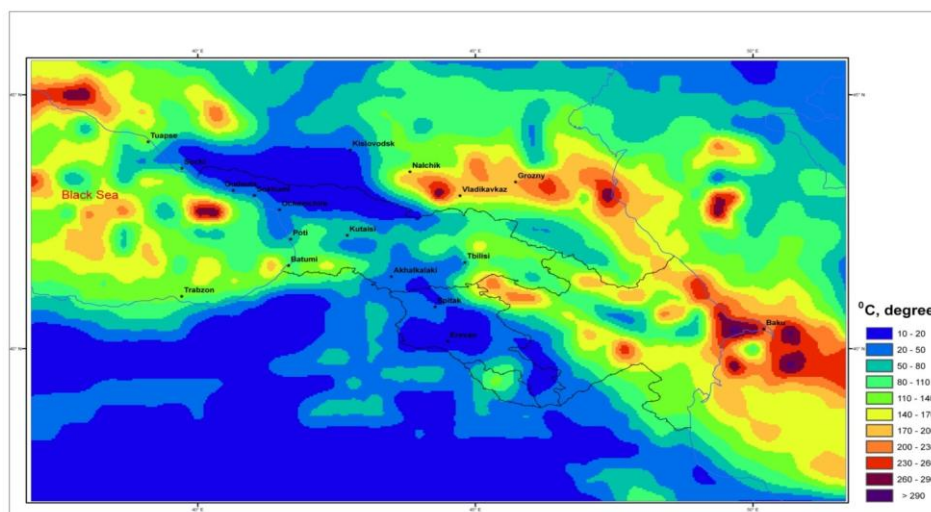


Fig.3 Distribution of deep temperatures on the border of sedimentary complex

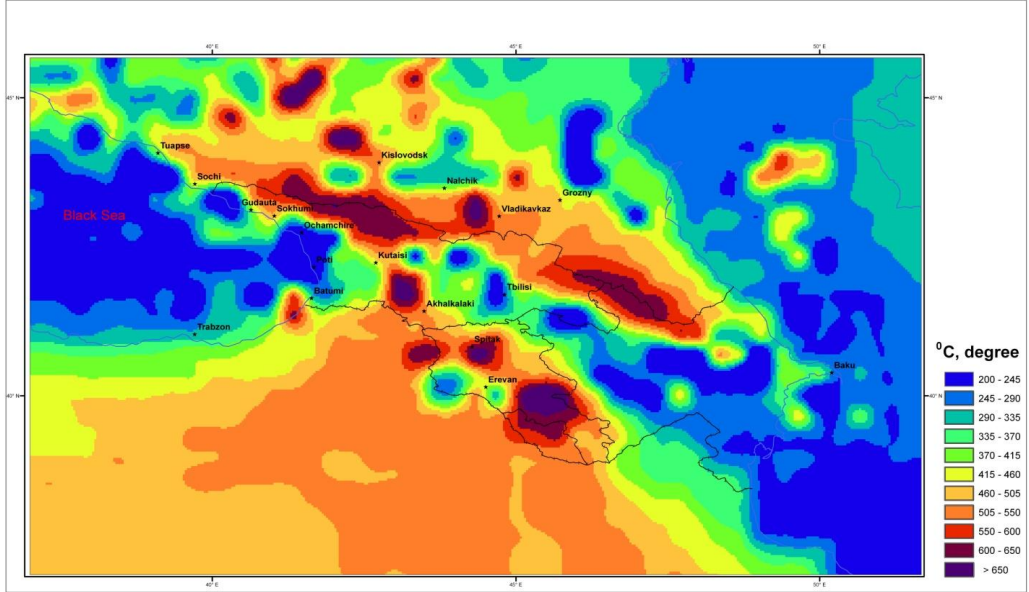


Fig.4 Distribution of deep temperatures on the border of Conrad

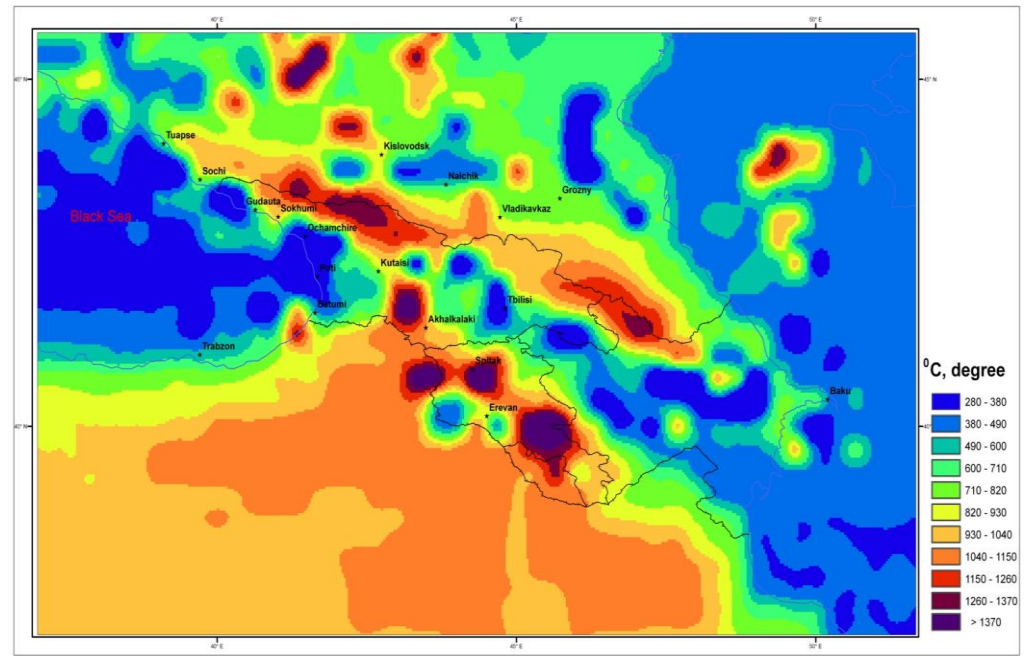


Fig.5 Distribution of deep temperatures on the border of Moho.

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კავკასიის რეგიონის სითბური ველის რადიოგენური კომპონენტი

ე. საყვარელიძე, ი. ამანათაშვილი, გ. ქუთელია, ვ. მესხია

რეზიუმე

ნაშრომში მოყვანილია კავკასიის რეგიონის სითბური ველის კვლევის შედეგები. შესწავლილი ტერიტორიისთვის გამოთვლილი არის სითბური ნაკადების რადიოგენური მდგენელები. შეფასებულია ნაკადების მანტიური მდგენელების მნიშვნელობები მთიანი რაიონებისთვის, მთათაშორისო დეპრესიისთვის (ქართული ბელტი) და შავი და კასპიის ზღვებისთვის. გამოთვლილია სიღრმითი ტემპერატურები ქერქის დანალექი კომპლექსისთვის, კონრადისა და მოხოს საზღვრებისთვის. აგებულია სითბური ნაკადების და სიღრმითი ტემპერატურების განაწილების რუკები.