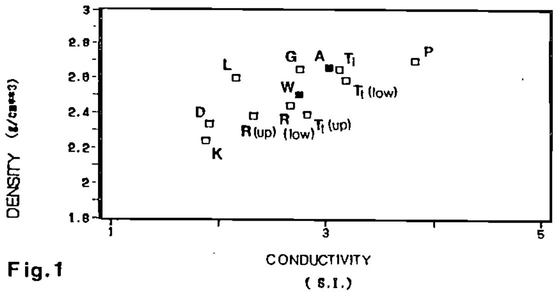

Fig.1

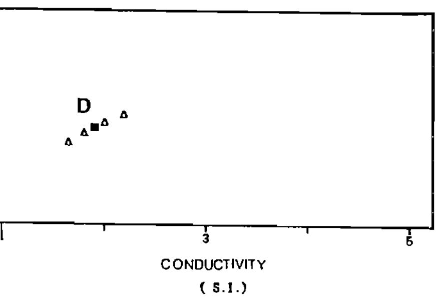

Fig. 2

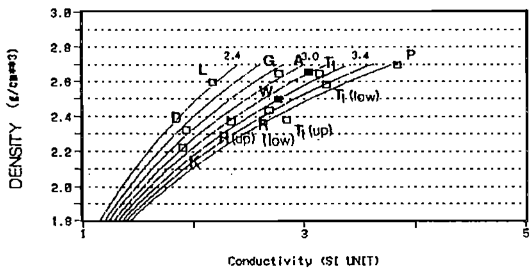

Fig.3

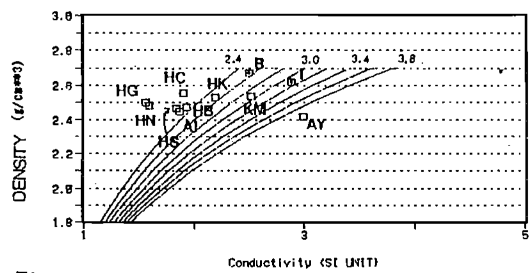

Fig.4

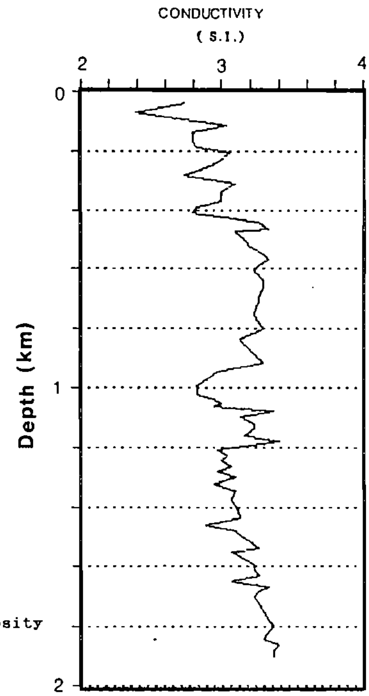

Fig. 5

Table 1. Unit-average thermal conductivity, bulk density and porosity of surface rocks and drill-hole samples in the Sengan field, Northeast Japan.

Unit name code	Sample N=	Conduct. (W/ mK)	Bulk Density (g/cm**3)	Porosity (%)
(1) Surface rocks				
L	46	2.17	2.6	7
D	4	1.92	2.33	16
R3 & R4	21	2.33	2.38	14
RB & R1, R2	39	2.67	2.44	12
K	25	1.89	2.24	23
Tt (upper)	13	3.19	2.59	15
Tt (lower)	12	2.83	2.39	7
Tl	13	3.13	2.65	3.5
G	30	2.78	2.63	2.9
P	26	3.97	2.69	3.9
(2) Drill-hole samples				
Rhyolite Welded Tuffs		2.75	2.504	7.2
Aniai Formations		3.03	2.657	4.2

THERMAL REGIME AND GROUND-WATER MOVEMENT IN THE PRIPYAT TROUGH

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The space-time structure of terrestrial temperature field of the Pripyat Trough and of the same name groundwater basin, which correspond to the upper part of platform cover section, is considered. Temperature measurements were fulfiled in 68 boreholes to the depths more than 2000 m. These data were used together with measured thermophysical properties of rosks to develop a stochastic model of terrestrial temperature field as the basis for three-dimensional model of heat flow density and its divergence distribution.

The geothermal model of the Pripyat Trough represents a system of equations for temperature and coefficient of heat conductivity polynomial regression three-dimensional coordinates and two-dimensional equations of margins, separating thermophysical complexes /1/.

The platform cover represents an anisotropic medium. It is caused by difference in thermo-physical properties of rocks composing different structural and formational complexes. Besides this peculiarity they differs also according to pattern of ground-water filtration in aquifers. Temperature fields evolution in anisotropic media are following some governing physical laws and require to take into account existing heterogeneities of the section. In this respect the platform cover was subdivided into large thermophysical complexes, which differ itself on the way of heat transfer. Two such complexes a and b, having similar thermophysical properties, but different conditions of ground-water filtration, were picked out. The a complex includes the mesozoic-cenozoic sediments, and b complex includes the carboniferous and the above--salt deposits. The upper halite layer (c complex) has high heat conductivity and is considered as impermeable. The inter-salt deposits and the lower salt body form the d and e complexes correspondingly. Every of these complexes has thickness, which is enough to study spatial peculiarities of its ambient temperature field using three-dimensional trend method.

The approximation of temperature field inside each of such complexes is realized by the expression

$$t(x,y,z) = \sum_{i=0}^{n}\sum_{j=0}^{m}\sum_{k=0}^{\ell} C_{ijk}\, x^i y^j z^k, \qquad (1)$$

where t = temperature; x , y , z = coordinates.

Representation of temperature distribution by the trend, even three-dimensional one, is not much effective, when the main purpose of investigations is the preparation of maps. An analytic representation of the field gives the character of its distribution in a medium and creates the necessary prerequisites for mapping of the field energetic parameters, namely of heat flow and heat sources density. In our case, if the temperature is approximated by three-dimensional power polynomial as (1), then calculation of every heat flow density component does not represent difficulties. In particular, for the vertical one it results from the expression

$$q_z(x,y,z) = \lambda(x,y,z)\sum_{i=0}^{n}\sum_{j=0}^{m}\sum_{k=0}^{\ell} k\, C_{ijk}\, x^i y^j z^{k-1}. \qquad (2)$$

Wrieting similar relations for components q_x and q_y , we receive the vector of total heat flow

$$q = q_x \alpha_x + q_y \alpha_y + q_z \alpha_z, \qquad (3)$$

where α_x , α_y and α_z = unit vectors.

Differentiating the components on corresponding coordinates by analogy with (2) and sum- ming them, it is possible to find the value of heat flow divergence for every point of the studied space. A physical meaning of divergence is an instant power of heat sources, including real ones, transient effects as well, and heat trasfer by medium movement (filtration). It directly results from the heat conductivity equation, which can written in the form

$$\nabla q = \rho C\, \partial t/\partial \tau + \rho_0 C_0 V \nabla t - W, \qquad (4)$$

where ρC and $\rho_0 C_0$ = heat capacity per unit volume for the rock and filtrating liquid; V = the filtration velocity vector; W = density of heat sources; ∇ =

Nabla operator.

Maps of heat flow divergence pernit to outline zones of transient and convective heat exchange. The errors of terrestrial temperature field approximation are in the range from 1,6 °C for d complex to 2,7 °C for c complex with field variations at loçal structures, with the exception of e complex. The error reaches here 10,3 °C. An examination showed that the coefficient of determination here is caused by grouping of data used. Taking it into account the sub-salt deposits were excluded from further joint consideration.

In limits of each complex the distribution of heat conductivity is nonuniform also, but its contrast is less evident. It permits to approximate the heat conductivity changing by continuous function of coordinates. The creation of heat conductivity trends is realized on the basis of calculated local values in correlation to lithologic sections for corresponding complexes. The determination of heat conductivity values for separate layers is fulfiled using empiric multifactor equations /2/, relating heat conductivity to mineralogic composition of rocks, porosity, and temperature. The error of heat conductivity trends is statisticaly undistinguishable from mistake of mean values estimation according to lithologic composition.

The model permits to study heat flow density distribution in the platform cover and to explain the deep seated anomaly in the north part of the trough. Heat flow density distribution was received on the basis of this model. The local values are calculated following to (2) and (3), which where used to find three-dimensional trend. Such representation permited to analyze the spatial peculiarities of heat flow distribution for the series of surfaces in range from the land surface to the depth of 2000 m. The gradual growth of heat flow with increasing of depth was found in the upper part of the section. It becomes stable with fluctuations about 5 mW/m^2 begining from the depth 1000-1500 m. In the north zone such stabilization exists below 1000-1200 m., but in central and sothern zones it take place from the depth 1500 m, reaching sometimes 2000 m. Heat flow distribution stabilization with increasing of depth permits assume an asimptotic approach to undistorted heat flow distribution pattern.

For the large territory including the south and central zones mean heat flow density unaffected by influence of near-surface factors has little difference from background values for the East-European Platform. The north zone anomaly is bounded by isolines 80, 70, and 60 mW/m^2 in the form of semi-ellipses, the main axes of which coincide with the position of North-Pripyat Marginal Fault. The extent of the anomaly, bounded by 80 mW/m^2 isoline is about 70 km. Under the ratio of main ellipse axes about 4:1. The interpretation of the anomaly is fulfiled on the basis of well known analytic solutions for semi-space, containing heat sources. The basic parameters of disturbing body were determined analyzing these solutions. It was shown that the anomaly has transient nature. The time, passed after the last source activity was estimated to be about 12 m.y. Its top position corresponds to depth 33-21 km, depending on the depth to its base. The source energy excess in relation to surrounding media is about 10^{22} J. Such interpretation of heat flow anomaly is in agreement with new geophysical data on the deep structure of considered territory. Geothermal data help to better understand the evolution mechanism of deep seated processes in the time.

The interpretation of received heat flow distribution in above-salt part of the Pripyat Trough sedimentary cover is given from the point of covective heat exchange in steady-state temperature field. The simplest type of regime corresponds to the field, when the main factors are stabilizing in time and its duration is enough the thermal processes to reach an equilibrium state. On the basis of analytical solutions of N.A.Ogilvi, D.Bredehoeft and J.Papadopulos, V.I.Lyalko and M.M.Mitnik, results of numerical simulationm fulfiled by L.Smith and D.S.Chapman /3-7/ the conclusion was done that terrestrial temperature field does not satisey to steady-state heat exchange conditions.

The spectral analysis is applied for the curve of mean annual long-term temperature of Earth's surface of the Byelorussian territory. It was derived by V.I.Nazarov from the data of paleoenthomofaunistic investigations. It was shown that the mechanism of the surface perturbations propagation to the depth due to heat conductivity only can not explain also the observed peculiarities of terrestrial temperature field. The solution of the problem on temperature fluctuations propagation from the surface under conditions of vertical downward filtration is obtained. For permeable thickness it is written in the form

$$t(z,\tau) = Re\{exp(i\omega\tau + pz)[A\,exp(Fz) + B\,exp(-Fz)]\}, \qquad (5)$$

where Re = real part of the complex expression under braces; ω = frequency of fluctuations; $F=(V^2a^2C_o^2/4\lambda^2+i\omega/a)^{1/2}$; A and B = constants, determined from boundary conditions and conjugation conditions at the interface between permeable thickness and impermeable base.

It follows from this solution that increase of filtration velocity, especially when it exceeds the rate of temperature wave propagation in the case of century-old fluctuations, changes significantly the character of thermal perturbations penetration. Surface temperature fluctuations reach the lower buondary of the active exchange zone practicaly without attenuation fig. 1. Heat flow density and its divergence distribution has also some peculiarities. For high infiltration velocities more than 0,3 m. Per year, these values are near to zero in permeable thickness, but in underlying formations their distribution correspond to mechanism of temperature wave propagation by molecular way at the shift of amplitudes from the surface to lower boundary of the active water exchange zone. A transitional type of distributions from convective to molecular-convective one corresponds to zone of slow water exchange.

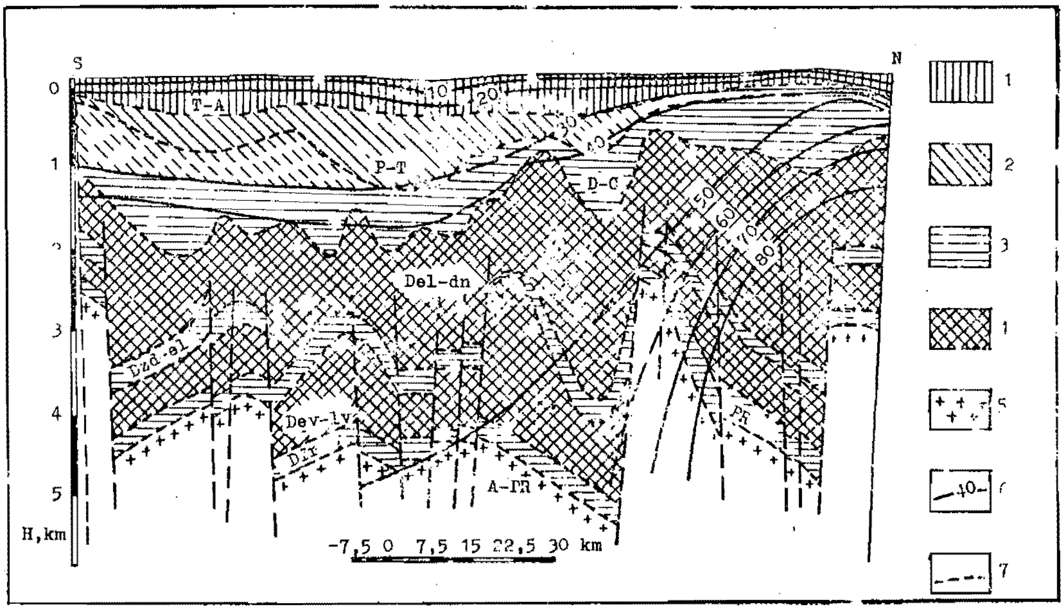

Fig.1. HYDROGEOTHERMAL SECTION OF THE PRIPYAT TROUGH ALONG VIII-VIII PROFILE: 1 - zone of active water exchange; 2 - zone of slow water exchange; 3 - zone of stagnant hydrodynamic regime; 4 - salt deposits; 5 - crystalline basement; 6 - heat flow density isolines, (mW/m^2); 7 - limits of structural complexes. Simplified tectonic situation corresponds to /8/.

The velocity of upward filtration in zones of ground-water draining by Berezina and Dnieper rivers is $3x10^{-9}$ m.p.s and $1,4x10^{-9}$ for the pripyat and its tributaries. The estimated filtration velocity in recharge area of the slow water exchange zone in South-West part of the trough is in the range $0,6-3x10^{-9}$ m.p.s. The lateral filtration velocity in this zone does not exceed $2x10^{-9}$ m.p.s.

Analysis of the terrestrial temperature field structure of the Pripyat Trough shows predominant influence of convective heat exchange in upper part of the platform cover section. The filtrating waters completely smooth heat flow anomaly picture in the zone of active water exchange.

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