DISTURBANCE OF THE GEOTHERMAL FIELD BY GAS POOLS UNDER CONDITIONS OF STEADY GROUND-WATER FLOW[1]

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(Presented by Academician V.V. Menner, December 23, 1971)

To determine the effect of gas pools and the hydrodynamic characteristics of the flow system around such pools in the geothermal field, we conducted observations in 30 piezometric wells. Temperatures were measured with maximum mercury thermometers. To increase the precision of measurements to fractions of a degree, we kept the number of observers as small as possible.[2] About half the measurements were made with the same No. 112 thermometer. All temperatures measured with other thermometers were reduced to the No. 112 thermometer readings by means of a previously found correction.

Thus, the number of temperature measurements, on which the analysis given below is based, is about 150. The data can be used to describe the temperature distribution both in plan and in section. Temperatures were measured at depths of 100, 250, 500 and 750 m (see the geothermal maps shown in Fig. 1). Our maps, in addition to primary geothermal data, which refer only to a specific depth level, we have plotted the typical lithofacies of the Khadum gas-bearing beds because they are important for interpreting the significance of ground-water flow and for the formation of the heat field itself. All productive gas pools are also indicated on the maps.

The following conclusions can be drawn from our data:

1. The heat flux in the geothermal field increases steadily with depth. Thus, the temperature gradient at each depth is:

	100 m	250 m	500 m	750 m
Temperature gradient, °C	6	10	18	22
Range, °C	15-21	20-30	31-49	45-67

2. Over the analyzed depths the geothermal field of each gas pool can be described in three dimensions over a fairly narrow temperature range (°C):

	100 m	250 m
North Stavropol'	16-19	27-29
Pelagiada	19-20	27-29
Kazinka	17-18	27
Rasshevatskaya	15-17	20-21
Bezopasnoye	16-17	23-27
Kugul'ta	15	21
Ivanovka	15	20

	500 m	750 m
North Stavropol'	44-48	60-64
Pelagiada	42-44	60-63
Kazinka	43-44	60-61
Rasshevatskaya	31-32	45-46
Bezopasnoye	37-42	52-60
Kugul'ta	34	50
Ivanovka	32	47

3. At all depth levels studied one observes a clear general tendency for the subsurface temperature to decrease in the direction of steady natural flow (undisturbed by production) of ground water of the Khadum beds. Accordingly, in most places, the further along the flow a given component of the heat field is situated, the lower is its temperature.

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[1]Translated from: O vozmushchenii geotermicheskogo polya pod vliyaniyem gazovykh zalezhey v usloviyakh ustanovivshegosya potoka podzemnykh vod. Doklady Akademii Nauk SSSR, 1973, Vol. 208, No. 3, pp. 673-676.

[2]All temperature readings were taken by the author and two technicians, S.S. Yakushin and N.S. Imankulov.

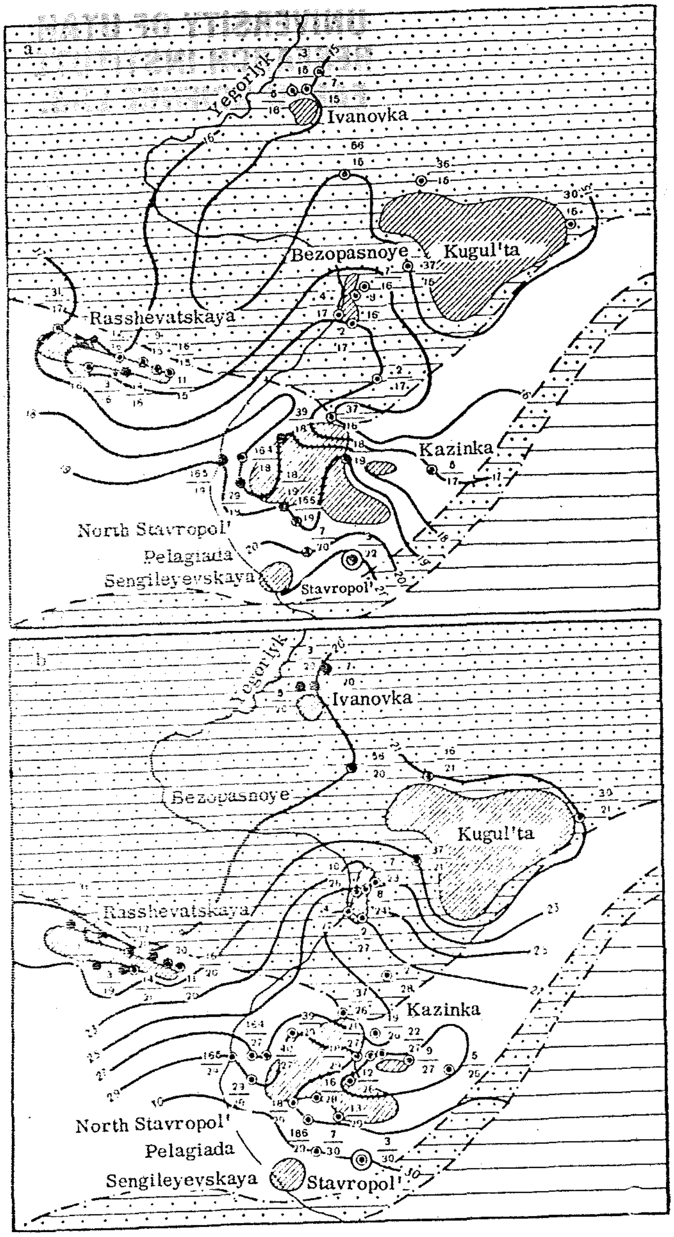

Fig. 1. Gas province of central Ciscaucasia. Geothermal maps at depths of 100 m (a), 250 m (b), 500 m (c) and 750 m (d). 1) geothermal test wells (nominator) well number-denominator) temperature, °C]; 2) isotherms, °C; 3) gas pools within the outer boundary; 4) zone dominated by sandy silty sediments; 5) same, clayey sediments; 6) same, clayey silty sediments.

4. The heat flux in the heat field is markedly nonuniform. It is also easy to see that large gas pools constitute thermal barriers, interfering with the uniform distribution of the heat-field gradient. This is illustrated especially clearly by the North Stavropol', the Pelagiada, the Kugul'ta and the Rasshevatskaya pools.

5. The steady flow of water of the Khadum and other, deeper beds, passing for millions of years through the deep East Kuban' trough, has transported much heat in an eastern direction [1]. The heat thus transmitted is redistributed over the Stavropol' uplift in complete conformity with the hydrodynamic and thermophysical characteristics of the section. In this respect the configuration of isotherms is extremely significant at all depth levels because it reflects the tendency for the heat flow to

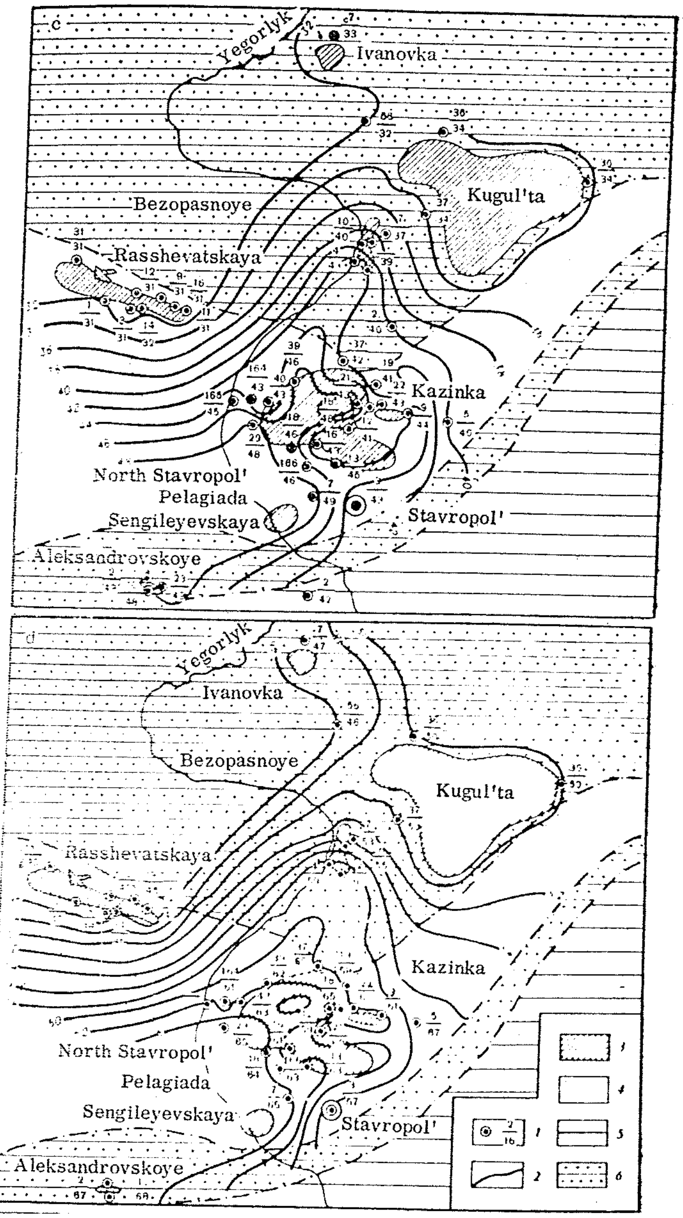

Fig. 1. (continued). See legend on page 231.

bypass the thermal barriers of gas pools wherever possible. These barriers, because of their high thermal resistance, cause the isotherms to become more closely spaced in the frontal parts of pools.

6. The above data are of interest as an example of the main factors distorting the geothermal field. They also show that the thermophysical and hydrodynamic characteristics of the flow system may be of extremely great importance.

7. The practical significance of these data is chiefly that they demonstrate the possible use of detailed features of the heat field in routine hydrogeologic surveys, in connection with locating accidental overflows of strata water in producing wells.

However, there may be cases where it may be possible to identify from the closer spacing of isotherms in the frontal parts of gas pools, fields that were missed during exploration. In particular, in the region studied the area between the Rasshevatskoye and the Ivanovka. This is interesting because productive pools may have been missed here.

Received December 23, 1971

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GAS-SATURATION OF STRATAL OILS AS A FUNCTION OF THICKNESS OF CAPROCK ABOVE OIL POOLS[1]

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(Presented by Academician A.A. Trofimuk, December 8, 1971)

Caprock above oil pools is essential to both their formation and their subsequent preservation. The caprock must, of course, be impermeable, a condition resulting from the ability of clays and salts under pressure of the overlying rock to become strongly compacted and acquire plasticity.

To evaluate the caprocks above Paleozoic oil pools, we investigated their sealing qualities in the Kuybyshev region, which contains 113 oil pools, 22 in the Middle Carboniferous (strata A_3 and A_4), 44 in the Carboniferous (strata B_2, B_1, C_{II}, C_{III}, C_{IV}) and 47 in clastic Devonian strata D_0, DG, D_I, D_{II}, D_{III}, D_{IV}) deposits.

The caprock clays here are everywhere montmorillonitic and underwent similar lithogenetic transformations in each stratigraphic interval. Thus, we thought it sufficient to ascertain the sealing quality of the caprocks as a function of their thickness alone. We based our theory on the fact that the main oil-bearing strata are confined to the regionally-persistent Lower and Middle Carboniferous clays and Devonian terrigenous sediments.

Because the saturation of oils with gas decreases from top to bottom of a pool, and this saturation decreases as oil is pumped out of the pool, our oil samples were collected from deep levels of prospecting wells drilled in the crests of anticlines. To test the dependence of the gas saturation of oils on the thickness of the caprock, graphs were drawn for each pool (Fig. 1). A linear relationship between the gas factor (quantity of gas, in m^3 per ton of oil) and the caprock thickness was found for all pools except those in strata B_1 and D_{II}. The correlation, calculated on the Minsk-22 computer, was very close, with correlation coefficients ranging from 0.7 to 0.9 and up. Such a high correlation shows that the factor controlling the gas-saturation of the stratal oils is caprock thickness, assuming that the deposits being compared are lithologically comparable and geologically similar.

We found it difficult to determine the thickness of the caprock in stratum B_2 in which clay partings alternate with dense sandy-limy beds. Figure 2 shows the various possible caprock thicknesses, the true thickness being depicted by variant III, with a correlation coefficient of 0.75. For the other variants this turned out to be lower, from 0.23 to 0.038. A lack of correlation was also found for strata B_1 and D_{II}, attributable to the thinness of their caprocks. These strata lost much of their methane and

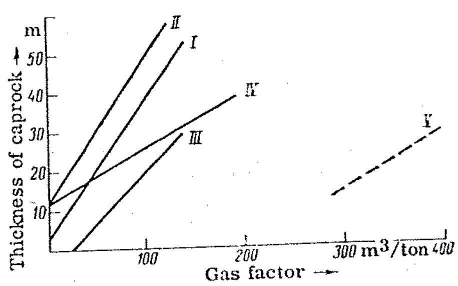

Fig. 1. Gas factor vs. thickness of the caprock: I) for strata A_3 and A_4 ($r = 0.85$); II) for stratum B_2 ($r = 0.75$); III) for strata $D_{0,k,k'}$, D_I and D_{III} ($r = 0.93$); IV) for strata $C_{II,III,IV}$ ($r = 0.68$); V) for stratum D_{IV}.

[1] Translated from: Gazonasyshchennost' plastovykh neftey kak funktsiya ot moshchnosti pokryshek nad zalezhami nefti. Doklady Akademii Nauk SSSR, 1973, Vol. 208, No. 4, pp. 928-931.