ГЕОЛОГО-ГЕОГРАФІЧНІ НАУКИ

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HEAT AND MASS TRANSPORTATION AS FACTOR OF FORMATION ABNORMALLY HIGH STRATUM PRESSURE (ON THE EXAMPLE OF THE EAST PART OF DNIPER-DONETS CAVITY)

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On the example of the eastern part of the Dnieper-Donets cavity (DDC) considered the role of the heat and mass transportation in the Earth's crust as a factor of the formation of abnormally high stratum pressure (AHPS). Investigated the regularity of the spatial distribution geochemical and positive anomalies of thermal field as indicators of AHPS zones.
Established restriction sites abnormally-high reservoir pressure to areas of deep faults activated and drawn schematic map of the distribution of abnormally high reservoir-ticks
Keywords: *tectonic fault, heat and mass transportation, abnormally high stratum pressure, anomalies, hydrocarbons, inversion*

На прикладі східної частини Дніпровсько-Донецької западини (ДДЗ) розглянуто роль тепломасоперенесення у земній корі як фактор формування аномально-високих пластових тисків (АВПТ). Досліджено закономірності просторового розподілу геохімічних та позитивних аномалій теплового поля, як індикаторів зон АВПТ.
Встановлено приуроченість ділянок АВПТ до зон активізованих глибинних розломів та складено схематичну карту розподілу аномально-високих пластових тиків
Ключові слова: *тектонічний розлом, тепломасоперенесення, аномально-високий пластовий тиск, аномалії, вуглеводні, інверсія*

1. Introduction

Abnormally high stratum pressure (AHPS), which influenced on fluids (water, oil, gas) exceeds conventional hydrostatic in 1,3–1,8 times and rarely in 2,0–2,2 times. In some cases at great depths (over 5–6 km) recorded AHPS that is the same or even greater than geostatic pressure that is much higher than hydrostatic. This is often attributed with geodynamic stresses in the crust that are caused by modern tectonic activation.

AHPS has positive effect on reservoir rock properties, increases the exploitation of natural gas fields, increasing inflows of fluids to wells without the use of measures to intensify. On the other hand, AHPS is the cause of accidents during drilling. Unexpected disclosure of AHPS zones creates technological complexity, the elimination of which causes great material costs. That is why forecasting the possible areas of abnormally high stratum pressure, based on various geological features is an urgent problem.

The main factor in the formation of AHPS except geodynamic tectogenic heat and mass transplantation stress is a phenomenon in the Earth's crust, one of the most characteristic features of which are tension of geothermal field [1].

With the interior part of the Earth to its surface always goes heat flow , the original density of which is formed in subcrustal layers and material nature provided with liquid-gas fluids [2, 3].

The upward movement of this flow can be either laminar (in pores and cracks) and turbulent (the zones of deep faults). Near the surface the heat flux is redistributed under the influence of structural-tectonic, lithologic, hydrogeological, gas dynamics and other factors. The degree of influence of each of them and, therefore, the degree of relative distortion of the primary heat flux

density is variable in the vertical and horizontal plane. Setting limits of these changes makes it possible to determine the impact of various factors on the formation of geological anomalies thermal field and back – to set parameters of these factors on size of thermal field intensity [4].

2. Literature review of scientific problem

Heat and mass transportation explains the process in connection with the formation of zones AHPS in the region dedicated to the work of various researchers. AHPS formation in rocks associated with the intensity of the thermal field and different power factors of heat and mass transportation [2–8]. In a significant number of works AHPS prognosis associated with degassing fluids on the stage of late katagenesis [2, 3, 9, 10], tectonic compression of geological structures [11, 12] with excessive hydrostatic pressure of crystalline basement, mantle degassing [13], deep hydrogeological inversion [4, 8], endogenous fluid pressure [1]. There are other theoretical model of AHPS in the region [12, 14, 15].

3. The purpose and objectives of the study

The aim of the investigation is an analysis of the phenomenon of the heat and mass transportation as a forming factor of abnormally high stratum pressure (AHPS) rocks in the eastern part of the Dnieper-Donets cavity (DDC).

So to solve this problem, you need to determine:

– the spatial relationship between areas with high strength of thermal field (geothermal anomalies) and relief cells of abnormal on the chemical composition of deep levels groundwater and endogenous gases;

– main factors and processes of formation of rocks in the region of AHPS zones;

– criteria of the composition of forecasting AHPS map-scheme zones on the territory of the eastern part of DDC.

To achieve these objectives we used the results of geological, geothermal, hydrogeological, geochemical and other studies conducted since the 1960s in various geological organizations.

4. The conditions and processes of formation of abnormally high stratum pressure (AHPS)

Heat treatment and movement of groundwater control processes of heat and mass transportation in the system “water-rock” and affect on the geochemical environment, which is reflected in the specific geochemical zonation of geothermal systems [1, 8, 15].

Lots of positive temperature anomalies and stress in the bowels of the Earth's crust appear in result of convective flow of deep water formation, rising to the surface in hydrodynamic weakened zones of tectonic faults and accompanied by plastic deformation of rocks, the result of which is folded and fault zone [7].

In conditions of the eastern part of DDC in fluid dynamic open fracture structures conducted rising unloading of deep water, gas and heat flux in the places of which formed hydrogeochemical, gasgeochemical and geothermal anomalies [16].

Manifestations of contemporary heat and mass transportation on the territory of the studies found within modern hydrothermal systems that coincide spatially with areas of modern tectonic activation and high intensity thermal field. With this process is associated the formation of hydrogeochemical and gasgeochemical inversion and areas of abnormally high stratum pressure (AHPS). This allows to use a variety of hydrogeochemical and gasgeochemical indicators for predicting AHPS. These include, in addition to the geochemical inversion manifestation, abnormally high concentrations of various hipogene minerals and gases in fluids, among which deserve special attention to boron, mercury, helium, hydrogen, lithium, rubidium, cesium on others [1, 4, 16].

Considering the effects associated with the movement of underground solutions, it should be noted that the water filtration process interacts with surrounding rocks, changes the distribution of temperature and concentrations of dissolved and settled matter. Fluctuations in temperature usually affect the intensity of diffusion transfer, the rate of chemical reactions, the nature of interactions in the system “water – rock” and the thermal conductivity, density and viscosity of the solution. However, changing the speed of interaction of the system components determines the location of sites mobilization and deposition of solutes and increasing porosity, which is thus affects the distribution of filtration properties of rocks, and hence the movement of underground solutions [4, 8, 10].

On the basis of the structure of the groundwater basin conditions of heat and mass transportation can be reduced to basic hydrodynamic scheme: their upward movement occurs in areas fluid dynamic open fractures (turbulent) and impermeable layers (capillaries). However, the horizontal movement is characteristic of aquifers. The process of convection heat and mass transportation can be considered in a one-dimensional system to obtain solutions that explain the distribution of temperature and heat flow depending on thermal properties containing rocks and velocity of the groundwater. Accelerating upward movement in the near-surface layers leads to increased contrast of temperature anomalies near the surface. Since certain value rising rate of filtration area is formed stable temperature [4].

Investigation of heat and mass transportation for hydrocarbon deposits indicate that the characteristics of the distribution of deep heat flux thermal anomalies affect the surface and geothermal anomalies are reliable oil and gas search criteria [3].

The main quantitative characteristic of heat treatment subsurface is tension of thermal field, which depends on the generation, acquisition and transmission in three-system "water-rock-fluid" heat during various geological processes occurring not only accessibling to research the range of the cut, but in the deep areas of the Earth's crust [2].

Within Kalmius-Toretska basin heat flux is uneven. This means that the deep levels of hydrocarbon deposits primary differentiation of geotemperature pitch due mainly features of the deep structure of the basin and the uneven distribution of geothermal anomalies of different intensity [8].

Features of geothermal fields in the region as well as the distribution of anomalies fluid flows are caused by different factors: variations in the heat flux density, folded and break tectonics, fracturing rocks, lithologic and physical parameters basement and sedimentary strata, activity of modern geodynamic stress, and as a consequence – the intensity of heat and mass transportation. With the depth observed changes as a natural increase stratum pressure and temperature, and spatial heterogeneity. On the top of the geological section stands anomalous zone, which controls the development of large massive reservoir of oil and gas of low Permian high coal productive complex. In the bounds of learning surface section (600 m) zone of AHPS recorded in local anticlinal structures in much of the region and often different minimum values of temperature and pressure gradients. In conditions of high neotectonic activity in the region and uneven volume-stress state of the rock mass reservoir fluids are indicators of the dynamic state of individual systems "geological structure-rock-water-oil-gas" and large scale migration processes in the lithosphere [3, 11].

Studies of planetary phenomena of AHPS observed in most oil and gas provinces, give us reason to associate them with nature invasion depth (crustal and subcrustal) fluid flow in rock mass. On the way of upward migration these flows, they are an essential component of hydrocarbons, press on fluid hard layers (salt, clay, and sometimes intrusive rocks) and form diapir "body bulging" – rods, stockworks and eventually – domes. Within these specific "fluidgene" deep structures heat and mass transportation process continues throughout entire geological eras and activated in periods of tectonogenesis. This, incidentally, may be due to the restriction of hydrocarbon deposits and hydrotermalities to the same anticlinal structures. This is evidenced by the presence of hydrocarbon compounds in the gas-liquid inclusions in hydrothermal minerals [1, 17].

5. Testing results

The example of the the formation of AHPS is Machuha gas condensate field located in the south central part of DDC within monoclonal southern slope of near axis graben. The deposit is located in fractured-porous-cavernous Paleozoic reservoir (D_3^3-S_1t) deposits to mark the anticlinal uplift. In the process of drilling wells parametric "Machuhska-500" (depth 5512 m) during the testing interval 5194–5247 m of carbonate reservoirs received industrial inflows of dry methane (95,5 %) of gas, but at a depth of 5160 recorded one of the highest in the DDC reservoir temperatures (139,2 ^oC). The maximum reservoir pressure (a record for DDC anomalous factor) at a depth of 5218 m was 97.97 MPa. This phenomenon is accompanied by the formation of pronounced inversion of hydrogeochemical anomalies. Water samples selected from the interval 5189–5247 m, characterized by sharply reduced mineralization (2.5–12.3 g/dm^3) and sodium bicarbonate composition, which, in our opinion, due to the processes of "boiling" overheated sodium chloride brines in the area of thinning rocks [14].

It should be noted that close to the geochemical features of desalinated water are in many anticlinal structures in the region [16]. Correlation of high-pressure water from fault tectonics, and their penetration faults zones withdrawal of geostatic pressure studies confirmed by Verhnoserpuhivska terrigenous strata. The existence of this inversion of hydrogeochemical anomalies associated with the formation of high-pressure sodium thermal waters hydrocarbon type with low salinity, high gas saturation, lack of boron, bromine sharply high content, dissolved silica, ferrous iron, a heavy isotope of hydrogen (deuterium), corresponding to high metamorphological Paleozoic brine mineralization, which is in 50–150 times higher. The pH of the water varies from 3–4 soon after sampling and to 8–9,5 after decontamination. Concentrations of some hipogeneous trace elements, including mercury, lanthanum, lithium and other that usually accumulate in the residual magma melts is high $n \cdot 10^{-6}$ – $n \cdot 10^{-4}$ mg^2 [1, 14].

Long-term studies in the region established spatial and genetic relationships between fluid flow and thermal fields and places of latest and modern tectonics, which in some areas is quite intense. Thus, within the territory of studies according to geophysical observations, the newest and modern tectonic movements with amplitudes up to 2–10 mm/year occurring within plicative structures controlled by deep faults lay. Similarly, in many cases fixed and increased tensions of thermal field. This phenomenon occurs in the territory of studies both within the influence of Central Donetsk fault (Golovna and Druzhkivka-Kostyntynivska anticlines) and the domes controlled by other faults (Chervonooskilskyy, Torskyy, Drobyshivskyy, Svyatogirskyy, Petrovskyy etc.) [5, 16, 18].

The research results allowed to make a predictive map-distribution scheme, abnormally high reservoir ticks (Fig. 1) are confined to deep faults and anticlinal structures that accompany them. There are particular areas:

a) Central Donetsk fault – the north-western part of the Golovna anticline; north-western and south-eastern part Druzhkivka-Konstantinovskaya anticline; Bantyshevskyy, Korulskyy, Veliko Komyshuvaskyy, Spivakivsky, Domes;

b) North Donetsk fault – Tomashivska brahianticline;

c) Korulsko-Dronivskoho zone fault – the northwestern Slavic brahianticline circuit (Adamivske rod);

d) Kryvorizko-Pavlov fault in the south-board of Kalmius Toretskoyi basin.

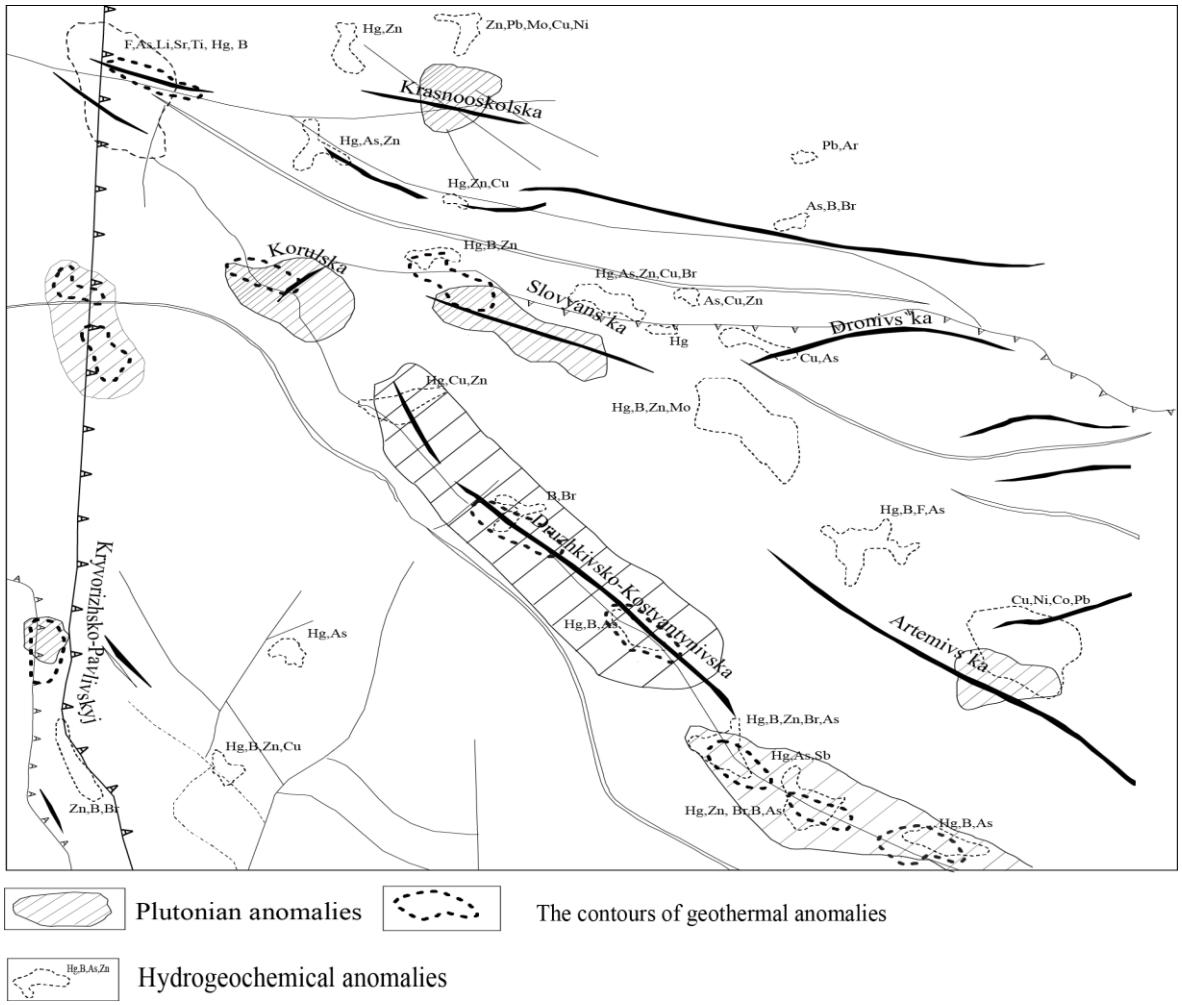

Fig. 1. Projected geological and geochemical map of abnormally-high stratum pressure in Western-Donetsk Graben

6. Conclusion

1. Lots of abnormally-high stratum pressure (AHPS) are characterized by an abrupt change of hydrogeochemical zoning and the presence of boron and mercury, which are indicators of halos reservoir water deep formation.

2. Features of the deep structure of the pool and the uneven distribution of the underlying cells generate heat on site studies causes uneven distribution of heat flux density and, consequently, the formation AHPS.

3. Distribution anomalies of geothermal field are caused by variations in the heat flux density, structural and tectonic structure of the region, fracturing, active modern geodynamic movements.

4. In the area of research AHPS is out within nature-killing active tectonic structures of the regime and the specific hydrogeochemical anomalies.

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