Problems of ecological and technical safety by exploration and production of natural gas hydrates

V.K. Chistyakov*[1], *Sun Youhong*[2], *Chen-Chen* and *Zhang Zupei

Problémy ekologickej a technickej bezpečnosti pri prieskume a ťažbe zemného plynu

Gas hydrates - the firm crystal connections form water (liquid water, ice, water vapor) and low-molecular waterproof natural gases (mainly methane) whose crystal structure effectively compresses gas e.s.: each cubic meter of hydrate can yield over 160 m^3 of methane.

In present time, the exploitation of the Messoyahsk (Russia) and Mallik (Canada) deposits of gas hydrates is conducted actively. The further perfection of prospecting methods in the field of studying gas hydrates containing sediments depends on the improvement of geophysical and the well test research, among which native-state core drilling is one of the major. Sampling a native-state core from gas hydrates sediments keeps not only the original composition but structural - textural features of their construction.

Despite of the appeal to use gas hydrates as a perspective and ecologically pure fuel possessing huge resources, the investigation and development of their deposits can lead to a number of negative consequences connected with hazards arising from the maintenance of their technical and ecological safety of carrying out. Scales of the arising problems can change from local to regional and even global.

***Key words**: gas, hydrate, methane, deposit, ecological, hazard, technical.*

A constantly growing demand for the energy carriers, the limitation and irretrievability of their now in use resources have forced to turn a close attention on searches of the non conventional sources possessing both more significant potential resources, and an opportunity of their constant completion. Sources of the energy carrier of organic carbon most widespread on the Earth and their relative resources are presented on Fig. 1. [1, 7, 12].

Among them, methane of carboniferous thicknesses, the water-dissolved gases of underground hydrosphere and natural gas hydrates are non conventional and perspective resources. Apparently, from Fig. 1, the resources of gas hydrates are prevailent and, by different estimations, on the order or exceed the resources of hydrocarbon raw material used more nowadays [4].

Gas hydrates represent crystal firm connections of $M \cdot nH_2O$ the type in which a gas with the molecular weight M keept inside n molecules of water H_2O with the help of hydrogen bonds. In the role of the substances forming hydrates there can be gases or gas compounds with a rather small molecular weight such as carbohydrates C_1 - C_4, CO_2, N_2 and others. At certain thermo-pressure dynamics conditions: negative or positive (up to some tens °C) temperatures and a pressure up to 25 MPa, their opportunity consist in the fact that 1 m^3 of the hydrate of methane equals to 160 m^3 gases under normal conditions [2].

For the first time, a commercial field gas hydrates a gas-condensate reservoir has been striked in 1964 at Messoyahsk in Western Siberia (Norilsk region) [5], but first messages the possible of existence of deposits of natural gas hydrates in the delta of the Mackenzie river (North-West territories, Canada) are dated to 70-th years of the last century. The first large-scale researched accumulations of gas hydrates on the land and an adjoining shelf were spent to the USA in 1982 - 1991 under an aegis of the Department on Energy [3].

Since 1995 in Great Britain, Germany, Canada, China, India, Russia, USA, South Korea, Japan etc. The financing of scientific and technical programs

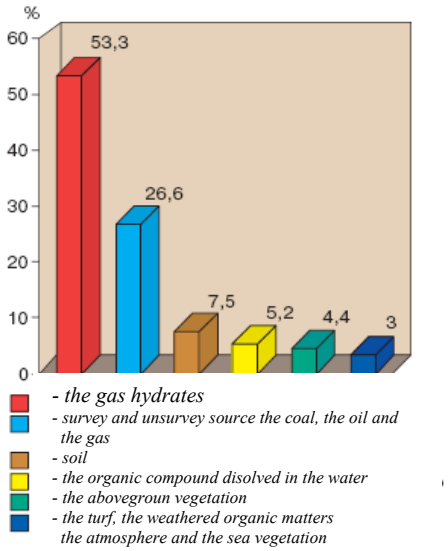

Fig. 1. Distribution of organic carbon on the Earth.

[1] *V. K. Chistyakov*, Sankt-Petersburg Mining Institute, Russia
[2] *Sun Youhong, Chen-Chen, Zhang Zupei*, College of Construction Engineering, Jilin University, China
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on the investigation and the development of resources of natural gas hydrates has been opened [9].

Gas hydrates form congestions only in the sedimentary thicknesses presented as breeds with a good rock permeability (sand, sandstones, fracturing and porous carbonic rocks, etc.), and low-permeability rocks (clay, silt, aleurolites, argillites). In high-permeability breeds, hydrates accumulate in rock pores, and in low-permeability breeds they form structures in which hydrate inclusions of various forms are divided by sites with zones which practically do not contain hydrates (Fig. 2).

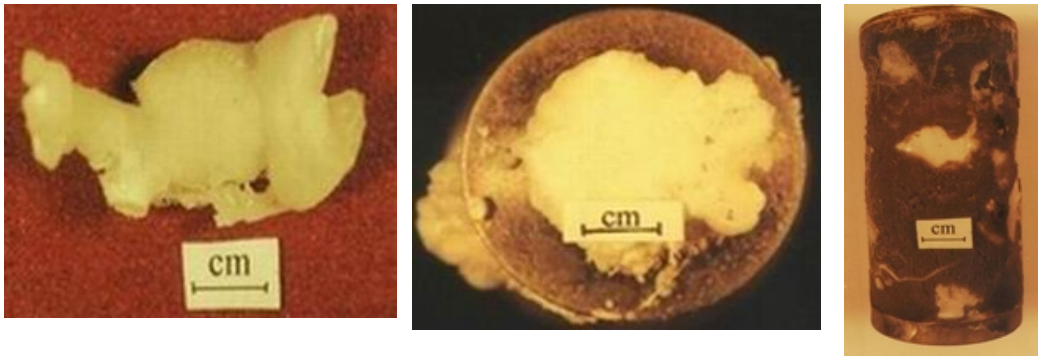

Fig. 2. A sample of natural hydrates from superficial «hydrates caps» (left and central) and a core from gas hydrates breeds with a mortar structure (right).

Fig. 3 shows a classification of gas hydrates deposits.

Despite of the appeal to use gas hydrates as a perspective and ecologically more pure fuel possessing huge resources, the investigation and development of their deposits can lead to a number of the negative consequences connected with hazards arising from difficulties of the maintenance of their technical and ecological safety of carrying out. Changes in the thermodynamic, geologic and the technical conditions in rocks and adjournment, and also in the technical systems (wells, pipelines, technological circulating systems and so forth) cause a formation of the so-called technogenic hydrates, or dissociated existing natural gas hydrates. Both in that, and in other cases, the character of arising complications is similar to with that occuring at prospecting and exploration works in the field of the distribution of permafrost [8]. However, the intensity and scales of display of these complications are much more serious.

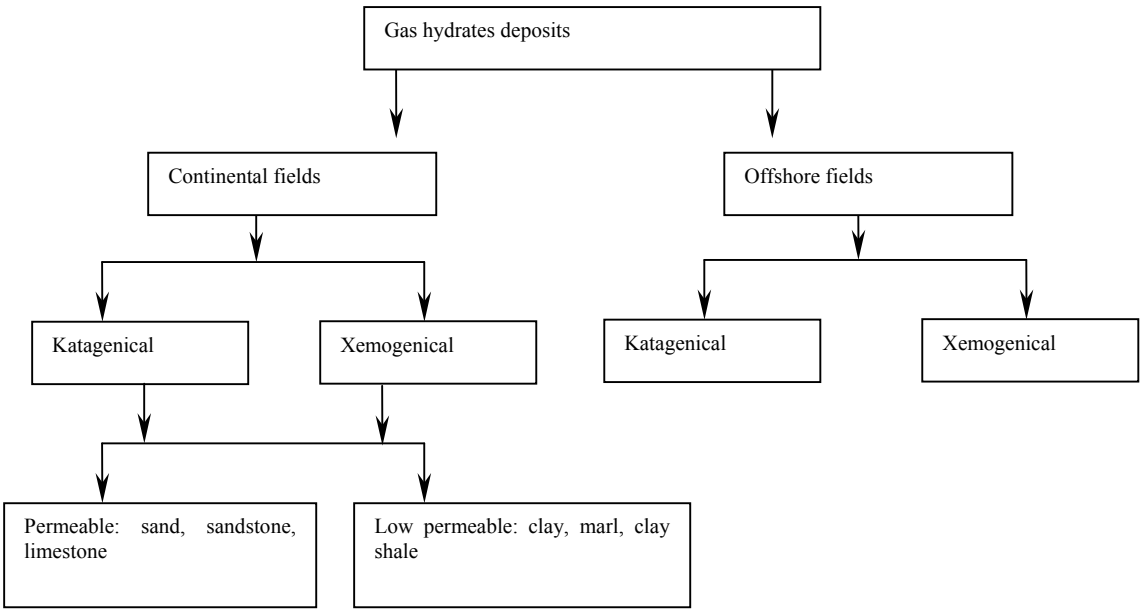

Fig. 3. Classification of gas hydrates deposits.

Scales of arising problems can change from local to regional and even global. There are three main hazards:

1. formation of technogenic hydrates;
2. dissociated gas hydrates – technical problems;
3. dissociated gas hydrates – ecological problems.

For the first, time the problem with technogenic gas hydrates at the drilling prospecting and operational wells, and also due to the preparation and transportation of oil and gas has arisen in Russia in 30th years of the last century when the basic amounts of works began to move steadily on the North. Formed in favorable conditions (at low temperatures) firm gas hydrate created an additional resistance to the movement of oil and gas, formed blocks in technological circulating systems, reduced permeability of borehole annulus zones in an interval of productive layers, interfered with carrying out of qualitative casing cementing, put out of action technological circulating systems and so forth.

When increasing the depth of drilling, especially in sea wells, a danger of formation of technogenic hydrate arises at the mixing of gas acting in a well with the aqueous medium of a water-base drilling mud or with the aqueous phase of oil-based or synthetic-based drilling muds. The most probable and dangerous complications are connected with throttle lines, kill lines and wellhead setup as these elements are located at places with lowest temperatures and quickly cooled at the termination of circulation. The output of these systems from the operation often leads to serious failures and even to the loss of the well.

The effective treatment technologies of field and factory natural gases are now developed for preventing the formation of technogenic hydrates, including those on the base of new, so-called "low dosing inhibitors" or LDH- inhibitor [7].

The drilling of prospecting and operational wells on the deposits of natural gas hydrates, as a rule, is accompanied with a raised gas ingress, connected with a fusion of hydrates (ice skeletons) and dissociated gas from the solid state in to gaseous. Even little changes of pressure and temperatures cause a fast phase transformation of the gas-cut water that further causes a sharp increase of the formation of pressure in the closed casing string-borehole annulus, and in the loose or freely moving environments – an intensive gas showing and even a gas bubble generation whose volume can exceed the initial volume of gas hydrates tens times. The typical complications are connected with the collapse of casing strings, the difficulty in carrying out a qualitative cementation, the intercasing and crossflow between the casing, formation of gas griffins, the setting casing, and so forth Their liquidation and prevention demands for additional expenses of means and time, and it is accompanied by a deterioration of conditions of technical and ecological safety of work.

The construction and operation of deep-water extracting platforms in the areas of distribution of underwater gas hydrates deposits, where there is a bias of a sea-bottom as well as, drilling oil and gas wells through gas hydrate-bearing deposits under a sea-bottom can cause thawing of hydrates and deformations of wells that raises a hazard of the failure of the platforms.

Nevertheless methane (being the basic component of natural gas hydrates) represents a danger to the Terrestrial atmosphere as one of the most effective, so-called greenhous, gases whose changes of concentration in the atmosphere can cause serious climatic problems. When the temperature of atmosphere increase by approximately 30 times CO_2, is more dangerous. There are hypotheses, which connect climatic changes in glacial ages with the decomposition and formation of gas hydrates [7, 10, 12].

The further perfection of exploration and production methods as to the use of gas hydrates deposits, besides more detailed studying their properties and laws of formation and destruction, substantially depends on an effective solution of the problem of ecological and technical safety of carrying out of these researches and development. In this direction, intensive researches in many countries of the world are conducted.

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