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GAS HYDRATES - SOURCE OF ENERGY OR GEOTECHNICAL HAZARDS?

Abstract:

Constantly growing demand for energy carriers, limitation and irretrievability of their now in use resources have forced to turn in the end of XX century the close attention on searches of the no conventional sources possessing both more significant potential resources, and an opportunity of their constant completion. Natural gas is a relatively clean-burning fuel, and it will continue to be an important part of the country's energy portfolio and is integral to expanded deployment of renewable energy resources. Over the long term, the development of new natural gas resources such as methane hydrate can play a major role in ensuring adequate future supplies of natural gas.

Introduction

Gas hydrates are solid crystalline compounds in which gas molecules **M** (referred to as guests) are lodged within the lattices of ice crystals (called hosts). Under suitable conditions (low temperature and high pressure), a gas **M** will react with water $\mathbf{H_2O}$ to form hydrates and under unsuitable conditions (high temperature, low pressure and the use of inhibitors) hydrates will dissociate to gas and water according to

$$\mathbf{M\ (g) + nH_2O\ (w) \leftrightarrow MnH_2O\ (h),}$$

where: **M** - a molecular weight low-molecular hydrophobic gas;
n - molecules of water $\mathbf{H_2O}$**:**
g, **w** and ***h*** - refer to gas, water and hydrate, respectively.

The compact nature of the hydrate structure (fig 1) makes for a highly effective packing of gas. A volume of gas hydrate expands between 150- and 180-fold when released in gaseous form at standard pressure and temperature (1 kPa, 20°C) [8].

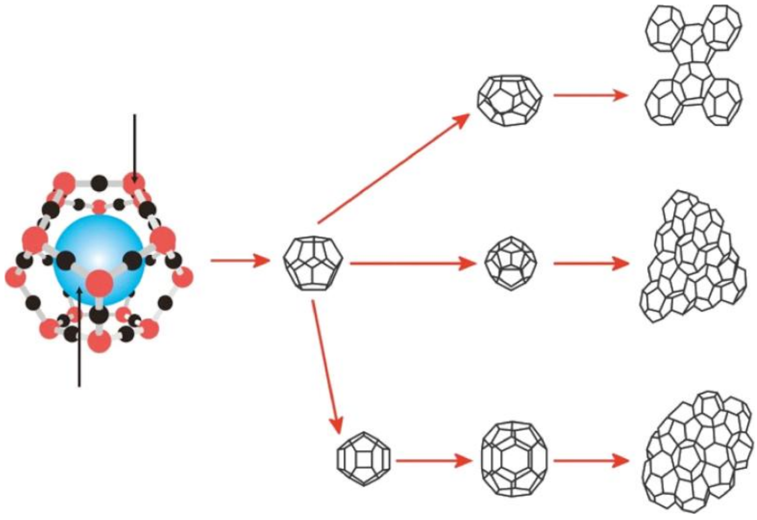

Fig. 1. Gas-hydrate crystal structures.

The five types of water cages that make up the gas-hydrate structures are the pentagonal dodecahedron (512), the tetrakaidecahedron (51262), the hexakaidecahedron (51264), the irregular dodecahedron (435663), and the icosahedrons (51268). The three structure types that have been observed for gas hydrates are also shown: structures I, II, and H. Representing guest gas molecules in each hydrate structure are also listed.

Natural gas-hydrates

Of particular interest are methane hydrates (**M** = $\mathbf{CH_4}$), which represent the majority of natural gas hydrates. Its opportunity concerns to the basic characteristics of hydrate at formation in a solid state 1 m^3 of natural methane hydrate contains up to 164 m^3 of gas and 0.87 m^3 of water with normal pressure/temperature conditions.

The priority in opening natural hydrates of hydrocarbon gases belongs to the Russian scientists: in 1946 Russian expert-oilman I.N. Strezhenov had made the assumption of natural gas-hydrates existence, and from the middle of 60-th years geological aspects of natural hydrates existing both on a land, and in water areas have already begun to develop widely. For the first time commercial gas hydrates field has been strike in 1964 in Russia on Messoyahsk pool in Western Siberia (Norilsk region) [5].

The first messages on an opportunity of existence of deposits natural gas hydrates in delta of the river Mackenzie (North-West territories, Canada) concern to 70-th years of the last century. The first large-scale researches accumulations of gas hydrates on a land and an adjoining shelf were spent to the USA in 1982 - 1991 under aegis of Department on Power [3]. Since 1995 in Great Britain, Germany, Canada, China, India, Russia, USA, South Korea, Japan and etc. financing scientific and technical programs on investigation and development of resources natural gas hydrates has been opened (fig. 2) [8].

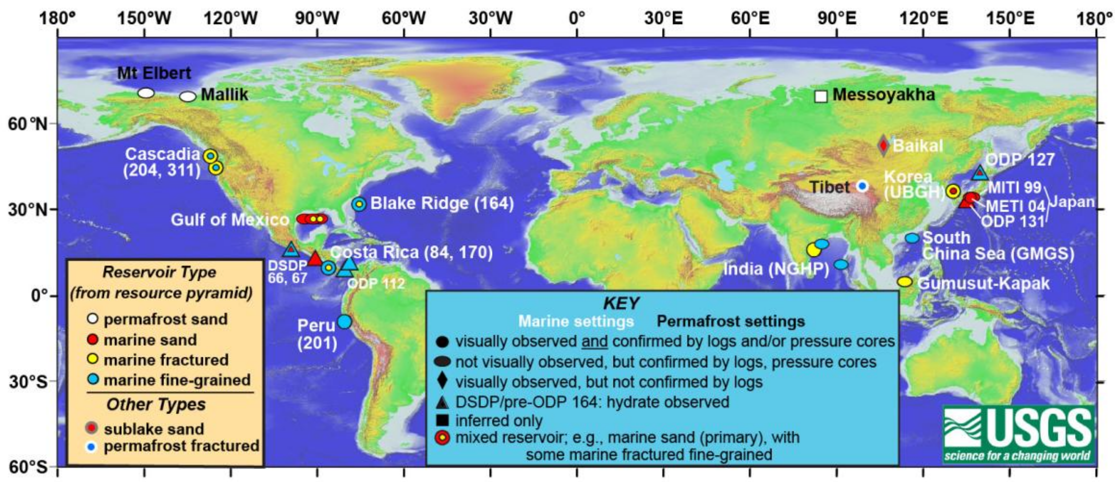

Fig. 2. Reservoir-based map of locations of gas hydrates found at subsea floor/subsurface depths greater than 50 m. Numbers in parentheses indicate DSDP/ODP/IODP expeditions. (Map courtesy of Timothy S. Collette, USGS)

Natural gas-hydrates occur in permafrost regions (including continental shelves), and in ocean-floor sediments under water depths of about 400 m. and in deep glacial ice in **Hydrate Stability Zone** (HSZ) - a surface-parallel zone of thermodynamic equilibrium. It extends from the sediment surface to a depth determined by temperature, pressure and local heat flow (fig. 3).

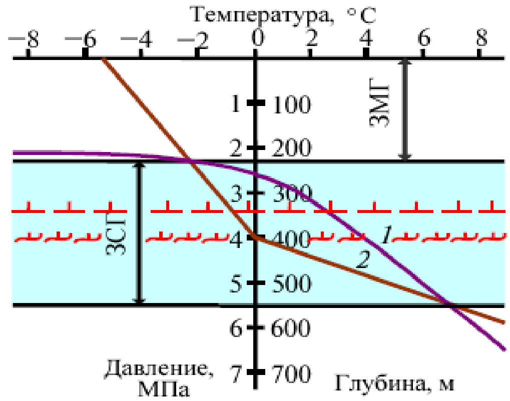

Fig. 3. Graf analytical method allocation of a zone of stability and zone of Metastability of gas Hydrates in continental conditions [8]: 1 – Hydrate Boundary Zone; 2 - temperature distribution; ЗСГ – Hydrate Stability Zone, HSZ; ЗМГ – Zone of Metastability Hydrate, ZMH ; ⊥ - bottom of permafrost; ~ - bottom of Criolitozone.

Gas hydrate resources

Globally, the amount of gas hydrate to be found offshore along Continental margins probably exceeds the Amount found onshore in permafrost regions according to available estimations makes from 2*1014 to 7,6*1018 m3 in normal condition [9]. With the exception of the assessments discussed above, none of the global gas hydrate estimates is well defined, and all are speculative to some extent. One way to depict the potential size and producibility of global gas hydrate resources is by using a resource Pyramid (fig. 4) [8].

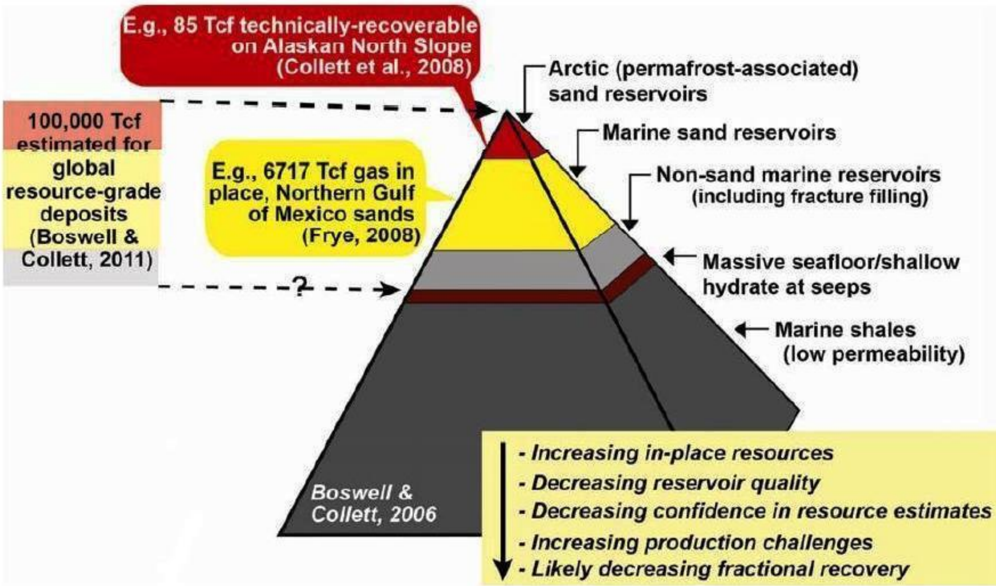

Fig. 4: Modified gas hydrate resource pyramid (Adapted from Boswell and Collett, 2006).

The apex of the pyramid shows the smallest but most promising gas hydrate reservoir — arctic and marine sandstones — which may host tens to hundreds of TCF. The bottom of the pyramid shows the largest but most technically challenging reservoir — continental shelf.

Hydrate Energy International (HEI), as part of the Global Energy Assessment being conducted by the International Institute for Applied Systems Analysis (IIASA), recently released the results (Fig. 5) of a new evaluation of gas hydrate resource potential utilizing a petroleum systems approach 43,311 tcf [7].

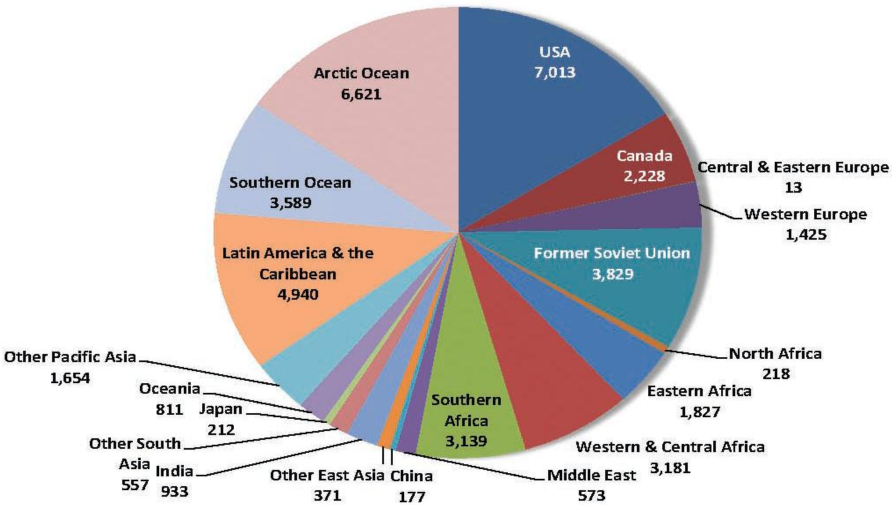

Fig. 5: Calculated gas in-place in hydrate-bearing sands (median, tcf) [7].

Gas Hydrate Hazards

Despite of appeal of use gas hydrates as the perspective and ecologically more pure fuel with possessing huge resources, investigation and development of their deposits can lead to a number of the negative consequences connected with hazards arising difficulties for maintenance of their technical and ecological safety of carrying out.
Change thermodynamic, geologic and technical conditions in rocks and adjournment, and also in technical systems (wells, pipelines, technological circulating systems and so forth) causes or formation of so-called technogenic hydrates, or dissociated existing natural gas hydrates. Both in that and in other cases character of arising complications is similar to with what collide at carrying out prospecting and exploration works in the field of distribution permafrost [1, 3, 5, 6, 10].

However intensity and scales of display of these complications incomparably became above. The complications most probable and dangerous here are connected with throttle lines, kill lines and wellhead setup as these elements are located in places with the lowest temperature and quickly cooled at the termination of circulation.

The output of these systems out of operation often leads to serious failures and even to loss of a well. Drilling of prospecting and operational wells on gas hydrates deposits, as a rule, is accompanied raised gas ingress, connected with fusion of hydrates (dissociated gas from solidify state in gaseous). The typical complications connected with it: collapse of casing strings, difficulty in carrying out of qualitative cementation, intercasing and crossflow between casing, formation of gas griffins, setting casing and so forth. Their liquidation and prevention demands additional expenses of means and time, is accompanied by deterioration of conditions of technical and ecological safety of work.
Evidence available suggests a link between hydrate instability and occurrence of landslides on the continental margin. A likely mechanism for initiation of landsliding involves a breakdown of hydrates at the base of the hydrate layer. The effect would be a change from a semi-cemented zone to one that is gas-charged and has little strength, thus facilitating sliding.

Besides the methane, being the basic component of natural gas hydrates represents danger to the Terrestrial atmosphere as one of the most effective, so-called, greenhouses gases which change of concentration in an atmosphere can cause serious climatic problems. This global warming might counteract cooling trends and thereby stabilize climatic fluctuation, or it could exacerbate climatic warming and thereby destabilize the climate. On the influence on rise in temperature of an atmosphere methane approximately in 30 times is more dangerous some CO_2. There are hypotheses which connect climatic changes in glacial ages with decomposition and formations hydrates [2, 6].
The Methane Hydrate Research and Development program mission is to advance the scientific understanding of naturally-occurring methane hydrate, such that its resource potential can be fully understood and realized. Specific goals are to confirm the scale, nature, and producibility of the resource, mainly through drilling and coring programs complemented by numerical simulation and laboratory experimentation. The program also aims to develop tools and knowledge needed to understand and control the impact of methane hydrate on seafloor stability and to develop a more robust understanding of the role methane hydrate plays in Geohazards and in global environmental processes.

Conclusions

The present level problems of interaction of the nature with the arising mining industry are very wide in their scope and a situation quickly worsens. The policy of use all new energy resources, in particular gas hydrates should be modified. The most important thing to be done is to take measures for environmental protection and use nature with care. These changes should involve deciding base economic, technological and ideological problems. Only then the situation with possible technogenic and natural accidents and hazards at development for new resources will seriously differ from present. In this direction intensive researches in many countries of the world are conducted.

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