Gas-emission craters puzzle - 4 years of investigations

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Gas-emission craters (GEC) were under study for 4 years since first reported in June 2014. We are presenting results obtained within the framework of the project funded by Russian Science Foundation №16-17-10203.

Various, often contradictory, ideas concerning the origin of GEC have been published recently, so there is a need to formulate the substantiation for our hypothesis, summarizing the facts presented in different publications of our team.

Some papers are hypothesizing the models of GEC formation by explosion of hydrolaccolith (bulgunnyakh or Pingo). The most consistent in defending this hypothesis are the researchers from Lomonosov Moscow State University (Khilimanuk et al., 2016; Buldovicz et al., 2018). Why do we not accept this hypothesis? First, saline marine sediments of Central Yamal provide poor conditions for the formation of large bulgunnyakhs due to a large amount of remaining unfrozen water. Second, even if cryogenic stress had occurred in the past, it is not clear how the warming may create conditions for the "explosion" of bulgunnyakh due to pressure in the water-gas core nowadays. Third, out of the 5 GEC, for which reliable field and remote-sensing materials were obtained, two GEC are located at the slope foot, two more in close proximity to the channels, and one more on the edge of the terrace. If close to the channels existence of sub-channel talik and its re-freezing can be assumed, in other cases such a talik is improbable.

Several known GEC formed in such different conditions that we should search for other mechanisms of their formation, which can be applied to all known craters. The mechanism we propose is based on the observed facts. One of these facts is high concentration of methane in the air of the crater at the first visit to GEC-1 and later detected in the water that filled all GECs. Second, isotopic analysis of methane from GEC showed its microbial origin. Observed is a decrease in the concentration of methane in the water of GEC lake with time. We conclude that the sources of methane are refreezing.

The essential object for understanding the nature of GEC is the mound-predecessor. It has been established by the dendrochronology that GEC-1 was

formed on the place of a mound, which started growing approximately since 1947. Analysis of the Corona images suggests that the mounds have grown at a high rate over the past decades, and could not be the result of freezing of a sublake talik.

We suggest that dissociation of gas hydrates and the release of gases from frozen ground and tabular ground ice follow an increase in their temperature. Plastic gas-tight existed in the form of a thick layer of tabular ground ice, and obvious traces of ice deformation were observed. We should assume the existence of a collector in which gas accumulated up to the critical pressure and explosion of the mound. Such a collector could be a cryopeg. Acceptance of cryopeg in the GEC section can explain the existence of a pronounced niche in the lower and middle part of the wall of GEC-1, which had no explanations before.

Search for ancient GEC ran across complications. Modern GECs were filled with water and sediment from the walls very fast. The inner lakes are now shallow (no more than 4 m the deepest), of irregular shape, no more than 80 m in diameter. With such limited dimensions and depth, we expect their re-freezing. Secondary deepening due to thermokarst processes and new opening of methane emission sources is unlikely. Therefore, deep modern lakes with detected funnel-shaped depressions cannot be considered descendants of ancient GEC.

The main question is prediction of the possible appearance of new GECs, since they pose significant risks for reindeer herders, gas pipelines and railways. We consider the search for “gas-inflated” mounds, positive landforms that formed on a variety of surface elements, but grew fast, as the main method of mapping GEC hazards.

Preliminary Results of a Study the Frost Mound in the North of Western Siberia

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The frost mound (hill) and gas emission crater (GEC) are located near infrastructure of gas fields. In theory and the according to the data of remote monitoring, in the area prior to crater formation the frost mound has grown up in the bottoms of drained lakes (locally called hasyrey) and outside of this area. The new hill sometimes arosed around future craters. This testifies to the ongoing active gasdynamics with possible repeated gas emissions. Today there is no consensus among causes of explosion and generating crater at the collapsed hill