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NATURAL AND TECHNOCENIC CATASTROPHIC BLOWOUTS AND GAS EXPLOSIONS IN THE ARCTIC AND OTHER REGIONS (ONSHORE AND OFFSHORE)

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Summary. The authors created the geoinformation system "The Arctic and World Ocean" (GIS "AWO") with a huge amount of constantly updated geospatial data, allowing a comprehensive analysis of various natural and man-made phenomenon directly or indirectly related to the degassing of the Earth. In the Arctic, a large amount of expeditionary work has been carried out with a wide range of geological and geophysical methods, which is analyzed in conjunction with remote sensing data from space and using unmanned aerial vehicles. This made it possible to obtain fundamentally new information about the gas-dynamic mechanisms of dangerous processes in the permafrost, including catastrophic gas blowouts and explosions with the formation of giant craters, and large mud volcanic structures. In total in the north of Western Siberia about 18.5 thousand potentially dangerous objects were identified, including 4.5 thousand intensive gas blowout zones on the bottoms of thermokarst lakes, as a result of which underwater craters-pockmarks are formed. This gave possibility to identify the most dangerous gas-explosive zones in the north of Western Siberia, mainly located in the eastern part of the Yamal peninsula. Taking into account previously discovered mud volcanoes on the land of Alaska, Greenland and Iceland, as well as on the bottom of the Beaufort, Kara and Norwegian seas, it can be argued that there is a Circum-Arctic mud volcanic province.

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Introduction

In recent decades due to the global warming attention has significantly increased to the study of various processes of greenhouse gas emissions into the atmosphere and changes in their concentration in the atmosphere (Jackson et al., 2020; Report..., 2022; State..., 2023). The concentration of greenhouse gases grow rapidly, which causes the intensification of greenhouse effect, melting of glaciers and rising of the World Ocean level up to 4.6 mm per year in last decade (State..., 2023).

Among the causes of natural and anthropogenic emissions of greenhouse gases, where methane is one of the most dangerous, deep and near-surface processes, only a part of which appears on the Earth surface, including the bottom of the World Ocean, as widespread seeps of underground fluids, mostly mixtures of hydrocarbon gases, are of particular importance (Hovland et al., 1984; Judd, Hovland, 2007; Bogoyavlensky, 2012; Etiope, 2015; Guliyev et al., 2018; Bogoyavlensky et al., 2020b; Kerimov, Abdullayeva, 2022). Over the half-century history of studying submarine gas emission from the bottom of various parts of the World Ocean, hundreds of papers have been published (Hovland et al., 1984; Judd, Hovland, 2007; Sergienko et al., 2012; Etiope, 2015; Paul et al., 2015; Andreassen et al., 2017; Guliyev et al., 2018; Mironyuk et al., 2019; Bogoyavlensky et al., 2021d; Bogoyavlensky et al., 2022a; Kerimov, Abdullayeva, 2022; Bogoyavlensky et al., 2022c; Kishankov et al., 2022; Bogoyavlensky, Kishankov, 2023; Sokolov et al., 2023).

Massive gas blowouts causing the formation of large and giant craters (tens or even hundreds of meters in diameter) are widely spread both onshore and offshore (Hovland et al., 1984; Judd, Hovland, 2007; Andreassen et al., 2017; Bogoyavlensky, 2020; Bogoyavlensky et al., 2020b; Bogoyavlensky, 2021; Bogoyavlensky et al., 2021a; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2022a).

Moreover some of the papers are dedicated to the study of active degassing from the bottoms of the Arctic thermokarst lakes with continuous or sporadic taliks (Kruglikov, Kuzin, 1973; Walter et al., 2006; Badu, 2018; Bogoyavlensky et al., 2018; Bogoyavlensky et al., 2020a; Bogoyavlensky, 2021; Bogo-
yalvensky et al., 2021c; Bogoyavlensky et al., 2021b). Many of these lakes have bubbles of frozen gas in their ice cover and numerous craters (pockmarks) on the bottom.

One of the most dangerous processes of the Earth degassing is the formation of mud volcanoes (MVs) (Kopf, 2002; Aliyev et al., 2015; Bogoyavlensky, Bogoyavlensky, 2022; Yusubov, Guliyev, 2022). The global research of Azerbaijani scientists (Aliyev et al., 2015) gives the information about 2505 MVs, the most of which (1401 or 55.9%) were discovered on the bottom of the World Ocean. The presence of MVs is one of the prospecting indicators for oil and gas, wherein they give significant information of sedimentary cover lithology. The gas erupted from MVs frequently explodes and self-ignites. The height of burning flares above MVs can reach hundreds of meters, the measured height is up to 500 m (Aliyev et al., 2015; Yusubov, Guliyev, 2022). In 1940 the height on the mud volcanic island Khare-Zirya (Bulla) was even 1200 m (Yusubov, Guliyev, 2022, p. 18).

In the Circum-Arctic region MVs were found onshore, in Alaska, Greenland and Iceland, and offshore, in the Beaufort, Kara, Norwegian and Barents seas (Haakon Mosby and Borealis) (Paull et al., 2015; Serov et al., 2015; Mironyuk et al., 2019; Bogoyavlensky, Bogoyavlensky, 2022).

Oil and Gas Research Institute of the Russian Academy of Sciences (OGRI RAS) studies the processes of the Earth degassing in their various geological and forms and appearances for more than 30 years, the results were reported on many conferences, including (Earth degassing ..., 2002). The studies of the authors are not limited geographically by the north latitudes of the Arctic regions with cryolithogenesis, but expand to other parts of the World related to different forms of natural and technogenic degassing, including mud volcanism, gas hydrate dissociation and behind-the-casing flows (Bogoyavlensky et al., 2018; Bogoyavlensky, 2020; Bogoyavlensky et al., 2020a; Bogoyavlensky et al., 2020b; Bogoyavlensky, 2021; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c; Bogoyavlensky, Bogoyavlensky, 2022; Bogoyavlensky et al., 2022; Bogoyavlensky et al., 2022a; Bogoyavlensky et al., 2022b).

The main goal of this work is to comprehensively analyze the insufficiently studied dangerous endogenous processes of generation, accumulation and migration of gaseous hydrocarbons up to their discharges on the Earth surface and the bottom of the World Ocean in the form of permanent, pulsating and/or periodic powerful impulse (explosive) degassing of the subsoil, often leading to catastrophic changes in terrain, including the formation of giant craters and landslides.

**Methods**

Over the past decade, the authors have annually carried out expeditionary work in the Arctic to study a new dangerous phenomenon associated with the processes of powerful emissions, self-ignition and explosions of gas on land, as well as from the bottoms of thermokarst lakes, rivers and coastal zones of the Kara Sea (Bogoyavlensky et al., 2018; Bogoyavlensky, 2020; Bogoyavlensky et al., 2020a; Bogoyavlensky et al., 2020b; Bogoyavlensky, 2021; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c; Bogoyavlensky et al., 2021d; Bogoyavlensky, Bogoyavlensky, 2022; Bogoyavlensky et al., 2022a). Also expeditions have been carried out in the Azov and Black seas, Tatarstan, Tula, Nizhniy Novgorod and Saratov regions. Field studies in the Arctic involves a wide set of geological and geophysical methods including seismic prospecting (2D-4D), ground penetrating radar studies, echo sounding, shallow drilling, gas, water and ground sampling for geochemical analysis.

In all of the studied regions the unmanned aerial vehicles (UAV) are used with great efficiency. They give possibility to receive fundamentally new data on unique objects. The photogrammetric processing of data from UAV Mavic Pro and Mavic Mini (DJI, China) in Agisoft Metashape («Geoscan», Russia) and ArcGIS (ESRI, USA) software allows building 3D-4D models of the investigated objects available for additional study in virtual reality (Bogoyavlensky, 2021; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c). The scaled layouts of digital models using additive technology are also made on a 3D printer.

Particular information is Earth remote sensing (RS) data from space, which in many cases provide an opportunity for a retrospective analysis of the features of potentially dangerous objects formation, as well as catastrophic events that have occurred since the first large-scale satellite imagery started in the early 1960s. The ArcticDEM digital elevation models are widely used allowing monitoring the changes of terrain, especially in places of catastrophic gas blowouts and explosions (Bogoyavlensky, 2021; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c).

In the study of methane concentration in the atmosphere we use the TROPOMI spectrometer data from Sentinel-5P satellite of the European Space Agency Copernicus program, held for the “Global monitoring for Environment and Security of Earth and its atmosphere” (GMES) (Bogoyavlensky et al., 2020b; Bogoyavlensky et al., 2022b).

The Arctic and World Ocean (AWO) GIS was created based on ArcGIS software in 2008 (Bogoyavlensky et al., 2018; Bogoyavlensky, 2020; Bogoyavlensky et al., 2020c; Bogoyavlensky et al., 2021a; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c; Bogoyavlensky et al., 2021d; Bogoyavlensky, Bogoyavlensky, 2022; Bogoyavlensky et al., 2022a; Bogoyavlensky et al., 2022b).
The geospatial data including the authors' and other scientists' information is uploading in it to form continuously developing and systematized data arrays (Big Data), available for complex analysis. In particular, the “AWO” GIS contains data on natural hazards like earthquakes, stratovolcanoes, MVs, meteorite craters, craters of gas blowouts, oil and gas seeps, gas hydrates, pingos and perennial heaving mounds (PHMs), thermokarst lakes with gas blowouts craters (TLGBCs) on the bottoms, sea ice, catastrophes while drilling and transportation of oil and gas, and others (Fig. 1). An integrated approach to the study of various geospatial data makes it possible to reveal hidden trigger relationships that have direct or indirect impact on the degassing of the Earth and other processes.

Fig. 1. The cartographic scheme of oil and gas shows onshore and offshore Arctic region (version-23, 2023). Legend: 1– MVs; 2 – stratovolcanoes; 3 – gas hydrates (proven); 4 – gas hydrates based on log data; 5 – gas hydrates based on BSR; 6 – gas seeps; 7 – oil seeps
Results and discussion

1. Explosive degassing in the Arctic

Since 2014 the authors study regions and objects of massive (explosive) gas blowouts with formation of craters. In “AWO” GIS there are about 20 of them analyzed in different degrees of detail (Fig. 2). Some of them (C1, C2, C9, C17 and others, as mentioned in “AWO” GIS) formed near the infrastructure of the Bovanenkovo oil and gas condensate field on the Yamal Peninsula. In all three eyewitness cases (C3, C11 and C12) there was self-ignition and explosion of gas (Bogoyavlensky et al., 2018; Bogoyavlensky, 2020; Bogoyavlensky et al., 2020a; Bogoyavlensky et al., 2020b; Bogoyavlensky, 2021; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c; Bogoyavlensky, Bogoyavlensky, 2022; Bogoyavlensky et al., 2022b). In our opinion, confirmed by a number of facts, these self-ignition and explosion have happened due to electrostatic discharges (Bogoyavlensky, 2020; Bogoyavlensky, 2021). We think that these processes are the main triggers of gas self-ignition during the MVs eruptions in the Azov and Black seas region and in other places (Bogoyavlensky, Bogoyavlensky, 2022).

The results of the Bovanenkovo C17 object studies, on which in May-June 2020 a powerful gas blowout occurred with the formation of a giant crater are Of particular interest (see Fig. 2 - C). As a result of photogrammetric processing of pictures taken during the expedition from the DJI Mavic Pro UAV at two height levels (including the photos from inside the crater), a digital 3D model was built in Agisoft Metashape software. Based on this model, a high-precision 3D plastic model on a scale of 1:800 was created using additive technology on a 3D printer (Fig. 3). The use of new technologies of “Industry 4.0” made it possible for the first time to create a high-precision digital twin of the underground cavity and gas blowout crater of the unique Bovanenkovo C17 object, which allows surveying the underground space in virtual reality.

As a result of the gas blowout and explosion study authors have no doubts that explosions in the Arctic were preceded by the formation of giant gas-saturated cavities in the ground ice (real thermokarst), the upper parts of which, under the action of a gas-dynamic mechanism, formed PHMs on the Earth surface (Bogoyavlensky, 2020; Bogoyavlensky, 2021). At abnormal gas pressures in the cavities, which significantly exceed the lithostatic pressure and the elastic-strength characteristics of frozen rocks, explosive destruction of the tops of the PHMs occurs with the formation of giant craters. In particular, during the formation of the C1 crater the pressure of gas exceeds the lithostatic more than 9 times (assuming the density of frozen rocks in the upper part of the section as 1.7 g/cm³) (Bogoyavlensky, Garagash, 2015; Bogoyavlensky, 2020; Bogoyavlensky, 2021).

![Fig. 2. Giant cavities in ground ice after the blowouts and explosions of gas on the Yamal Peninsula. A - C1, B - C12, C - C17 (photos by V.I.Bogoyavlensky, 2014, 2015 and 2020)](image)

![Fig. 3. Physical 3D-model of the underground cavity and gas blowout crater on the Bovanenkovo C17 object](image)
With the use of RS data, including winter satellite images and ArcticDEM, more than 14000 PHMs were detected in the north of Western Siberia. In a comprehensive analysis of the detected objects of powerful gas blowouts, it was found that the greatest danger is presented by PHMs, located not in khasyreys, like classic frost mounds - bulgunyakhs (closed systems), but by PHMs with an open inflow of underground gas-saturated fluids (gas in free and/or dissolved states), usually located on the hills and slopes of sea terraces, as well as in the channels and floodplains of rivers (Bogoyavlensky, 2020; Bogoyavlensky, 2021). Such PHMs are formed by the gas-dynamic mechanism.

2. Degassing from the bottoms of thermokarst lakes

More than half a century ago, in the north of Western Siberia, near the Urengoy oil and gas condensate field, thermokarst lakes with gas blowout craters (TLGBC) at the bottoms were discovered for the first time, while geochemical studies of methane in them showed its deep genesis (Kruglikov, Kuzin, 1973). The authors continued the search and study of TLGBCs in the last decade using RS data from space and during numerous helicopter flights over the Yamal Peninsula (Bogoyavlensky et al., 2020a; Bogoyavlensky et al., 2020b; Bogoyavlensky et al., 2021b; Bogoyavlensky et al., 2021c; Bogoyavlensky et al., 2022b).

Figure 4-A shows the WorldView-2 satellite image (July 20, 2022, ultra-high resolution 30-50 cm) of the previously unnamed TLGBC discovered in the central part of Yamal 60 m north of Lake Tobato and named by us Tobato-Severnoye (70.697° N, 71.0234° E). This lake has dimensions of 320x500 m, and the diameters of the largest craters at its bottom reach 19 m (not counting the sizes of the merged craters). Such objects have also been found on a number of neighboring lakes, including Tobato. It should be noted that the number of pockmark craters at the bottom of some of the lakes is many hundreds, and possibly even thousands. The visible by the resolution of WorldView-2 satellite image number of craters on the bottom of Tobato-Severnoye lake (Fig. 4-A) is about 350.

It should be noted that at the bottoms of the TLGBCs, small accumulative uplifts (parapets) are observed around the recently formed craters, which are made of bottom sediments ejected by gas (for example, see Fig. 4-A). Different-temporal satellite images show that over the course of several years, loose accumulative deposits of parapets are washed out and slide inward, while the diameters of the craters increase, and the depths decrease.

As a result of the studies in the north of Western Siberia (the Yamal, Gydansky and Tazovsky peninsulas), according to RS data from space, more than 4.4 thousands of degassing zones from TLGBCs, as well as rivers and coastal zones of the Kara Sea, were discovered and shown on Fig. 4-B. Based on a comprehensive analysis of the TROPOMI spectrometer data (Sentinel-5P satellite), an unambiguous regional relationship between the identified degassing zones and areas of increased methane concentration in the atmosphere was established (Bogoyavlensky et al., 2020b).

Fig. 4. WorldView-2 satellite image of the Tobato-Severnoye lake with gas blowout craters on the bottom (A) and cartographic scheme of TLGBC distribution in the north of Western Siberia (B)
3. Mud volcanism

On a number of discovered objects of intensive degassing on the Yamal Peninsula, the authors substantiate the mud volcanic mechanism of eruptions. According to GOST R 57123-2016 (GOST…, 2016), an MV is “a geological formation that constantly or periodically erupts mud and gases”, usually confined to faults.

Periodical eruptions of underground fluids were detected and explored on TLGBC Otkrytiye (Fig. 5-A) with size of 440x750 m, situated in the central part of the Yamal Peninsula (70.006° N, 72.01° E). In 2019 there was a powerful gas blowout (pneumatic explosion) on a crater C (see Fig. 5-A), which broke the ice of 1.5 m thickness and spread the ice boulders on more than 50 m distance (Bogoyavlensky et al., 2020a). The analysis of satellite images from Sentinel-2 and Landsat-8 during the melting of ice (May-June) proved that the blowouts had occurred from the same crater C during winters of 2016-2019. But in 2020-2023 there were no witnesses of significant gas blowouts.

According to RS data and on the basis of expeditionary work at the TLGBC Otkrytiye, four neighboring large craters (diameter from 30 to 40 m) were found, located along the predicted deep submeridional fault (azimuth 345°), as well as several craters of smaller diameter up to 4-6 m (Fig.5-B). Conducting expeditionary studies using echo sounding and ground penetrating radar made it possible to detect landslide bodies on the walls of the craters and the bottom of the lake, formed by presumably loamy rock erupted from vents. In connection with the foregoing, four underwater objects with large craters on Lake Otkrytiye can be classified as MVs with a high probability according to GOST R 57123-2016 (GOST…, 2016).

RS data also showed several thermokarst lakes on Yamal, at the bottom of which, with clear water, cone-shaped volcano-like uplifts are observed (Bogoyavlensky, 2023). Fig. 6-A shows the WorldView-2 summer satellite image, from 13th of July, 2018 with ultra-high spatial resolution, of a large (1.6x2.1 km) thermokarst lake Labvarto, located in the central part of the Yamal Peninsula (69.985° N, 71.9356° E), situated in 3.7 km to the south-west from Lake Otkrytiye., Three zones of pockmark existence (P1, P2 and P3) and two objects (V1 and V2), which we identified as mud volcanic structures, were found at its bottom. This is confirmed by their specific conical shape and the presence of rounded/elliptical calderas with vents, which are especially visible on the V1 volcano, together with the sinter forms on its surface (see Fig. 6-B1).

Taking into account the fact that the thickness of lake ice can reach 1.5-2.0 m in these latitudes, we believe that the depth of the top of the V1 volcano is not less than these values. The top of the V1 object has dimensions of 75x80 m, and its visible base is 150x185 m. Due to new eruptions of mud breccia, the top of the volcano can rise above the water level, but its formation is limited by erosion and annual shearing by melting ice moving downwind.

According to RS data in 1985-2022 (Landsat and Sentinel) direct signs of winter gas eruptions from V1 and V2 tops were found in the form of annual early (May-June) thaws in ice above them, as well as trails of distribution of gas jets and/or reservoir fluids with dissolved gas in the water during the summer ice-free period (Fig. 6-B2).
4. Technogenic eruptions of hydrocarbon mixtures

The authors analyzed the consequences of catastrophic blowouts (fountains) of mixtures of gas and oil with the formation of giant craters near the heads of emergency exploration wells drilled in the Arctic, in the southern regions of Russia and in the Caspian region, as well as in a number of oil and gas producing countries of the world (USA, Mexico, Canada, Indonesia, etc.) (Bogoyavlensky et al., 2017a; Bogoyavlensky, Bogoyavlensky, 2019). Thus, important information was obtained on the basis of RS data from space. Despite the liquidation of the fountains many decades ago, it has been proven that active emission of hydrocarbons continues at the present time at some of the studied objects.

As one of the examples, let us cite one of the biggest disasters in the Arctic happened on November, 1980 during the postcompletional flow test of the Kumzhinskaya-9 well located near the mouth of the Pechora River, on the left bank of the Maliy Gusinets channel in the north of the Kumzhinskoye gas condensate field, discovered in 1973 (Bogoyavlensky et al., 2017b). Due to the technogenic pool, formed in the upper part of the section with the area of around 30 km² (gas blowouts were detected in the 3 km radius), the gas escaped in the atmosphere in a number of points, including wells 9, 5, 10 and 134. It led to the formation of 3 giant craters from 70 to 130 m in diameter near the heads of destructed wells, flooded by river water, on the emergency site with the size of 260x600 m (Fig. 7A). The hard fight with catastrophic gushing continued for about 6.5 years (2362 days). The fire on the gushing fountain was put out only on the 18th of May in 1987. The lake, closed with the dams, was created on the emergency site in the channel of the Pechora River (Bogoyavlensky, 2020; Bogoyavlensky et al., 2017b).

On the WorldView-2 satellite image (taken from ESRI database) the pronounced thaws and holes in the ice are seen, polluted with liquid hydrocarbons even 36 years after the catastrophe (Fig. 7-B). Such ice cover breaches are visible every year from 2016 to 2023 on the different satellite images, including Sentinel-2 and Landsat-8. In 2023 the emission of HCs was seen on images from Sentinel-2 on May 3, 17, 20, 22, 23 and 25 (the traces of fluids were detected also on of March 18 and 24).

Conclusion

The authors performed a large amount of expeditionary work with a wide range of geological and geophysical methods in the Arctic, which, together with RS data from space, made it possible to obtain fundamentally new information about the gas-dynamic mechanisms of dangerous processes in the permafrost, including catastrophic gas blowouts and explosions with the formation of giant craters. There is no doubt that the studied craters were formed at the sites of existence of underground gas-saturated cavities (thermokarst) formed under the action of endogenous mechanisms, and the explosions occurred due to a gas-dynamic mechanism with superlithostatic gas pressure in the cavity.

There is a widely spread Earth degassing happening in the Western Siberia. About 4.5 thousand of intensive gas blowout zones were detected from the bottoms of thermokarst lakes. On the basis of statistical data on the distribution of perennial heaving mounds and thermokarst lakes with gas blowouts craters the most dangerous areas were identified in the north of the Western Siberia.

On Yamal at the bottoms of thermokarst lakes with through and/or non-through taliks, a number of mud volcanic degassing objects, including large mud volcanic structures were discovered for the first time. Taking into account a number of previously discovered MVs onshore Alaska, Greenland and Iceland, as well as on the bottom of the Beaufort, Kara and Norwegian seas, it can be argued that there is a Circum-Arctic mud volcanic province.
Fig. 7. Kumzhinskoye field disaster: 3D digital elevation model of technogenic lake bottom with craters and surrounding land (A) and WorldView-2 satellite image from the 2nd of May 2016 (B)

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ПРИРОДНЫЕ И ТЕХНОГЕННЫЕ КАТАСТРОФИЧЕСКИЕ ВЫБРОСЫ И ВЗРЫВЫ ГАЗА В АРКТИКЕ И ДРУГИХ РЕГИОНАХ МИРА (СУША И АКВАТОРИЯ)

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Резюме. Авторы статьи создали геоинформационную систему «Арктика и Мир овой океан» с огромным объемом постоянно дополняемых геопространственных данных, позволяющих проводить комплексный анализ различий природных и техногенных явлений, прямо или косвенно связанных с деагазацией Земли. В Арктике выполнен большой объем экспедиционных работ с широким комплексом геолого-геофизических методов, которые проанализированы в комплексе с данными дистанционного зондирования Земли (ДЗЗ) из космоса и с применением беспилотных летательных аппаратов. Это позволило получить принципиальную новую информацию о газодинамических механизмах опасных процессов в криолитозоне, включая катастрофические выбросы и взрывы газа с образованием гигантских кратеров и крупных грязевулканических построек. Всего на севере Западной Сибири выявлено около 18.5 тысяч потенциально опасных объектов, включая катастрофические выбросы и взрывы газа со дна термокрассовых озер, в результате которых образуются подводные кратеры-столбы. Это позволило выделить наиболее газовзрывоопасные зоны интенсивных выбросов газа с образованием гигантских кратеров и крупных грязевулканических построек. Всего на севере Западной Сибири выявлено около 18.5 тысяч потенциально опасных объектов, включая катастрофические выбросы и взрывы газа со дна термокрассовых озер, в результате которых образуются подводные кратеры-столбы.

Ключевые слова: деагазация земли, выбросы и взрывы газа, грязевые вулканы, сизы газы, дистанционное зондирование Земли, беспилотные летательные аппараты

АРКТИКАДА ВЪ ДУНЯНИН ДИГОР REGIONLARINDA (QURU ВЪ AKVATORIYALARDA) ТӘБИИ ВЪ ТЕХНОГЕН ALMATILAR ВЪ QAZ PARTLASYILAR

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Çarş sildir: York demqasyasyn, qaz atlama və partlasyqlar, pilotsuz vulkanlar, qaz ağışı, Yerin distansion zondlaşdırılması (YDZ), pilotsuz uçur aparaları (PUA)

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