IMPLEMENTATION OF AEROSPACE MONITORING TO IDENTIFY ECOLOGICALLY HAZARDOUS AREAS OF METHANE LEAK FROM THE SEA BED

Assoc. Prof. Dr. **Sergii Goshovskyi** (The state institution "Scientific Hydro-physical Center of the NAS of Ukraine")
PhD, Senior Researcher. **Oleksii Zurian** (Institute of Renewable Energy of The National Academy of Sciences of Ukraine)

ANNOTATION

Offshore hydrocarbon prospecting and exploration require substantial investment. It is impossible to solve this problem qualitatively using traditional seismic methods with insufficient financial resources.. The aim of work is to develop new methodological approaches in the use of Earth remote sensing technologies to identify ecologically hazardous areas for methane gas to the sea surface.

This direction has a technical focus, which requires a solution a many number of tasks, in particular, the identification small volumes of hydrocarbons emissions on the sea surface by subtracting regular interference.

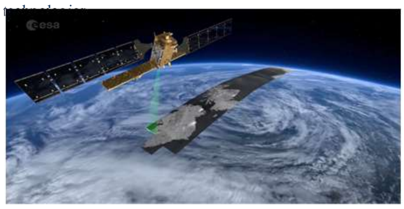
The authors applied the Copernicus system to solve the problem of detecting gas emissions from the seabed. The main features of the system are: automated archiving process, preview viewing images via the Internet, etc.

On the basis of the studies, a high level of hydrodynamic activity has been established, which prevents the detection of anomalies associated with methane emissions. It is found that satellite imageries are more informative from August to October. It has also proven that to establish the validity of the detected seeps, it is important to use the recurrence of associated anomalies in the imagery of other satellites.

INTRODUCTION

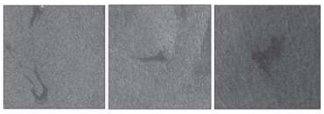
In the joint work carried out by scientists from the leading institutes of the Academy of Sciences of Ukraine, a methodology has been developed that determines the mechanism for identifying zones of formation, migration and seepage of hydrate gas, gas from seeps and mud volcanoes to the surface. It is scientifically substantiated that the Black Sea has significant potential unconventional methane gas deposits.

The search and exploration of offshore hydrocarbon deposits (especially in the sea) require significant investments. It is impossible to quickly solve this problem using traditional seismic methods with the available financial resources. In this regard, it becomes necessary to apply new, innovative approaches to identifying hydrocarbon deposits in sea areas, an important place among which is occupied by aerospace methods and technologies.

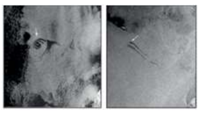


METHOD AND/OR THEORY

As the results of oil and gas exploration work on the North-West shelf of the Black Sea show, there are favorable conditions for the generation and formation of gas fields. Existing deep faults and associated fracture systems can be channels for gas leakage from existing fields. Methane migrating from individual deposits and large deposits reaches the bottom of the sea and penetrates into the sea mass. Bubbles of methane from the bottom of the sea float to the sea surface and lead to various anomalies on the sea surface. These anomalies can be detected using specially developed satellite remote sensing technologies.



Oil spills at the water surface



Gas venting at the water surface. Bondur V.G., Kuznetsova T.V. (2015)

RESULTS

Researches of gas seeps in the Black Sea have been carried out by scientists of the National Academy of Sciences of Ukraine for many years. The Black Sea is an unusual pool. It is characterized by increased gas recovery of the seabed. Ancient Roman authors wrote about the release of gases off the Bulgarian coast. The gas recovery of the Black Sea bottom is much higher than in other seas.

The continental slope of the northwestern part of the Black Sea is characterized by a wide distribution of jet methane gas emissions. Here it was possible to establish certain patterns in the distribution of methane seeps and to identify the bottom areas characterized by the greatest fluid and gas dynamics. In particular, the key role of faults as gas delivery channels has been established [Shnyukov and Kutniy, 2003]. Almost the overwhelming majority of gas outlets are located in a 45 km wide strip on both sides of the shelf edge, which spatially corresponds to the Tsirkum Black Sea fault zone, along which there was a significant displacement of the basement and the Moho section, a sharp change in the thickness, structure of the earth's crust and the location of deep-sea sediments [Kobolev, 2017].

The results of experimental observations [Shnyukov et al, 1999] convincingly indicate the relationship of gas seeps with tectonic disturbances of the upper layers of sedimentary deposits. The elucidation of the nature of hydrocarbons and the origin of gas seeps largely depend on the depth to which the faults penetrate.

Comparison of zones of active gas evolution with the location of tectonic structures of the northwestern shelf showed the confinement of gas flares to the space between the Odessa and West Crimean fault zones [Shnyukov et al, 2005]. The information obtained in the course of the research convincingly testifies to the confinement of gas emissions to regional and currently active faults. Sometimes they are located between faults, this is due to echeloned disturbances, especially along the continental slope, as well as secondary disturbances in sediment continuity, canyons and landslides.

On the northwestern shelf of the Black Sea, many oil and gas structures are located close to the fields of intense gas flares. The same relationship is observed with hydrocarbon deposits in other water areas of the world. Of greatest interest is the Kalamitskaya structure, as it is located near the Paleo-Dnepr channel, the Paleo-Dnepr underwater canyon associated with tectonic dislocation, and the largest accumulation of gas seeps (Figure 1).

Figure 1. Comparison of main reservoirs of oil and gas deposit structures with areas of gas seeps (according to S.V. Goshovskyi)

The need to study the peculiarities of the occurrence of natural oil and gas manifestations on the sea surface - seeps (from the English Seep - seepage) - touches upon four most urgent scientific and practical problems [Bondur and Kuznetsova, 2015:

1. Questions of search for various types of hydrocarbon raw materials. Since seeps are the end points of oil and gas migration routes, their detection on the surface is highly likely to confirm the presence of hydrocarbons.

2. The widespread occurrence of submarine volcanoes and gas hydrates in the bottom sediments of the seas and oceans, in addition to the positive possibility of an increase in hydrocarbon reserves, creates a major serious problem for the industrial development of the shelf and the exploitation of fields.

3. Gas seeps are sources of natural pollution of water areas, which must be known and taken into account in private and general assessments of the ecological state of the seas.

4. The problem of the influence of methane emission from gas hydrates on climate change. Gas hydrates are at the boundary of phase stability, changes in temperature or pressure can lead to their destruction with the release of a significant amount of methane, which will contribute to the development of the "greenhouse effect" and, accordingly, to a change in the planet's climate.

The authors used the Copernicus system to solve the problem of detecting gas emissions from the seabed. It has a service-oriented satellite imagery infrastructure, including data archive processing procedures and makes them available to end users (Figure 2). The main features of the system are: automated archiving process, preview of images via the Internet, etc.

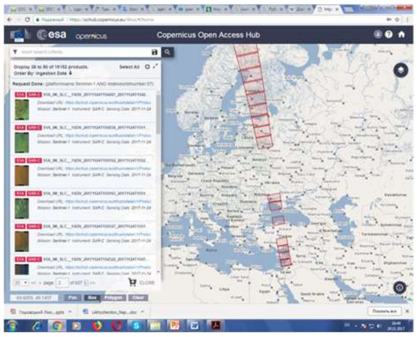


Figure 2. Access to the resource of the ESA family of Earth remote sensing satellites, created within the framework of the Copernicus global environmental and safety monitoring project

Based on the studies already carried out, it can be concluded that the task of identifying small-volume methane emissions from the seabed is very difficult. In particular, a high level of hydrodynamic activity has been established, which interferes with the identification of anomalies associated with methane emissions. It was found that satellite imagery materials in August-October of the year have a higher information content for detecting vultures. It has been proven that in order to establish the reliability of the identified seeps, it is important to use the frequency of associated anomalies on the materials of other satellites. To determine the optimal search parameters for seeps, it is necessary to compare images obtained in different spectral ranges and their combinations, with different dynamic characteristics of interference. So, to analyze the nature of seeps, it is possible to use images of the Sentinel 1 radar satellite. Figure 3 shows an example of anomalies that may be associated with manifestations of

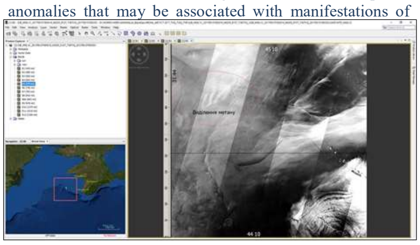


Figure 3. An example of anomalies that can be associated with the manifestations of methane emissions on the continental slope of the North-Western part of the Black Sea. (Registered on channel B9 (450 nm).

CONCLUSIONS

The most promising for the search for hydrocarbons in marine conditions are three types of satellite imagery. Multispectral imaging makes it possible to identify areas of anomalous hydrocarbon leakage, while infrared imaging provides fixation of increased heat fluxes caused by fluid-thermodynamic processes in the geological environment, and radar space systems have an advantage over others due to the provision of all-weather research and the ability to assess the dynamic state of aquatic gas fields.

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