Results of a survey within gas seeps area on Brazilian offshore using frequency-resonance methods of satellite images and photo images processing

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SUMMARY

The paper presents the results of survey within area of gas seeps location on Brazilian offshore. Experimental studies using direct-prospecting technology of satellite and photo images frequency-resonance processing were carried out to study the features of deep structure at site of seeps location. The results of instrumental measurements indicate that the survey area on offshore is located above a sedimentary rocks volcano, within which the synthesis of oil, condensate and gas is carried out at the border of 57 km. In the contours of such volcanoes, there are deep channels through which oil, condensate and gas migrate to upper horizons of cross-section and can replenish the already formed hydrocarbon deposits. In the absence of reliable seals over such channels, oil, condensate and gas migrate into water column, and gas further into atmosphere. During this migration, gas seeps are formed on the seabed and oil slicks on water surface. Additional evidence has been obtained in favor of oil, condensate and gas abiogenic genesis. Numerous facts of fixing signals from oil, condensate and gas at the boundary of their synthesis 57 km on Brazilian offshore and in other regions of world indicate of abiogenic methane migration into Earth's atmosphere in colossal volumes!

Introduction. In August 2020, information appeared about the discovery of a large gas field in the Turkish economic zone of the Black Sea (block Tuna-1) *(Turkey…, n.d.)*. Reconnaissance studies using direct- prospecting methods within this area recorded very intense responses at the frequencies of oil, condensate and gas, and it was also established that gas migrates through the water column into the atmosphere.
In the article *(Palabiyik et al., 2020)*, local areas for drilling wells in the Turkish sector of the sea are proposed. The proposed SK-6 well is located northeast of the Tuna-1 block. The results of the survey of the local site of the location of this well made it possible to draw a conclusion about the migration of gas with phosphorus from the sediments of the cross-section through the water column into the air (atmosphere).
In this regard, it became necessary to promptly survey the areas of known gas seeps in the different region. This report presents the results of using direct-prospecting methods to survey the area of gas seeps on the Brazilian offshore *(Researchers…, n.d.; Ketzer et al., 2020)*.

Research methods. Experimental studies were carried out in order to demonstrate the efficiency and effectiveness of a low-cost direct-prospecting technology of the integrated assessment of the prospects for oil and gas potential of large exploration blocks and local areas. Mobile technology includes methods of frequency-resonance processing of satellite images and photo images, as well as vertical sounding (scanning) of the cross-section in order to determine the depth and thickness of productive horizons and cross-section rocks. The features of the methods used, as well as the results of their testing and practical application, are described in articles and conference proceedings, including in *(Yakymchuk et al., 2019; Yakymchuk and Korchagin, 2019; 2020)*.

Site of gas seeps on Brazil offshore. The article *(Ketzer et al., 2020)* presents the results of expeditionary studies in the area of the discovered gas seeps. Figure 1 from this article shows the position of the survey area, as well as its coordinates. Using the coordinates of the site, a satellite image was prepared (Figure 2) for frequency-resonance processing.
When processing an image of the survey area (Figure 2) from the surface, responses from oil, condensate, gas, amber, phosphorus, oil shale, argillite breccia, gas hydrate rock, gas hydrate, coal and anthracite were recorded. No responses from hydrogen, deep water, dead water and salt were received.
Signals from 1-6 groups of sedimentary rocks were recorded; responses from igneous rocks were absent.
By fixing responses at various depths from the 2nd group of sedimentary rocks (50, 150, 450, 550, 470 km), the root of the volcano of sedimentary rocks was determined at a depth of 470 km.
On the surface of 57 km, responses from oil, condensate, gas, amber, phosphorus and living (deep) water were recorded.
At a depth of 1 m, responses from oil, condensate, gas (intense) and phosphorus were obtained from the upper part of the cross-section. This indicates that hydrocarbons and phosphorus migrate through the water column to the surface.
On the surface of 0 m, the responses from gas and phosphorus were obtained from the upper part of the cross-section. This indicates that the gas with phosphorus is migrating into the atmosphere.
By scanning the cross-section from the surface, with a step of 1 m, responses from the 2nd group of sedimentary rocks began to be recorded from 240 m.
At the surface of 240 m from the upper part of the cross-section, signals from potassium-magnesium salt and dead water were received.
When scanning the cross-section from 240 m, a step of 1 m, the responses from oil began to be recorded from 850 m. However, the intervals of recording the responses were not determined.
When scanning the cross-section from 240 m, step 1 m, the responses from the gas began to be recorded from 240 m and were traced only up to 800 m. Further scanning was not carried out. A similar situation was also observed when determining the intervals of responses from phosphorus by scanning. These results indicate the migration of gas with phosphorus to the surface.

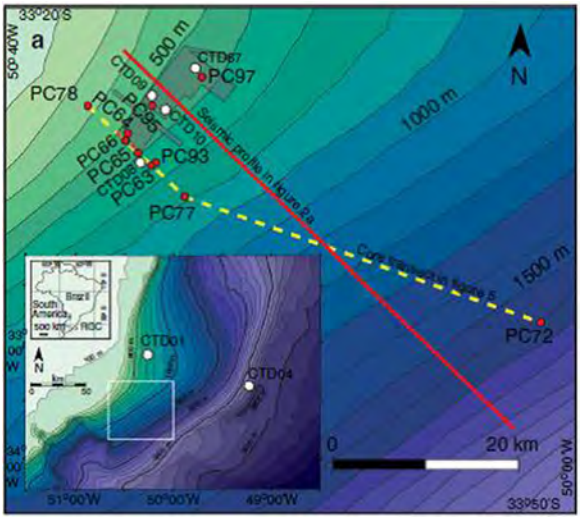

Figure 1 *Map of the location of points and profiles of marine geological and geophysical studies (Ketzer et al., 2020)*

Figure 2 *Satellite image of the research area shown in Figure 1*

When scanning the cross-section from 240 m, step -1 m (up), the responses from gas began to be recorded from 240 m and traced to 0 m (surface).

Figure 1 show that most of the points of geological and geophysical research are located in the upper left corner. In this regard, the processing of individual fragments of the image in Figure 2 has been conducted.

When processing a fragment of the image in Figure 2, outlined by a rectangle, the responses from oil, condensate (more intense), gas (intense), amber, phosphorus, oil shale, argillite breccia, gas hydrate rocks, gas hydrates, ice, coal, anthracite are recorded.

Signals from 1-6 groups of sedimentary rocks were also recorded; there were no responses from salt and igneous rocks.

During processing the image in Figure 2, without a fragment in the rectangle, signals from oil, condensate, gas, phosphorus, salt and igneous rocks were not recorded.

There were recorded responses from 8 (dolomites) and 9 (marls) groups of sedimentary rocks. By fixing signals at different depths (50, 150, 450, 550, 650, 750, 723 km), the root of a volcano filled with marls was determined at a depth of 723 km. The position of the upper edge of marls is established in the range of 25-26 km. On the surface of 25 km from the upper part of the cross-section, responses were obtained only from dolomites.

The results of processing individual fragments of the satellite image in Figure 2 show that within this area there are two volcanic complexes filled with sedimentary rocks of 1-6 and 9th (dolomite) groups.

During the research, satellite images were also processed for three large areas on the Brazilian offshore, the position of which is indicated in Figure 3 and 4 by rectangular contours.

When processing a fragment of an image in a rectangular contour in Figure 3 signals from oil, condensate, gas, amber, phosphorus, hydrogen, deep water, dead water and salt were not received.

Signals were recorded only from the 9th (marls) and 10th (siliceous rocks) groups of sedimentary rocks; there were no responses from igneous rocks.

By fixing responses at various depths from the 9th group of sedimentary rocks (50, 150, 450, 550, 750, 723 km), the root of the volcano of marls was determined at a depth of 723 km.

Fixations of responses from siliceous rocks at different depths revealed that the lower edge of these rocks is located in the interval of 3.0-3.5 km. On the 3.5 km surface, responses from the lower part of the section were obtained only from marls, and from the upper part, only from siliceous rocks.

During processing a fragment of the image in the upper rectangle in Figure 4 signals from oil, condensate, gas, hydrogen, deep water, dead water and salt are not recorded.

Only responses from 9 (marl) and 10 (siliceous) sedimentary rock groups were recorded. The root of the volcano of siliceous rocks was determined at a depth of 470 km.

The lower border of marls is established in the interval of 23-24 km. On the surface of 24 km from the upper part of the cross-section, responses were obtained only from marls.

Figure 3 *Satellite image of the Brazilian offshore in the region of the study area, indicated by yellow markers*

Figure 4 *Satellite image of the Brazilian offshore in the region of the study area, indicated by yellow markers*

When processing a fragment of the image in the lower rectangle in Figure 4, responses from gas and phosphorus are recorded from the surface. Signals from oil, condensate, amber and salt were not obtained.
Only responses from 7 (limestones) and 8 (dolomites) groups of sedimentary rocks were recorded. The upper edge of the limestone is defined in the interval 44-45 km. On the surface 44 km from the upper part of the cross-section, signals were received only from dolomites.
On the surface of 44 km, signals from oil, condensate, gas and phosphorus were received from the lower part of the cross-section.

Main results. When examining many areas of oil slicks in the Gulf of Mexico *(Oil…, n.d.),* it was found that they are all located above volcanic complexes within which the synthesis of oil, condensate and gas takes place at a border of 57 km *(Yakymchuk and Korchagin, 2020)*. In the contours of such volcanoes, there are deep channels through which oil, condensate and gas migrate to the upper horizons of the cross-section and can replenish the already formed hydrocarbon deposits both on known fields and in those that have not yet been discovered. In the absence of reliable seals over such channels, oil, condensate and gas can migrate into the water column and gas further into the atmosphere. During this migration, gas seeps are formed on the seabed and oil slicks on the water surface. The area of gas seeps on the Brazilian offshore is located within one of these volcanoes, filled with sedimentary rocks of 1-6 groups.
In the Gulf of Mexico, measurements have confirmed the presence of all previously identified types of volcanoes, in which conditions for the synthesis of oil, condensate, gas and amber can be created at a depth of 57 km. These are volcanic structures filled with 1) salt, 2) 1-6th and 3) 7th (limestones) groups of sedimentary rocks, 4) 1st (granites) and 5) 7th (ultramafic) groups of igneous rocks. Within the surveyed areas on the Brazilian offshore, responses at hydrocarbon frequencies were recorded in volcanoes filled with the 1-6th and 7th (limestones) groups of sedimentary rocks. However, the limestone volcano is overlain by a thick dolomite mass.
Studies in the Gulf of Mexico and in other regions have also discovered volcanoes, within which conditions are not created for the synthesis of hydrocarbons and amber. These are volcanoes filled with 1) 8th (dolomites), 2) 9th (marls) and 3) 10th (siliceous) groups of sedimentary rocks, as well as by 4) 6th (basalts) and 5) 11th (kimberlites) groups of igneous rocks. Volcanoes of dolomites, marls and siliceous rocks are also found on the Brazilian offshore.
A fundamentally important result of the performed experimental work is additional facts (evidence) obtained by instrumental measurements in favor of the deep (abiogenic) genesis of oil, condensate and gas. At the moment, most specialists are guided in their practice by the principles and provisions of the biogenic theory of hydrocarbons genesis. From this point of view, the estimates of the volumes of methane that migrate into the planet's atmosphere can be significantly underestimated. Numerous

facts of fixing signals (responses) from oil, condensate and gas at the boundary of their synthesis 57 km in various regions of the world (on the Brazil offshore and in the Gulf of Mexico as well) allow us to make an assumption about the migration of abiogenic methane into the Earth's atmosphere in colossal volumes!
Methane seeps and oil slicks can serve as indicators of the activity of volcanic complexes in which hydrocarbons are synthesized. In these cases, the drilling of prospecting, exploration and production wells in the areas of deep channels location of the abiogenic hydrocarbons migration to the upper horizons of the cross-section may be associated with great risks - with accidents during drilling.

Conclusions. The results of the studies indicate the efficiency, effectiveness and feasibility of practical application of frequency-resonance methods for satellite images processing in the search and exploration of hydrocarbons on offshore and onshore. It is also advisable to note that in the course of the research, a technique was developed for localizing areas within which the migration of hydrocarbons into the water column and gas into the atmosphere is carried out based on the results of frequency-resonance processing of satellite and photo images. This technique can be applied when conducting research to detect and localize oil slicks and gas seeps.

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