Mud volcanoes of the Black Sea Region

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Mud volcanism is a geological phenomenon widespread in the Black Sea region, which has been studied ever since the time of P. Pallas (1975). As a result, onshore mud volcanoes have been studied well enough (G. Abikh, N. I. Andrusov, V.V. Belousov, L.A. Yarotskiy, Avdusin, Fyodorov, Y.F. Shnyukov, P.I. Naumenko et.al.). For the last fifty years, particular emphasis has been placed on offshore exploration of mud volcanoes of the Azov-Black Sea Basin. Those involved in the studies included numerous specialists representing the Yuzhmorgheologhiya Association, Moscow State University, National Academy of Sciences of Ukraine and other organizations. Currently, mud volcanoes are regarded as manifestation of diapiric tectonics accompanied by outbursts of clay breccia; gases, most often methane; fragmentary broken-rock material.

As such, mud volcanoes are widespread in the Black Sea and the Azov Sea as well. Exact calculation of the number of volcanoes is problematic due to uncertain initial data. In many cases, the coordinates are inaccurate; quite often volcanoes are described by different authors under different names, etc. Therefore, the number of volcanoes can be determined only roughly.

To date, the number of mud volcanoes found in the Azov-Black Sea Basin is close to 70. They are located mostly in the northern part of the sea while the southern, Turkish, part of the sea is still insufficiently explored. As a rule, mud volcanoes are positive, most often cone-shaped, formations on the sea floor. The initial hydrographic survey documentation that we were able to obtain enabled us to locate quite a number of new unexplored cone-shaped morphostructures on the bottom of the Black Sea, the study of which will most likely substantially increase 'the fund' of mud volcanoes in that basin. As far as we are currently aware, the areas most abundant in mud volcanoes include the northern part of the Western Black Sea Sorokin trough, Tuapsinskaya trough; Shatskiy arch; Kerch downfold (the area south of the Kerch peninsula), and some others.

Mud volcanoes, as a rule, are associated with the axial lines of anticlines, and their exploration may be helpful for structural mapping of the sea floor.

Explorations have also resu1ted in the discovery in the Black Sea and, to a lesser extent, in the Azov Sea, of seeps - gas flames most often associated with fau1t tectonics. Unlike mud volcanoes, they eject only gas. The gas mixture mostly consists of methane. The number of seeps in the aquatory of the Azov-Black Sea Basin runs to

a few thousand. So far, no gas flames have been discovered in the inland part of the Black / Sea region, but, most likely, they are simply overlooked by geological parties. Most of the Black Sea gas flames are located on the outer shelf and continental slope, along the valleys of paleorivers, detected on the shelf. Gas flames are virtually nonexistent at depths below 600-700 meters. For example, V.N. Yeremeyev et al. (2006) described gas flames of the Sevastopol Bay; N.V. Shik (2006) described flames located on the bottom of the Laspi Bay, A.A. Pasynkov* described those existing in the Sudak Bay and in the area of Kerch Straits, etc. Therefore, the scale of gas recovery in the Black Sea and in the Black Sea region as a whole is enormous. Mud volcanoes are also known to exist to the north-west of the Black Sea. For example, geologists in Romania have found close to 250 points of gas seepage, some of which are mud volcanoes. They include large ones, such as Piklele Mari and Piklele Maci. Mud volcanoes have been studied on the Kerch and Taman peninsulas, with up to 70 discovered gas-volcano structures, including large ones, such as Dzhau-Tepe, Bulganak, Karabet Mountain, Rotten Mountain, Shugo and some others. More to the east, the strip of mud volcanoes extends into the limits of Stavropol Territory, Dagestan, Georgia, Azerbaijan, Caspian Sea and Turkmenia. That is an immense belt of development of mud volcanoes, located within the territory of former Paleo-Tetis. The total number of mud volcanoes in that belt amounts to a few hundred. Mud volcanoes of the Black Sea region developed on sedimentary columns of varied age. In Romania, they are localized on Sarmatian sediments; the Black Sea, Azov Sea and Kerch mud-volcano morphostructures are localized on Maikop sediments, while the Taman ones on Maikop and Upper Cretacious rocks.

It is generally recognized that mud volcanoes are an indication of the presence of oil and gas in the earth depths. As clearly shown by the world practice, the areas of development of mud volcanism, as a rule, are oil- and gas-bearing provinces. Mud volcanoes are often observed to throw out not only gases but oil as well, as was the case, for example, with the Nasyrskaya salse, and others (Kerch peninsula), Neftyanaya mountain, etc. (Taman). The author of this paper, for example, once had the experience of recovering a core with Cimmerian iron ore saturated with oil from the Repyevskaya mud-volcano structure, at a point located 25 km south-west of Kerch. Of special interest are the facts of recovery of oil from the mud volcanoes of Manganari 1 and Neftyanaya mountain, 10cated at the vertex of the axis of the Manganari ridge in the Tuapse trough. There, oil is localized in the New Euxeinos sediments concealed by Holocene deposits, occupying up to 10% of the rock volume. Oil has been found at 8 stations, out of the 1 O set up on Manganari 1 volcano. The oozes contain primarily methane, small amounts of ethane and insignificant quantities of ethylene, propane, propylene, butane, pentane, hexane, and carbon dioxide (V.M. Andreyev, D.D. Tugolesov, S.N. Khrenov, 2006). Therefore, mud volcanoes are not just a regional prospective indicators but sometimes can be used for precise localization of oil traps. In most cases, the activity of mud volcanoes proceeds in a

smooth and orderly way, accompanied by the activity of gas sources, but in some cases it is interrupted by catastrophic outbursts of gases which, at times, may inflame. On land, such catastrophic eruptions have been observed on the Kerch peninsula (Dzhau-Tepe in 1909 and 1914, Dzhardzhava in 1982, and others), but especially frequently on the Taman peninsula (the Karabetova mountain - more than once in recent years, and some others).

Geologically long outbursts of masses of gases and salse breccia resulted in formation of peculiar subsidence structures which on the Kerch peninsula were dubbed 'depressed synclines'. In some cases, they contain Cimmerian iron ores in their subsurface, which sometimes build up iron ore deposits. The Novosyolovskaya deposit, with reserves of up to 200 million tons, is one of the biggest. It was discovered by the present author in the eighties of the past century. In a number of cases, formations resembling such depressed synclines were found on the northwestern shelf of the Black Sea as well.

Catastrophic eruptions have been observed at the Golubitskiy mud volcano in the Azov Sea and Dvurechenskiy's volcano in the Black Sea (2004 and others). A single eruption can produce a volume of gases coming up to hundreds of millions of cubic meters. To this must be added the multi-year activity of gas flames in the sea. Given the number of existing gas flames, one can imagine the scale of the phenomenon of gas recovery in the Black Sea region. In other words, the region's gas recovery is colossal. It can be expected that its earth depths conceal enormous reserves of oil and gas. If one takes into consideration the geological duration of gas recovery processes, this view can be expressed with yet greater confidence.

Very often, catastrophic eruptions of gases and compositional changes of gas mixtures are facilitated By seismic events. As shown By our two-year observations of the composition of gases from eight mud volcanoes of the Kerch peninsula (Bulganak site), immediately before an earthquake the composition of gas mixtures coming from mud volcanoes tends to change, with the content of carbon dioxide rising. This generality can be used in the future for developing criteria of earthquake forecasting.

There is no doubt that gas outbursts from mud volcanoes and seeps in the sea produce an effect on the hydrochemical regime of the sea, possible currents and acoustic regime of the sea. In this connection it is necessary to undertake investigations in order to evaluate the effect produced by gas volcanism on all developed miotas and, first and foremost, routes of fish flocks during seasonal migrations. To a certain degree, the entire life of biota in the Black Sea is determined By fluctuations of the level of hydrogen-sulfide treatment. In recent years, the present author, jointly with Y.N. Goryachkin, found that some of the active mud volcanoes either throw out hydrogen sulfide as part of the gas mixture or are accompanied by

hydrogen-sulfide sources. Such observations were made over Admiral Mitin's volcano located on the Kerch shelf. Those observations provide reasons to assume that" mud volcanism, along with some other factors, is involved in hydrogen-sulfide treatment of the Black Sea.

In the process of their activity, mud volcanoes can cause great damage to the environment. Powerful eruptions cause ground subsidence in nearby areas and, if located within the limits of urban agglomerations, the volcanoes present a threat to such towns, for example, Kerch in the Crimea and Temryuk in the Krasnodar Territory. Contamination of airspace with mercury and some other elements can also be hazardous to people.

Mud volcanoes can have a significant effect on maritime traffic, especially in narrow waters. F or instance, seven mud volcanoes have been found offshore in the Kerch Strait. Every year nearly 10 thousand ships cleave their way through the strait. There have been cases of ships running aground right in the navigational channel (e.g., S/S "Caesar" in 1914 and some others). The shoal proved to be of mud-volcano nature. At times, mud volcanoes of the strait gave rise to the formation of small islets. Some researchers set forth ideas of methane outbursts as the cause of loss of ships in the Bermuda Triangle. Accidents of that kind are likely to happen in the Black Sea as well. The probability of such accidents has been shown experimentally.

On the whole, mud volcanism of the Black Sea region is an extremely interesting phenomenon of multidimensional importance, deserving in-depth study, primarily as an indicator of oil- and gas-bearing capacity of the earth depths.

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