Lithology, biochemistry, and micropaleontology of mud volcanoes and high-intensity cold seeps on the bottom of the Black Sea and Sea of Azov

Yanko-Hombach, V.,[1] Konikov, E.,[2] Kravchuk, A.,[3] Kadurin, S.,[4] Kravtsov, V.,[5] Larchenkov, E.,[6] and Smyntyna, O.[7]

[1-7]Scientific and Educational Center of Geoarchaeology, Marine and Environmental Geology (SECGMEG), Odessa I.I. Mechnikov National University, 2 Dvorisnskaia St., Odessa, 65026, Ukraine, [1]valyan@ onu.edu.ua, valyan@avalon-institute.org, [2]konikov2006@mail.ru , [3]aokravchuk@gmail.com, [4]kadurin@paco.net, [5]vadim_kravtsov@ukr.net, [6]larchenkov@onu.edu.ua, [7]smyntyna_olena@onu.edu.ua

Introduction

The Odessa National I.I. Mechnikov University Team focused on the geological, geochemical, mineralogical, and micropaleontological study of mud volcanoes and high intensity gas seeps in the northern Black Sea in order to assess their origin and possible influence on ecosystems, thus, contributing to HERMES WP1 and WP3.

As a first step, compiling and integration of existing data (published and archival) obtained by previous projects was conducted by a variety of organizations. This enabled us to create a GIS-aided map of previous research, at least in the northwestern part of the Black Sea (Fig. 1).

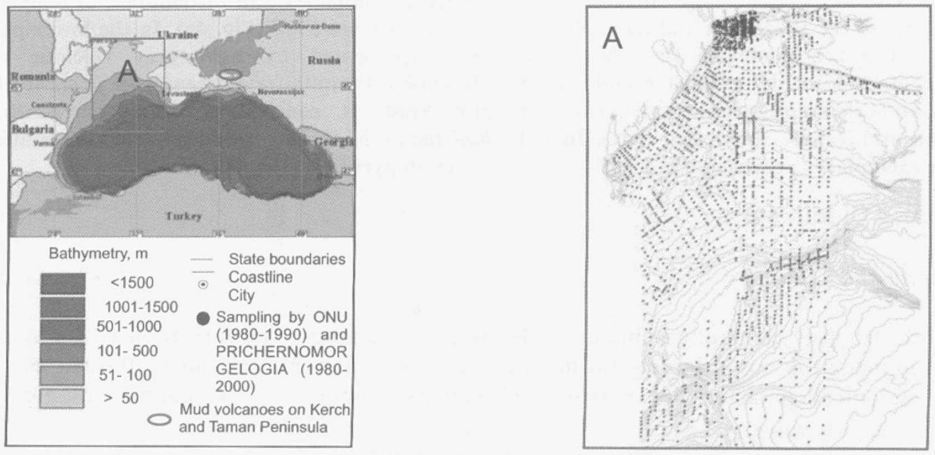

Figure 1. A - GIS-aided mapping of previous research in the north-western shelf and continental slope of the Black Sea (compiled by S. Kadurin based upon archival and published materials).

As a second step, a GIS-aided schematic map was created of the northern part of the Black Sea and part of the Sea of Azov indicating the locations of faults, mud volcanoes, and cold seeps (Fig. 2).

As a third step, the most representative geological material has been chosen and further investigated. This material was obtained over the course of a large-scale geological survey of the Black Sea performed by ONU since 1971 (Yanko-Hombach et al., 2007) as well as recent marine campaigns using *R/V "Vodianitskii"* and *R/V "Vladimir Parshin"*. These campaigns were carried out by the Department of Marine Geology and Mineral Resources of the Ukrainian Academy of Sciences, with whom ONU has a strong collaboration (Shnyukov et al., 2006).

This enabled us to delineate the distribution of mud volcanoes and cold seeps on the sea bottom, to assess their physical and chemical properties, and to provide insight into their origin. The work is still in progress, but some results can be reported.

Methods

Our methods follow an ecosystem approach, use equipment that preserves original properties of water and sediments, synchronously determine gasbiogeochemical parameters, and apply a multidisciplinary interpretation to obtained results in order to assess the environmental conditions of mud volcanoes and cold seeps and their possible influence on ecosystems.

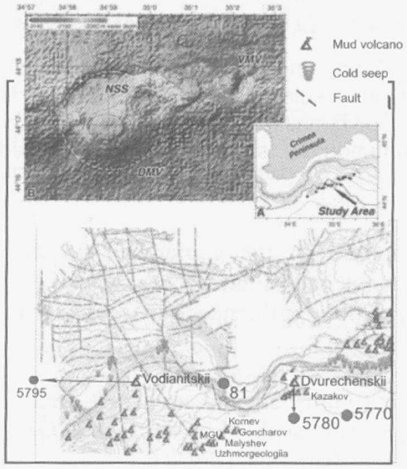

Figure 3. GIS-aided schematic map of the northern part of the Black Sea and partially Sea of Azov and Kerch Peninsula (modified after Greinert et al., 2006) with locations of faults, mud volcanoes, and cold seeps (compiled by S. Kadurin based upon archival and published data). In red circles are exemplary cores shown in Fig. 5.

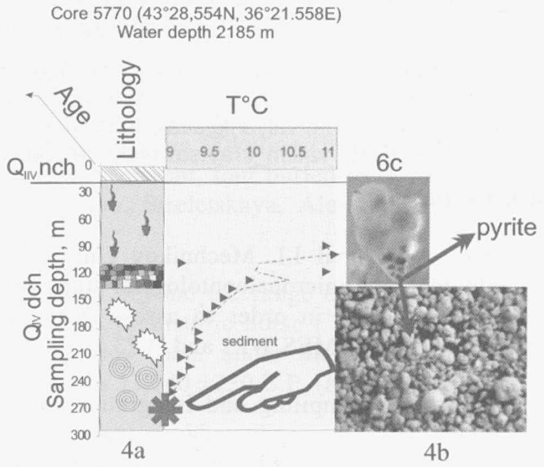

Figure 4. Lithology and distribution of temperature in exemplary Core 5770 (Fig. 4a). In the lower part of the core represented by light grey volcanic mud the Maikopian foraminiferal assemblage (Fig. 4b) has been discovered. It consists of abundant benthic, e..g., *Bolivina cf. budensis* - dominant, etc. Foraminiferal tests are often pyritized (Fig. 4c).

Results and Discussion

Stratigraphy and Lithology

In our work, we used ecostratigraphic and lithological techniques. The former (used for stratigraphy of shelf sediments) is based largely on the alternation of foraminiferal and molluscan assemblages and their ecological characteristics in geological sections, supported by ^{14}C and palynological assays.

The sediment columns on the shelf are divided into Upper Pleistocene and Holocene sections. The former is represented by the Lower and Upper Neoeuxinian beds, while the latter contains Drevnechernomorian (Old Black Sea) and Novochernomorian (New Black Sea) beds with a boundary at ca. 7.8 ka B.P. [uncalibrated] (Yanko-Hombach et al., 2007).

On the continental slope and abyssal plain, where no *in situ* faunistic remains are present, the litho-stratigraphic technique was used enabling us to subdivide sediments into coccolithic (Novocherno-morian), sapropel (Drevnechernomorian), and hydrotroilite (Neoeuxinian), quite often interlayered with turbidites, especially at the bottom of the continental slope.

Mud Volcanoes and Cold Seeps

Mud volcanoes show recent activity, not only on the sea bottom but on land as well. Geological survey conducted by the ONU Team on the easternmost part of Kerch Peninsula has shown that they often form a series of hills.

The mud volcanoes demonstrate a wide range of morphologies, ranging from flat mud pies (Fig. 7a) to large cones with or without calderas. Some of them are aligned, which points to a strong underlying structural control.

Conclusions

The source level for the mud volcanoes in the Black Sea and Kerch Peninsula are sandy-clayey sediments of the Maikopian (Oligocene-Early Miocene) series as indicated by foraminiferal assemblages. The Maikopian series is folded and enriched with water and gases that migrate along tectonic cracks and/or hydrodynamic drainage systems and explode on the surface.

There are two main types of vertical distribution of gas-biogeochemical parameters in the sediments (Fig. 3): 1. An increase of methane and decrease of ATP and APA under the presence of CO_2 down the core. An anomalously high concentration of methane occurs as a result of its release from deeper sediments, which under favorable thermo-barometrical conditions and sedimentological properties, forms gas hydrates. This type is related to mud volcanoes. 2. A synchronous increase of methane and ATP down the core showing that methane is most likely forming from microbial organisms through hemolytic-autotrophic metabolism that increases the intensity of the gas release at the water-sediment boundary forming colds seeps.

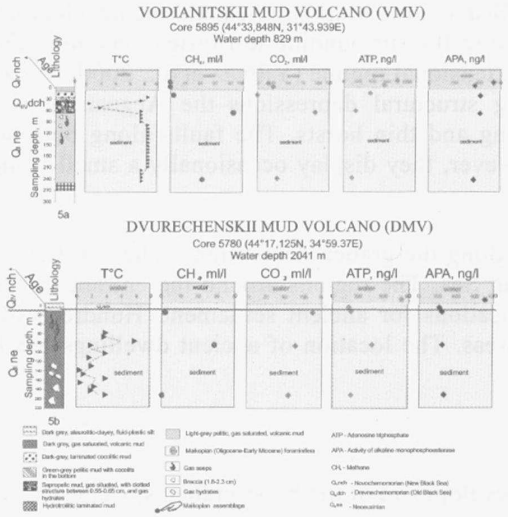

Figure 3. Distribution of temperature, CH4, CO2, ATP, and APA in exemplary cores recovered from mud volcanoes Vodianitskii (a), Dvurechenskii (b), and an unnamed one. Note: the temperature of the sediments drops in those parts of the cores where gas-hydrates are present. The Maikopian age of mud volcanic sediments is supported by foraminiferal assemblage.

Acknowledgments

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References

Greinert, J., Artemov, Yu., Egorov, V., De Batist, M., and McGinnis, S. (2006). 1300-m-high rising bubbles from mud volcanoes at 2080 m in the Black Sea: Hydroacoustic characteristics and temporal variability. *Earth and Planetary Science Letters* 244:115.

Shnyukov, E.F., ed. (2006). *Geological Investigations of the Black Sea.* GNU "Otdelenie Morskoi Geologii i Rudoobrazovaniia NNPM NAN Ukraine. ISBN 966-02-3834-7. (In Russian)

Yanko-Hombach, V., Gilbert, A.S., Panin, N., Dolukhanov, P.M., eds. (2007). *The Black Sea Flood Question: Changes in Coastline, Climate and Human Settlement.* Springer, Dordrecht.