Geological—Geophysical and Oceanographic Research in the Sea of Japan, Tatar Strait, on Cruise 61 of the R/V Akademik Oparin

M. G. Valitov*, R. B. Shakirov, N. S. Lee, A. A. Legkodimov, T. S. Yakimov, A. L. Ponomareva, V. V. Kalinchuk, M. A. Bovsun, V. A. Bulanov, Z. N. Proshkina, N. S. Syrbru, I. V. Korskov, V. Yu. Kalgin, K. O. Baldanova, A. K. Okulov, and D. S. Makseev

*Il’ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences, Vladivostok, Russia

**Far Eastern Federal University, School of Natural Sciences, Department of Soil Science, Vladivostok, Russia

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Abstract—The paper presents brief results of comprehensive studies of the water area of the Tatar Strait and Sea of Japan obtained on cruise 61 of the R/V Akademik Oparin in November—December 2020. The bottom relief and geophysical and gas-geochemical fields were refined, and new features of the geochemistry and mineralogy of bottom sediments were revealed.

Keywords: gravimetry, magnetometry, hydrocarbons, gas geochemistry, microbiology, glendonite

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In accordance with the Marine Expeditionary Research Plan, in spite of the worldwide COVID-19 pandemic, an international integrated expedition organized by the Il’ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences (POI FEB RAS) took place from November 17 to December 10, 2020.

The main objective of the expedition was integrated geological—geophysical, gas-geochemical, microbiological, and oceanographic research to study the conditions and mechanisms of the formation of the Sea of Japan, Tatar Strait, and the correlation of gas-fluid flux distribution with a tectonic fault network.

Expeditionary research was carried out in two regions: the northern and central part of the Tatar Strait and the northern part of the Sea of Japan. In the first area, two test sites were delineated; in the second area, five (Fig. 1).

The set of methods along the vessel’s entire route included gravimetric studies, continuous acoustic profiling of the water column, magnetometry, recording of the sea surface temperature and salinity, and atmochemical measurements of methane, CO₂, and mercury in atmospheric surface layer. At stations, geological sampling of bottom sediments was carried out with gravity corers to determine their mineral, gas-geochemical, and bacterial composition.

As a result, data were obtained on the distribution of the magnetic and gravitational fields in the northern part of the Tatar Strait, which not only made it possible to increase the previously studied water area, but also provided new material for physical and geological modeling of the deep structure of this region. A new seamount was mapped in detail at test site no. 3, discovered on the borderland margin of Hokkaido on cruise 85 (2019) of the R/V Akademik M.A. Lavrentyev.

Based on the results of hydroacoustic studies, data were acquired on sound scattering in the upper layer of the sea, caused by small-scale inhomogeneities (plankton, turbulent layers, bubbles). Two near-bottom acoustic anomalies were found, probably associated with the possible gas seeps in the Tatar Strait and Sea of Japan.

A large array of data on the content of atmospheric mercury (Hg(0)) obtained during the cruise made it possible to determine (by CWT analysis) the most probable source areas of this element into the atmosphere of the northwestern Sea of Japan.

During the expedition, sediment sampling was carried out at sites 1, 2, 4–6. As a result, new anomalous gas-geochemical fields—indicators of hydrocarbon accumulations—have been discovered; others already known were categorized in detail. In the central Tatar Strait, in a new area north of Cape Surkum, a sediment layer was discovered, almost black in color due to the abundant manifestation of hydrotroilite mineralization, which marks reducing conditions with a low oxygen content and fluxes of reduced gas.

In the area of the continental slope of northern Primorye (water area near Amgu), a new area with unique sulfide and carbonate authigenic mineralization was found. An entire collection of authigenic minerals was
discovered: ikaite, glendonite crystals, carbonate nodules, several generations of sulfides, barite crystals, including in an assemblage with sulfides.

In addition, the expedition acquired a valuable collection of benthic fauna and infauna, in particular, many sea worms inhabiting different subbottom horizons, as well as mollusks. It is possible that we discovered an unusual ecosystem in gravel-pebble deposits, covered by a dense layer of sand with silt (about 20–30 cm).

The methods of the expedition also included microbiological core studies. The main emphasis was on studying oil-oxidizing, hydrocarbon-oxidizing, methanotrophic, and sulfate-reducing bacteria. It has been established that oil-oxidizing microorganisms are the most widespread in the studied water area. The distribution of hydrocarbon-oxidizing microorganisms strongly depended on the nitrogen concentration in the medium. Growth of sulfate-reducing microorganisms was recorded only at seven stations.

Fig. 1. Sketch map of survey route and location of operations areas on cruise 61 of R/V Akademik Oparin, November 17–December 10, 2020 (insets: sampling stations in test sites are shown on left; glendonite and carbonate nodules in section, on right): (1) operations areas with corresponding numbers; (2) test sites with corresponding numbers; (3) geophysical profiles; (4) geological stations with corresponding numbers; (5) route of vessel.
As a result of gas-geochemical studies of bottom sediments, the distribution areas of anomalous hydrocarbon gas fields (methane and its homologues) have been refined. Based on the research results, the water area containing abnormally high methane concentrations near gas hydrate occurrences in the southern Tatar Strait was significantly increased and new anomalies were discovered in areas of intense manifestation of authigenic carbonate mineralization on the continental slope of Primorsky krai (up to 18,884,805 nL/dm³ in the sediment core at station OP61-41GC, 350 cm horizon).

Elevated helium concentrations were found in sediments on the continental slope of Primorye. Also in the central Tatar Strait, in the active flux-conducting degassing zone established from the results of previous studies (cruise 54 of the R/V Akademik Oparin and cruise 81 of the R/V Akademik M.A. Lavrentyev), helium anomalies exceeding 1.8% were recorded. The results of gas-geochemical studies showed that the hydrogen distribution of in sediment cores of the study area remains at the background level for the northern Sea of Japan and does not exceed 6.5 ppm.

During the expedition, pore water samples were taken, to be analyzed for the content of basic ions (Cl, SO₄, Na, K, Mg, Ca) to estimate the methane flux by sulfate ion analysis. Trace elements (Li, Sr, etc.) will also be identified in order to assess the contribution of deep-seated fluid sources. To study the paleoceanological characteristics and construct a chronostratigraphic model, sediment samples were taken to study microalgae (benthic diatoms, foraminifera), as well as samples of carbon-containing objects (wood, remains of fish skeletons, shells, foraminifera).

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