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## Gas-Geochemical Studies of the Outer Water Area of Peter the Great Bay (Sea of Japan) on the R/V *Professor Gagarinskiy*, Cruise 83

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**Abstract**—The paper presents brief results of gas-geochemical and hydrometeorological studies of the outer water area of Peter the Great Bay (Sea of Japan), obtained as a result of a marine expedition study on the R/V *Professor Gagarinskiy* (cruise 83) in October–November 2022. Areal atmochemical measurements of climatically active gases (CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>O vapor) and Hg(0) in the near layer of the atmosphere of the outer water area of Peter the Great Bay were performed for the first time. Gas geochemical fields in bottom sediments and water column are detailed. The current position of gas flares within the outer shelf of Posyet Bay is determined. Long-term stations for marine daily monitoring were carried out.

**Keywords:** atmochemistry, gas geochemistry, climatically active gases, methane, gas flares, Peter the Great Bay, Sea of Japan

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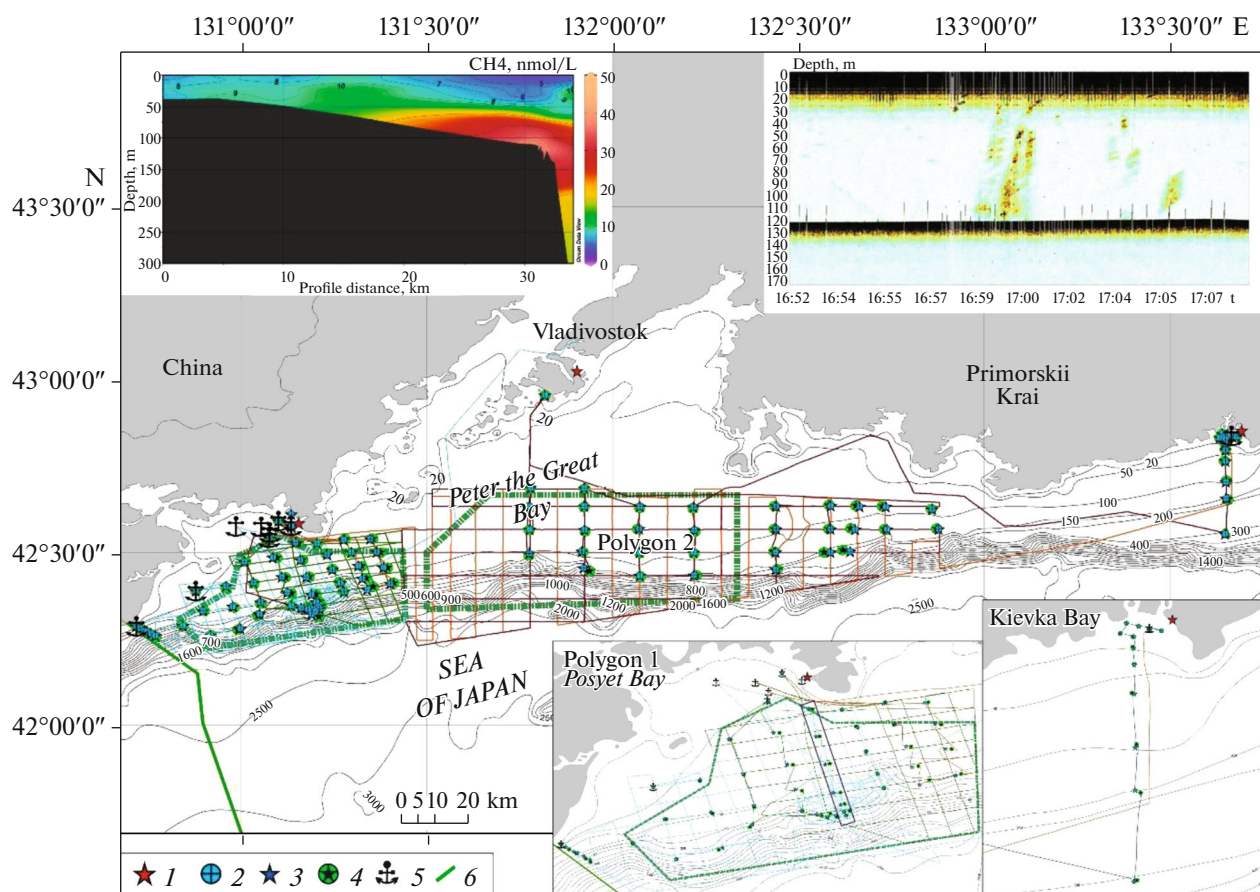
Expeditionary marine research on the R/V *Professor Gagarinskiy* (cruise 83) was carried out from October 20 to November 30, 2022. The expedition was organized by the Il'ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences, as part of the basic scientific research program in the Russian Federation for the long term (2021–2030). The main goal of the expedition was to study the gas-geochemical and hydrometeorological state of the outer water area of the Peter the Great Bay (Sea of Japan), taking into account the influence of climatic factors and abiotic environmental factors.

The main objectives of the expedition were: study the current state of the gas-geochemical and lithochemical fields in bottom sediments and the water column; organize daily marine stations for atmochemical, hydrological, and meteorological monitoring in shallow-water shelf conditions; carry out areal associated atmochemical, gas-geochemical, oceanological and meteorological measurements to study gas exchange processes in the water–atmosphere system in the outer water area of Peter the Great Bay (PGB).

The overall implementation of scientific research was divided into three stages at two main sites (Fig. 1). The expedition included seven researchers, including four young specialists under the age of 35 (one student and two graduate students).

The set of research methods included work at oceanographic stations, accompanying measurements along the vessel's route, and daily monitoring of climate-active gases at anchorages (ten daily stations). Sounding of the water column was carried out at integrated oceanographic stations with a CTD probe SBE-19 (114 stations), water sampling with Niskin bottles, and bottom sediment sampling with a Box Core sampler (95 stations). Incidental studies (2730 nautical miles of continuous profiling) at the crossings included temperature and salinity measurements using an SBE 45 flow thermosalinograph, discrete sampling, and onboard gas chromatographic analysis of surface seawater samples; atmochemical (Hg(0), CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>O vapors), and meteorological measurements in the atmospheric surface layer.

As a result of the expedition, for the first time, synchronous and mutually complementary atmochemical measurements of atomic mercury Hg(0) and climate-active gases (CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>O vapors) within the entire outer water area of PGB, making it possible to model seasonal atmospheric transport and verify possible sources in the land-sea and sea-atmosphere systems. The results formed the basis of registered databases [3, 4] and supplemented studies on the deep-water areas of the Sea of Japan [5].



**Fig. 1.** Sketch map of research route and location of main work sites on cruise 83 of R/V *Professor Gagarinskiy*, October 20–November 30, 2022. Insets show examples of indication of gas flares (right) and methane distribution (in nmol/L) along the profile in water column of Posyet Bay (left). (1) Sites of the Far Eastern carbon test site of Primorsky krai; (2) stations for sounding of water column; (3) sampling of water column; (4) sampling of bottom sediments; (5) stations of daily climatic and atmochemical monitoring.

Near Gamov Canyon (outer shelf of Posyet Bay), detailed hydroacoustic studies of underwater gas manifestations were carried out (figure), as a result of which their current position was clarified. In total, about 113 gas shows of various shapes and intensities were discovered at depths of 100–150 m. The presence of such an active fluid discharge zone in the immediate vicinity of Vladivostok (within 30 km) is an excellent marine survey site for testing methods of recording gas emissions and validating gas geochemical data obtained at various levels of research (from remote sensing to in situ measurements). In Posyet Bay, an anomalous gas-geochemical field of methane was discovered (methane concentrations above 40 nmol/L, with background concentrations of 4–6 nmol/L) in the bottom water horizons of the seep field (Fig. 1). This area requires further detailed comprehensive studies, including in the deep-sea part, which is promising for the search for marine gas hydrates and other forms of mineral resources [1, 2].

The gas-geochemical sampling of the water column and bottom sediments of PGB carried out during

the expedition, significantly expanded the modern gas-geochemical knowledge of the study area. Important information was obtained on the basic lithological and geochemical characteristics of bottom sediments (physicochemical properties, organic saturation, microbiological parameters, etc.) within two locations of the Far Eastern Carbon Survey Site site of Primorsky krai (MES “Shultz Cape” and Kievka Bay), which will be used in further studies of the carbon cycle of marine ecosystems at these sites.

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#### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects.

#### CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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