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INFORMATION

Field Studies of Anoxic Conditions in the Baltic Sea during the Cruise of R/V *Professor Albrecht Penck* in July 2006

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The Baltic Sea Research Institute (Warnemuende, Germany) carries out regular investigations of the H₂S-containing deep waters of the Baltic Sea. In July of 2006, an international scientific team, Russian scien-

tists included, conducted studies on board the R/V *Professor Albrecht Penck*. The vertical hydrophysical, hydrochemical, and microbiological structures of the Gotland (station TF0271) and Landsort (station

Fig. 1. Scheme of the studies during the cruise of R/V *Albrecht Penck* in July 2006.

Fig. 2. *T,S* curves based on the results of five CTD profiles at station 271 (at 05:29; 06:12; 10:59; 13:50, and 16:13 GMT) on July 9, 2006.

TF0284) deeps were studied during this cruise (Fig. 1). Its purpose was to investigate the influence of the intrusions that are formed near the chemocline and clarify the fine hydrochemical structure of the near-bottom waters.

The water was sampled using a Rosette complex equipped with a Sea Bird-19 hydrophysical probe with sensors of the pressure, temperature, electrical conductivity, turbidity, fluorescence, and oxygen, as well as with 13 Free-Flo (5 l) bottle samplers. The contents of dissolved oxygen (Winkler titration), phosphates, silicates, nitrates, nitrites, ammonium, and hydrogen sulfide (photometrically) were determined in line with the traditional techniques [2, 3]. Samples collected for determining the dissolved metals were filtered through Nuclepore filters with a mesh size of 0.45 μm immediately after sampling. Fe and Mn were determined photometrically using ferrozine and formaldoxime in line with [3]. In addition, samples for determining the alkalinity and methane (at station TF0284 in the Landsort Basin) and suspended metal forms were taken.

The Landsort chemocline was out of the influence of intrusions during the cruise, which made it possible to observe the undisturbed vertical chemical structure, which appeared to be similar with that typical of the Black Sea. The nitrate maximum was located near the lower boundary of the oxycline, while the nitrite maximum corresponded to the layer marked by a decline in the deep ammonium and dissolved Mn, the disappearance of nitrates, and a sharp decrease in the phosphate content. The Winkler method (titration using an automatic Titrino burette with proprietary software) failed

to estimate oxygen in the samples with detectable contents of hydrogen sulfide (0.3 $\mu\text{mol/l}$).

In the Gotland chemocline, the hydrochemical structure of the redox layer was under the influence of intrusions during practically the entire observation period. These intrusions were responsible for both the deepening of the redoxcline relative to its typical position and the instability in the layer from 105 to 145 m as is evident from the variations in the *T-S* curves characterizing a single day (Fig. 2). Figure 3a demonstrates the parameters of the fine hydrochemical structure measured during the same day. It is seen that these intrusions with elevated oxygen contents resulted in an extreme temporal variability of the distribution profiles of the hydrochemical parameters. The most unusual structure was observed at station 0003F02 (Fig. 3b), where it was characterized by a narrow phosphate minimum immediately beneath the hydrogen sulfide boundary and a maximum under the latter. The distribution of the dissolved (bivalent) manganese appeared to be similar: its distinct maximum coincided with that of phosphates. This may indicate that the distribution of these parameters is controlled by the same mechanism, namely, by the formation of phosphate-bearing complexes with oxidized dissolved trivalent manganese. The measured content of trivalent manganese was comparable with the detection limit of the method (approximately 1 μM) and its role remains unclear so far. During the cruise, we also conducted an experiment to study the distribution of manganese in different size fractions—suspended ($>0.2 \mu\text{m}$), colloid (from 0.2 to 0.02 μm), and dissolved ($<0.02 \mu\text{m}$). The preliminary

Fig. 3. Vertical distributions of the temperature (T), salinity (S), turbidity (X_{miss}), dissolved oxygen according to the O_2 -SBE sensor, dissolved oxygen according to titration (O_2), hydrogen sulfide (H_2S), phosphates (PO_4), silicates (Si), nitrates (NO_3), nitrites (NO_2), ammonium (NH_4), dissolved manganese (Mn(II)), particulate manganese (MnPART), reduced iron (Fe(II)), and oxidized iron (Fe(III)) at stations (a) 0003F04, (b) 0003F02, and (c) 0011007.

results of the experiment show that colloid manganese is missing (below the detection limit of 100 nM).

Figure 3c demonstrates the data on the near-bottom layer of the Gotland basin studied with a sampling distance of every 2–3 m. They depict the 20-m-thick near-bottom mixed layer (NBML), which is characterized by a slight (approximately 0.002°C) temperature increase and uniform distributions of salinity, hydrogen sulfide, ammonium, phosphates, silicates, dissolved Fe, and dissolved Mn. Their gradients are substantially lower than those in the upper water layers. A step with a sharp gradient increase in all the parameters is recorded at a depth of 215 m at the NBML boundary. A similar distribution of the chemical parameters is characteristic of the Black Sea basin [1], although the near-bottom layer in the latter is thicker (300–500 m). A small step in the gradient changes in the Baltic Sea NBML may be

defined at a depth of 223 m. It is conceivable that the latter is related to an intrusion of the waters with elevated salinity.

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