TRANSVERSE CIRCULATION AND WATER EXCHANGE BETWEEN SURFACE AND DEEP WATERS OF THE BLACK SEA

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Abstract

In this work all the components of the transverse circulation of the Black Sea waters with allowance for the climatic factor during the last 130 years are briefly discussed.

Key-words : Air-sea interactions, water convection, intermediate waters, Black Sea

The studies of hydrophysical processes in the Black Sea during the last 10 -15 years allowed to get a series of new fundamental results. As it was established by the numerous experimental data, the most active processes of water exchange between the surface and deep waters which determine the vertical structure of hydrological and hydrochemical fields, the ecological condition of waters and their bioproductivity, take place in the central deep part of the sea and in the nearshore zone (in the continental slope area) in winter.

Dynamic processes in the central part of the sea

The vertical exchange between the surface and deep waters is the most intensive in winter in the centres of the large-scale quasi-stationary cyclonic gyres (eastern and western). As the result of intensification of winter water circulation, an active kinematic rising of rather clean deep waters, saturated with hydrogen sulphide and biogens, to the pycnocline dome takes place here. In this case the constant pycnocline which is a boundary between the surface and deep waters, is rising in the centres of the cyclonic gyres in the form of a dome to the depth of 25-30 m (Fig.1a,b). [1,2].

In the period of autumn-winter cooling, the thin layer (25-30 m) of the surface waters over the pycnocline dome (in the centres of cyclonic gyres) which has the minimal heat content, cools down quicker than in the other regions. Its salinity is increased due to intensive evaporation, and its water density grows that leads to vertical winter convection down to the pycnocline dome (Fig.1a,b).

At the same time in the pycnocline layer which separates the surface and deep waters, internal waves (inertial and others) with the amplitudes from 10 to 12 m are developed. They destabilize the pycnocline and favour the interexchange between the surface and deep waters (Fig.2) [3]. As a result of such interaction between the cold surface waters and the deep waters of high salinity the cold intermediate waters (CIW) with the density of 15.0 are formed on the pycnocline dome. Slipping down its slope they spread to the periphery of the cyclonic gyres. Flowing under the less cold surface waters they form the cold intermediate layer (CIL) with the volume of about 21 000 km^3.

In such a way the kinematic rising of the deep waters from below, the convective mixing (sinking) of the surface waters from above and the internal waves at their boundary (within the pycnocline) are the major factors of winter interaction between the surface and deep waters in the centres of the Black Sea cyclonic gyres. As a result of such interaction the following important processes take place here.

a) The complete oxidation of hydrogen sulphide in the rising deep waters with oxygen from the surface waters which are sinking under the influence of the internal waves into the pycnocline layer.

b) The possible redox-zone formation as the result of dynamic (turbulent) interaction of the surface and deep waters at the boundary of their division under the action of the internal waves.

c) The replenishment and renewal of the surface waters at the expense of more clean deep waters (3 000 km^3/year) and the improvement of ecological condition in the upper sea level.

d) The formation or partial renewal of the cold intermediate layer (CIL) (21 000 km^3) and its distribution within the subsurface layer all over the deep sea area.

e) The enrichment of the surface waters (primarily the CIL) with biogenous elements from the deep waters (nitrates, phosphates etc.) and the increasing of the upper layer productivity in the open part of the Black Sea.

f) The active rising of the deep waters in the middle of cyclonic gyres in winter (3 000 km^3) could result in the sea level rising by more than 9 meters. But the absence of such a catastrophic rising is an evidence of the active transverse water circulation in the Black Sea.

g) The conservation of the balance of heat, salts and mass in the water exchange between the oxygen and hydrogen sulphide zones, the maintaining of the constant depth of the hydrogen sulphide zone upper boundary in the mean perennial aspect.

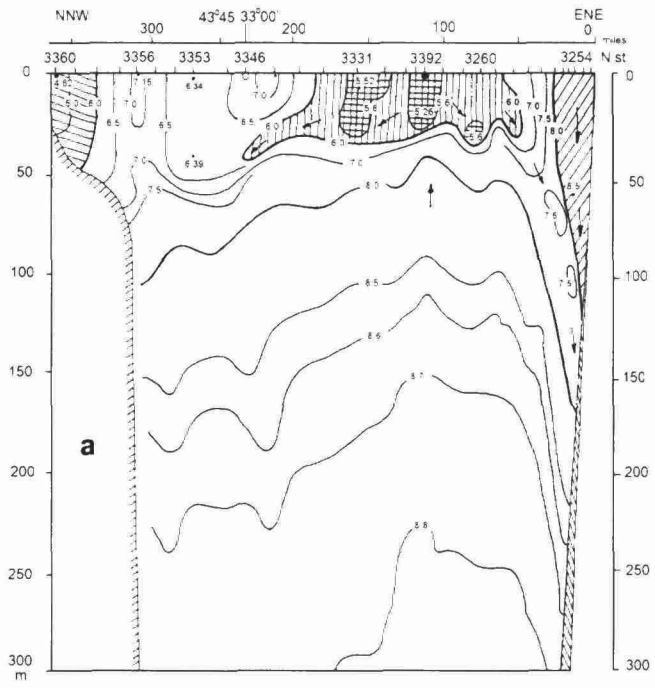

Fig.1a. Distribution of water temperature along the section directed from Odessa to SSE, across the middle of the north-western shelf, towards the supposed centre of the western cyclonic gyre (St.3346: 43°45'N; 33°00'E), and then to ENE, across the centre of the eastern cyclonic gyre, towards Novorossiysk. (According to the data of the 21-st cruise on board the r/v *Vityaz* in winter and spring 1991: 09.02-06.03.91).

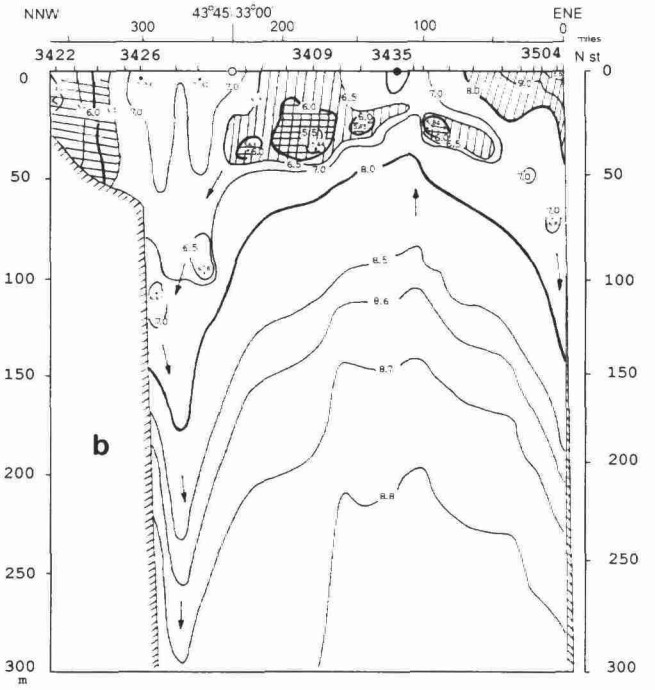

Fig.1b. Distribution of water temperature along the section directed from Odessa to SSE, across the middle of the north-western shelf, towards the supposed centre of the western cyclonic gyre (St.3346: 43°45'N; 33°00'E), and then to ENE, across the centre of the eastern cyclonic gyre, towards Novorossiysk. (According to the data of the 21-st cruise on board the r/v *Vityaz* in winter and spring 1991: 10.03-09.04.91).