C14 dating and facies control of paleo-shorelines location on NW Black Sea shelf in Holocene

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Introduction

At present, an extensive number of competing theories has been devoted to sea-level change in the Black Sea (Yanko-Hombach, 2007).

While the method of dating bottom sediments by ^{14}C is debatable (AMS versus conventional [β-counting]), the classical methods of geological research cannot be excluded. The latter include stratigraphy (bio-, litho- and sequence stratigraphy), and facies analysis to reconstruct sea-level stands. This requires a dense network of cores properly sampled and dated.

The northwestern Black Sea shelf was an alluvial plain that was flooded in the course of the Late Neoeuxinian and Chernomorian transgression (Larchenov and Kadurin, 2011). The latter started ca. 9.4 ka BP (all radiocarbon dates in this paper are in non-calibrated years BP), and occurred in an oscillatory or transgressive-regressive manner. Each transgressive-regressive stage formed its own paleocoastline, which is well expressed in the shelf relief (Larchenkov and Kadurin, 2011). Because the number of samples dated by ^{14}C from paleocoastlines is relatively small, interpolation and extrapolation methods along with facies analysis of bottom sediments are required.

The purpose of this study is to assess the hypsometric level of paleocoastlines on the northwestern shelf of the Black Sea in order to reconstruct sea-level stands based on facies characteristics of the sediments, including those dated by ^{14}C, and to establish a sea-level curve for the last 13 kyr.

Study area

The study area includes the northwestern shelf of the Black Sea, ranging from the Ukrainian part of the Danube Delta to the northwestern coast of Crimea (Fig. 1). This is a key region for at least two reasons: (1) it is the widest (125–240 km) shelf in the basin, encompassing about 25% of the total area of the sea compared to other parts of the shelf with widths ranging between 2.5 km (Turkey) to 2.5–15 km (Caucasus); (2) it is located within stable platform-type structures with a gentle slope (0.001–0.002°), and there are no known expressions of active tectonic movements (Dolukhanov et al., 2009) that would strongly influence the positions of ancient shorelines in contrast to its southern margins which are tectonically active (Koral, 2007).

Materials and methods

Sampling has been conducted continuously since 1971 to the present over the course of a medium-to-large scale (1:200000 and 1:50000 sampled on a grid 2x2 km and 0.5x0.5 km, respectively) marine geological survey of the northwestern Black Sea shelf. Marine expeditionary investigations have been carried out mainly onboard the R/Vs "Topaz," "Diorit," "Mechnikov," "Odessa University," and "Antares" using seismic profiling, and seafloor sampling by vibra-, gravity coring, and drilling. The survey has been performed by Prichernomorskoe State Regional Geological Enterprise "Prichernomor GRGP," Odessa I.I. Mechnikov National University, and Department of Marine Geology and Mineral Resources of the Ukrainian Academy of Sciences (e.g., Podoplelov et al., 1973–1975; Sibirchenko et al., 1983; Avrametz et al., 2007).

Obtained material was studied as part of a multidisciplinary effort. Radiocarbon dating of sediments was performed by the conventional [β-counting] method on 81 samples across the northwestern shelf in the laboratories of Kiev and Leningrad (today St. Petersburg).

Results

As an outcome of the geological survey, a set of geological and facies maps of the northwestern Black Sea shelf bottom sediments was established. Based on these maps, paleogeographic reconstructions were performed, and seven shorelines were identified (Fig. 1) as described in Larchenkov and Kadurin (2011).

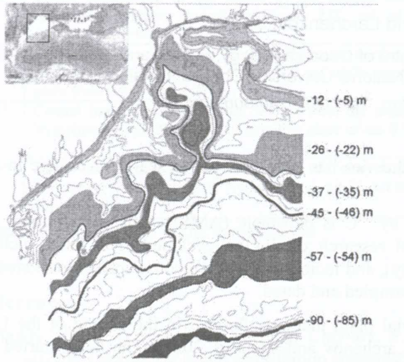

Figure 1. Location and hypsometric level of paleocoastlines on the northwestern shelf of the Black Sea.

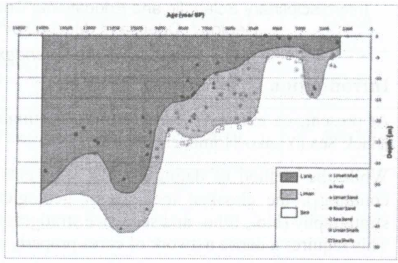

Figure 2. Hypsometric levels of alluvial, liman, and marine paleoenvironments on the northwestern shelf of the Black Sea.

Each paleocoastline is characterized by specific lithological (e.g., coarse fraction) and geomorphological (e.g., coastal cliffs, bars, siltings, etc.) properties formed under equal environmental conditions existing in space and time at specific hypsometric levels. Samples for ^{14}C dates were taken from sand, coquina, mud, and peat that reflected alluvial, liman, and marine facies. At present, these sediments are located at the following hypsometric levels (Table 1). Their ^{14}C ages range between 13.0 and 1.44 ka BP.

Table 1. Recent hypsometric levels of accumulated alluvial, liman, and marine sediments in the northwestern Black Sea shelf.

	Depositional environments		
	River valley	Liman	Marine
Peat	−2 to +5		
Sand	0 to +20	−15 to +2	−15 to 0
Shells		−15 to +1	−30 to 0
Mud		−15 to 0	

The spatial and temporal distribution of facies enabled us to delineate the land and sea areas (Fig 2).

Discussion

The sea-level curve consists of a solid and dotted black line corresponding to definite (dated by ^{14}C) and approximate (extrapolated) hypsometric positions (Table 2) of the samples (Fig. 3).

Table 2. Hypsometric position of the coastlines on the northwestern Black Sea shelf over the last 13 kyr.

Sea level (–) m	37–35	46–45	22–21	12–11	4–3	13–12
Age, ka BP	12.5–11.5	11–10	9.5–8	6.2–5.5	4.4–3.5	2.5–2.2

Looking at the curve (Fig. 3), there was a gradual sea-level rise staring from ca. 9.4 ka BP. However, this gradual sea-level rise was complicated by a series of transgressive rises and regressive drops. The intensity of the stages varies over rather wide limits. At the beginning of the Holocene, there was a

regression that brought sea level from –30 m to –40 m, and even –45 m as shown by peats dated at 10–9.4 ka BP.

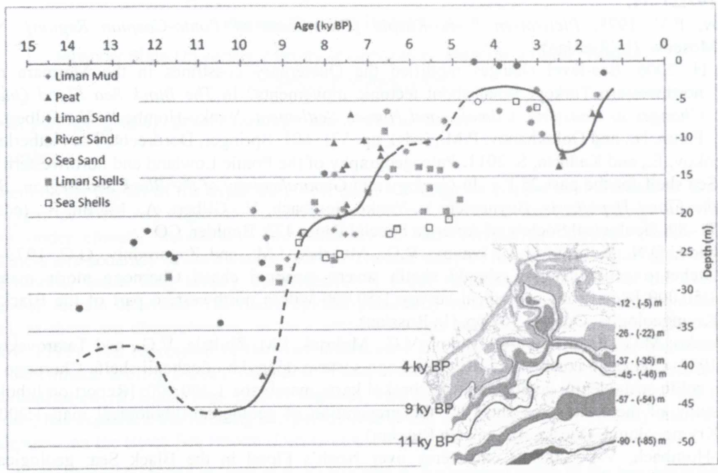

Figure 3. The Black Sea level curve constructed from the facies affinity of bottom sediments dated by ^{14}C.

This regression was followed by an intensive transgression that occurred between 9.4 and 8.5 ka BP and brought sea level up 25 m (from ca. –45 to ca. –20 m) with an average rate of 2.5 cm/y^{-1}. Then, the sea-level rise stopped, and a coastline at ca. –20 m was formed between 8.5 and 7.4 ka BP. Starting from 7.4 ka BP, the next transgression brought sea level to ca. –12 m at 6.7 ka BP. Then, sea-level rise stopped, enabling the formation of the next coastline between 6.4 and 5.0 ka BP. This was followed by the next transgression, which brought sea level to –3 m at 4.5 ka BP. Sea level stood at that position for 1.5 ka. At 3.0 ka BP, sea level started to drop again, forming the next coastline at ca. –12 m within the age interval of 2.5–2.6 ka BP. Time-wise, this sea-level drop corresponds to the Phanagorian regression described first by Fedorov (1978) and later found in other parts of the basin (e.g., Yanko-Hombach et al., 2007). By 2.0–1.9 ka BP, the sea level returned to its previous position at ca. 2 m and later reached its present mark.

Acknowledgments

This paper is a contribution to the Russian-Ukrainian project No. Ф28/428-2009 "The Northwestern Black Sea Region and Global Climate Change: Environmental evolution during the last 20 ka and forecast for the 21st century" sponsored by the State Fund for Fundamental Research, Ukraine.

We are very grateful to Valentina Yanko-Hombach and Allan Gilbert for English translation and editing of this paper, respectively.

Our sincere gratitude goes to an anonymous reviewer for critical comments that allowed us to improve the paper.

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