Geological-lithological structure of limans as a key to decoding Late Neoeuxinian and Holocene history of the Black Sea

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Introduction

The Black Sea (Prichernomorian) limans are unique geographical and geological features. The study of the geological structure of liman deposits can aid in unraveling some of the pages of the geological history of the Black Sea basin during Late Neoeuxinian and Holocene. The uniqueness of limans consists of the following: 1) the thickness of Neoeuxinian and Holocene deposits greatly exceeds their thickness on the shelf, continental slope, and the deep sea (where it reaches in the some cases 10-25 m); 2) the lithological structure of deposits is rather diverse; based on lithological composition, the deposits are clearly stratified; 3) the majjor faunal complexes range from freshwater up to stenohaline, and 4) limans belong to the first belt of avalanche sedimentation and represent a zone of a geochemical barrier.

There is an extensive bibliography about various aspects of geology of the Black Sea limans (Shnyukov, 1984).

The analysis of the literature and our data provide the basis for summarizing the paleogeography of limans and for reconstruction of sea-level changes of the Black Sea during Late Neoeuxinian and Holocene.

Study area

Our study sites include limans of the Northwestern Black Sea: Sasyc, Dzhanshey, Shagani, Alibey, Burnas, Budaksky, Dneistrovsky, Suhoy, Hadzhibey, Kuyal'nik, Grigorievsky, Tiligulsky, Berezansky, and Dnepro-Bugsky.

Data and methods

The study of the geological structure and geochemistry of liman deposits is based on boreholes (more than 300), vibracores (more than 50), and sediment samples. The following characteristics were investigated: grain size, faunal content, structure of deposits, chemical composition of deposits and pore waters, and their physical and mechanical properties. The parameters of properties were determined using traditional techniques and standards of the former USSR and the Ukraine (Konikov, 2006). The statistical laboratory data-processing included: cross-correlation, factorial, cluster and spectral analyses, as well as methods of cyclic analysis (analysis of Markov properties of linear series).

Results

Based on borehole data, the geological structure of limans has been analyzed. Erosive valleys of limans were formed in the Late Würm (Neoeuxinian regression) and expose the Quaternary deposits, as well as Pontian, Meotian and Sarmatian (N_1s_3) horizons of the Neogene. Depth of erosive valleys has absolute marks from -19 to -32 m (Sasyc, Dzhansheisky, Shagani, Alibei, Burnas), and up to -45 to -52 m (Dneistrovsky, Suhoy, Hadzhibeisky, Kuyal'nik, Grigorievsky, Tiligulsky, Berezansky, Dnepro-Bugsky). The valleys of limans extend onto the shelf.

Incised valleys are filled with Neoeuxinian (regressive stage) alluvial deposits, marine, and liman-marine deposits of Late Neoeuxinian and Holocene age. Their total thickness changes from 7-10 m up to 45 m. The age of alluvium is 26.8 - 11.7 ^{14}C ky BP (uncorrected). Thickness of alluvial deposits has a rhythmic structure. The rhythms consist of alternation of river-bed sand with gravel and facies of fluvio-lacustrine silt and clay. The maximum number of rhythms ranges from three to four.

Alluvial deposits are overlain by transgressive liman-lacustrine deposits (11.5-9.2 ky BP). Sometimes, the surface of these deposits is covered by peat ranging from 0.3-0.5 m to 1.0-1.2 m in thickness. The liman-marine and liman deposits are represented by cyclic strata (Voskoboinikov et al., 1982; Konikov, 1993). Based on their lithological structure, these cycles represent alternation of clayey mud, silty mud, and muddy shell-rich strata with average thickness from 0.5-1.5 m to 2.5 m.

The thickness of these deposits hardly varies. In the liman mouths (baymouth barrier), their thickness sometimes reaches 20 m, and in liman valleys these deposits disappear 7-20 km from the mouth. In Sasyc, Dzhansheisky, Shagani, Alibey, Burnas, and Suhoy limans these deposits are absent. The absolute marks of the upper contact of Neoeuxinian transgressive deposits vary from -28 –26 m up to -16 m.

The cyclical structure of the Holocene deposits is expressed also in the variability of their physical and mechanical properties, as well as chemical structure and salinity of pore waters (Konikov, 1993). This was proven through analysis of properties of Markov's chains, based on which we document four cycles.

Of special interest are laminae of sand in layers of mud and the study of the structure of buried wave-accumulative forms. The generations of wave-accumulative forms in cross-section are separated by strata of muddy sediments, and laminae and lenses of sand are frequently found at the same hypsometric level as coastal accumulative forms.

Discussion

The cyclical structure of Late Neoeuxinian and Holocene sediments of the Prichernomorian limans testifies to periodic oscillations of sea level. The cyclical structure of alluvium (Early Neoeuxinian) can be attributed to possibly three transgressive-regressive phases of the sedimentary basin or to sea-level stillstands. However, elevations of the upper surface of the fluvio-lacustrine deposits by themselves do not represent a similar lowering of sea level.

Availability of sand laminae, structure of the buried coastal accumulative forms, and valley incisions in the Holocene deposits unequivocally indicate the regressive phases of the Black Sea level. For example, in cross-sections of nearly all limans close to their mouths, the Fanagorean (Olbian) regression is precisely fixed.

The regressive series is represented by deposits of the wave-formed facies with characteristic faunal complex (Shnuykov et al., 1984). Elevations of the upper surface of these deposits range from 5-7 m to 10-12 m. We have fixed the following regressive level of the marine basin at -12 to -16 m (Voskoboinikov et al., 1982; Konikov, 2004). For the first time this level was documented in sediments of the Hadzhibeisky liman, and the regression was called Hadzhibeian. Obviously, this regression happened rather fast, starting ca. 4.5-4.4 ky BP and ending about 3.8 ky BP.

Approximately 6.2-6.1 ky BP, the Black Sea was in a regressive stage. This event is manifested by incised valleys in the Holocene sediments of limans. Most clearly these ancient valleys are documented in the structure of Budaksky and Dniestrovsky limans up to depths of -16 -20 m (cross-sections of baymouth barriers). Here they are infilled with liman sand and silty mud. Ancient incised valleys are overlain by sediments of Kalamitian and Dzhemetinian age (younger than 5.7 ky BP). The maximum elevations of Holocene deposits in the limans are +0.5 to +2.0 m.

Conclusions

Incised valleys of the Prichernomorian limans, which formed about 20 ky BP, are filled with cyclically-stratified Late Neoeuxinian and Holocene deposits. The Late Neoeuxinian strata are represented by alluvium (sand, silt, clay) and liman-lagoon clay. In alluvial section, a minimum of three transgressive-regressive cycles can be differentiated with confidence.

In cross-sections of Holocene sediments, wave-accumulative forms and buried incised valleys can be used to determine the levels of regressions of the Black Sea. We recognize at least four such levels. Their stratigraphic relationships are ascertained based on studies of mollusk fauna and radiocarbon dating. The fourth regression - medieval - is recognized by us based on indirect data (results of Markov's chains analysis). The amplitude of transgressive-regressive oscillations varied from 3-5 m to 10-15 m. Thus, on the basis of the studies of geological structure of the Prichernomorian limans, it is possible to reconstruct the Late Neoeuxinian – Holocene sea-level oscillations of the Black Sea.

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