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Identification and age of submarine Girkanian sediment beds (Upper Pleistocene) in the Caspian Sea

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ABSTRACT

For the first time, the Upper Pleistocene Girkanian sediment subhorizon was recorded in the submarine boreholes of the northern Caspian Sea and its radiocarbon age was estimated. Girkanian beds lying at a depth of 25 m beneath the seafloor were studied by lithological, biostratigraphical, seismic and radiocarbon dating methods. They were distinguished based on the characteristic assemblage of Mollusca (*Didacna subcatillus*, *D. cristata*, *Corbicula fluminalis*, etc.). This assemblage is similar to its onshore analogue and differs from the fauna of the underlying Upper Khazarian (*D. surahanica*, *D. nalivkini*, etc.) and overlying Lower Khvalynian (*D. ebersini*, *D. parallella*, *D. protracta*, etc.) layers. Acoustic profiling indicates the ubiquity of the horizon in the northern Caspian Sea, as seen from the clear correlation between boreholes. AMS ^{14}C dating has shown that the age of the Girkanian deposits exceeds 55 ka. Their real age haze to be about 80 ka. The obtained results on identification and age estimation of Girkanian beds are an important contribution to the verification of the Upper Pleistocene stratigraphy of the Caspian Sea region.

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1. Introduction

The Girkanian epoch is the least studied and most controversial part of the Quaternary history of the Caspian Sea. It has received scant attention from the research community. Goretskiy (1957) first reported Girkanian deposits in the material of cores of the northwest of the Caspian region and Manych valley. He correlated them to the Upper Khazarian beds of the Caspian Sea. Based on the same materials, Popov (1957, 1961) described transgressive Girkanian beds in the northern Near Caspian Sea Region and eastern Manych valley as the third, lowermost horizon of the Khvalynian sediment sequence. These beds contained Khvalynian-type fauna but temporally preceded the maximum stage of the Caspian Sea Khvalynian transgression. Later Popov (1967, 1983) distinguished a separate Girkanian transgression of the Caspian Sea due to the finding of a thick layer of Atelian subaerial sands separating Girkanian and Khvalynian beds. From the malacological point of view, this transgression is characterized by the dominance of *Didacna cristata*, *D. subcatillus*, *D. hyrcana* and the occurrence of thermophilous freshwater species *Corbicula fluminalis*.

Popov's ideas were criticized by Vasil'ev and Fedorov (1965, 1978), Shkatova (1975, 2005, 2010), Svitoch (2013, 2014), Svitoch and Yanina (1997), Svitoch et al. (1998). The main objection was that the Girkanian beds of the Lower Volga River Region represent the freshened facies of the Upper Khazarian beds with molluscan assemblage dominated by *Didacna trigonoides* and extremely rare small-sized *D. surachanica*. Svitoch and Yanina (1997), Svitoch et al. (1998) supposed that Popov erroneously regarded Khazarian malacofauna of different age (both, early and late Khazarian) as Girkanian one. Most researchers accept Fedorov's opinion that the Girkanian and Upper Khazarian horizons represent the same horizon of the Caspian Sea Pleistocene stratigraphic sequence. Nevesskaya (2007) included molluscan assemblage from Girkanian beds systematically described by Popov (1983) into Khvalynian fauna. Yanina (2006, 2012, 2014) and Yanina et al. (2014) regarded the Late Khazarian and Girkanian faunas as the two assemblages of the Late Khazarian malacofauna of different age, of which the younger one (Girkanian) characterized the freshened environment of the second half of the Late Khazarian transgression.

No absolute age estimation of Girkanian beds has been done so far although this might have solved the above-mentioned contradictions. Only one questionable AMS^{14}C dating of 43 cal ka has been published (Tudryn et al., 2013; Lavrushin et al., 2014). Its

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interpretation is controversial. In one case, this dating is assigned to the Upper Khazarian beds (Tudryn et al., 2013), in another case, to the Girkanian ones (Lavrushin et al., 2014). Unfortunately, in the latter case, the Girkanian horizon was not substantiated, since the authors did not provide its paleontological description.

Due to recent oil prospecting activities in the northern Caspian Sea, new high-quality seismoacoustic records were obtained and numerous prospecting boreholes were drilled. This allows for a re-assessment of the problem of a separate Girkanian stage in the Pleistocene history of the Caspian Sea. This research is aimed at the substantiation of the Girkanian subhorizon in the stratigraphic sediment sequence of the northern Caspian Sea and its age range estimation by means of AMS ^{14}C radiocarbon dating.

2. Study area

The Caspian Sea occupies the heterogeneous depression in the structure of the Earth's crust. At the southern half, it belongs to the Alpine orogen (Caucasus) and at the northern part to the Eastern European Platform and Scythian Plate (Fig. 1) (Glumov et al., 2004). The northern Caspian Sea is a shallow basin with an area of less than 90,000 km^2. The northern coast is a lowland, lying below the sea level (−28 m). The modern seabed morphology is a result of the long development of accumulative and denudation processes under conditions of repeated sea-level changes. Water depth increases from the north (Volga River delta) to the south (Mangyshlak threshold) from 0 m to 50 m (Fig. 1) (Svitoch, 2014).

The climate in the area of the northern Caspian Sea and adjacent land is arid. Therefore, water balance is determined by a combination of river discharge (Volga, Ural, Terek, Kuma, Emba) and precipitation/evaporation ratio. These factors cause past and present sea-level fluctuations. Large input of freshwater by rivers lowers salinity in the northern Caspian Sea. Unlike other parts of the sea, salinity here varies from 1 psμ in the north (Volga River delta) to 10 psμ at the boundary with the middle Caspian Sea that runs along the Mangyshlak threshold. This fact affects the development of freshwater, brackish water, and marine species of fauna and flora, the ratio between which varied during transgressive and regressive epochs.

3. Materials and methods

This research is based on the data collected in several areas of the northern Caspian Sea within the water depth interval 5–50 m by means of seismic profiles covering several hundreds of kilometres and dozens of up to 100 m long Quaternary sediment cores. The paper presents the results from three areas located in the central part of the shelf at water depths of 8–12 m (see Fig. 1).

Sediment cores up to 6 m in length were retrieved by a piston corer. Drilling of boreholes was carried out from drilling vessel "Zokhrab Veliev" (Azerbaijan) and from a special drilling platform. In order to decipher the sediment structure down to 200 m and to correlate core sections, seismic acoustic profiling was performed in low-frequency (Sparker) and high-frequency (Boomer) modifications. Profiles varied in length from several kilometers to several dozens of kilometers. Lithological description of the cores and sampling for paleontological investigations were carried out onboard.

Biostratigraphic subdivision of the sections is based on the downcore variability between freshwater, brackish water, and marine assemblages of Mollusca belonging to the genera *Cerastoderma*, *Mytilaster*, *Abra*, *Didacna*, *Adacna*, *Hypanis*, *Monodacna*, *Dreissena*, *Unio*, *Limnaea*, *Radix*, etc.

Radiocarbon ages of sediments were determined on mollusc shells by means of AMS method. Only complete well-preserved specimens without any signs of redeposition were collected for dating. X-ray diffraction analysis was used to confirm the absence of re-crystallization. The measurements were conducted at Lawrence Livermore National Laboratory (LLNL, USA) by T.Guilderson and 14CHRONO Centre University of Belfast (Northern Ireland) by P.Reimer.The measurement procedure in LLNL is described in detail elsewhere (Fairbanks et al., 2005). Age calibration was performed using the program Calpal-2007 online (Danzeglocke et al., 2015).

4. Results

4.1. Biostratigraphy

According to seismic acoustic profiling, Quaternary deposits

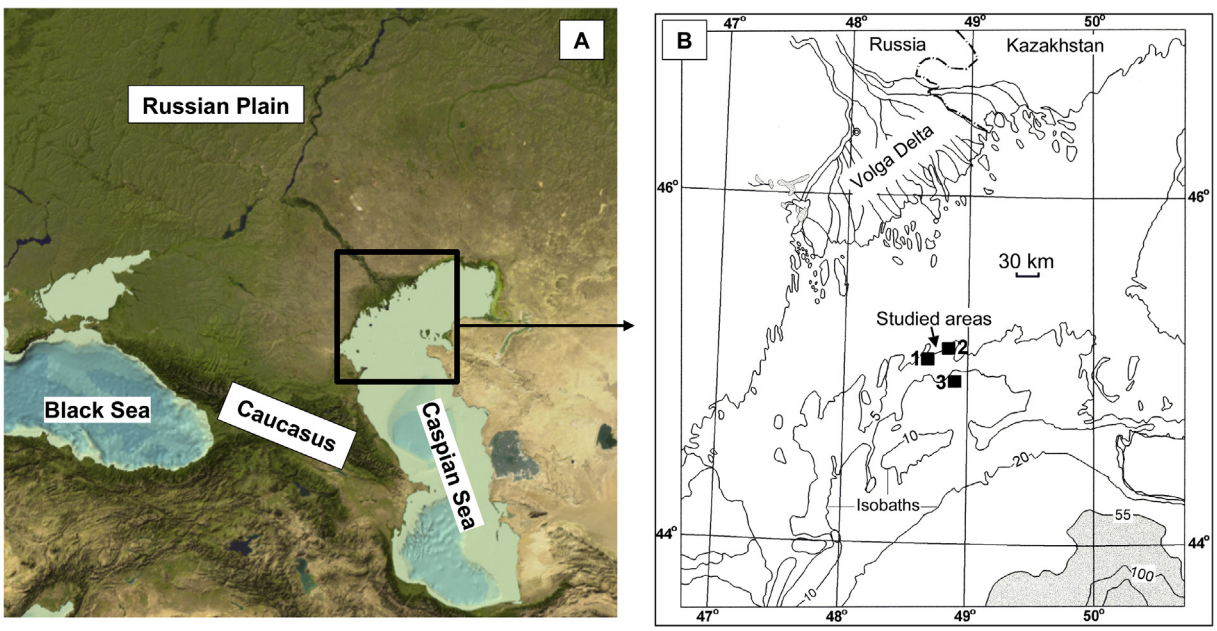

Fig. 1. Topography and location of the study areas. A) The Caspian and Black Seas showed on a part of the GEBCO world map; B) location of the study areas.

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