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GEOGRAPHY

The Khvalynian Fauna of the Manych Depression

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The Manych Depression confined to the eponymous trough comprises three neotectonic depressions (West Manych, Manych–Gudilov, and East Manych) separated by the Zunda–Tolga and Sal'sk uplifts. In the Pleistocene, it served as a strait between the Caspian and Azov–Black Sea basins. This is suggested by a marine sequence alternating with lacustrine and alluvial deposits, which form up to five terraces in valleys of the West Manych and East Manych depressions [7]. The first (Khvalynian) terrace is developed throughout the region and clearly traced in the region testifying to the last opening of the strait during the Khvalynian transgression epoch of the Caspian Sea.

Consensus of opinion on this event is lacking among researchers of the Ponto–Caspian region. Kvasov [2], Chepalyga [10], and other researchers assumed a catastrophic water overflow from the Khvalynian Caspian Sea filled with meltwater into the Neoeuxinian basin of the Pontian. According to Fedorov [9], Popov [7], Menabde and Svitoch [5], and Yanina [11], the process was not catastrophic and promoted the development of the equilibrium profile with slopes characteristic of lowland rivers. Concepts of water salinity in this strait vary from water desalinated by meltwater [2, 4, 9] to brackish water (with normal Caspian-type salinity) [5, 10, 11], which was desalinated by river runoff.

One of the reasons for this ambiguity is the lack of the factual material, particularly on the Khvalynian fauna of the Manych Depression, which is mainly known from finds in the core of boreholes [1, 7, 9]. Natural sections (localities of Khvalynian mollusks) were described only in the West Manych depression [3, 7, 8], and such descriptions are unavailable for the eastern part of the paleostrait.

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During the field season of 2006, we found and studied a series of new localities of the Khvalynian fauna (Fig. 1), the analysis of which allowed us to elucidate some problems of the Khvalynian history of the Manych Depression.

(Locality A) The right bank of the Vostochnyi Manych River, 1 km east of the Chograi reservoir dam. The structure of the low fluvial terrace above the floodplain with an altitude of about 20 m is exposed in a quarry (Fig. 2a). The eolian silt and chestnut soil bed (Bed 1) is underlain by the following beds:

(Bed 2) Brown, tight sandy loam, 0.2 m thick (terrestrial aqueous sediments?).

(Bed 3) Yellow and brown-gray, well graded, tight sand with fragments of *Didacna* sp., *Hypanis plicatus* (Eichw.), and *Monodacna* sp. mollusk shells. The boundary is even. The thickness is 1.5 m.

(Bed 4) Thin laminas of sand and muddy gray-brown silt alternating with gray, thin-layered and fine sand. Two interlayers of Khvalynian coquina with a similar species composition are revealed in the bed, the upper one differing by the shell abundance. Taphocoenoses are mainly represented by *Hypanis plicatus* (Eichw.) with a prevalence of large and medium-size

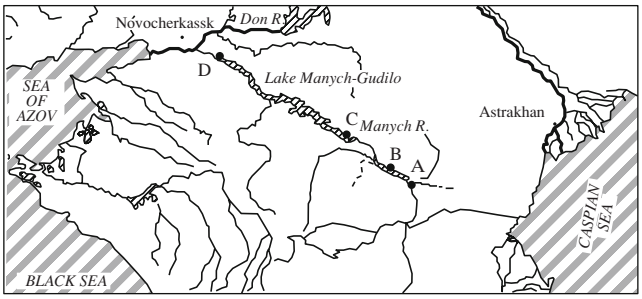

Fig. 1. Localities of the Khvalynian malacofauna. (A) Chograi dam; (B) Zunda–Tolga; (C) Levyi Island; (D) Manych–Balabino.

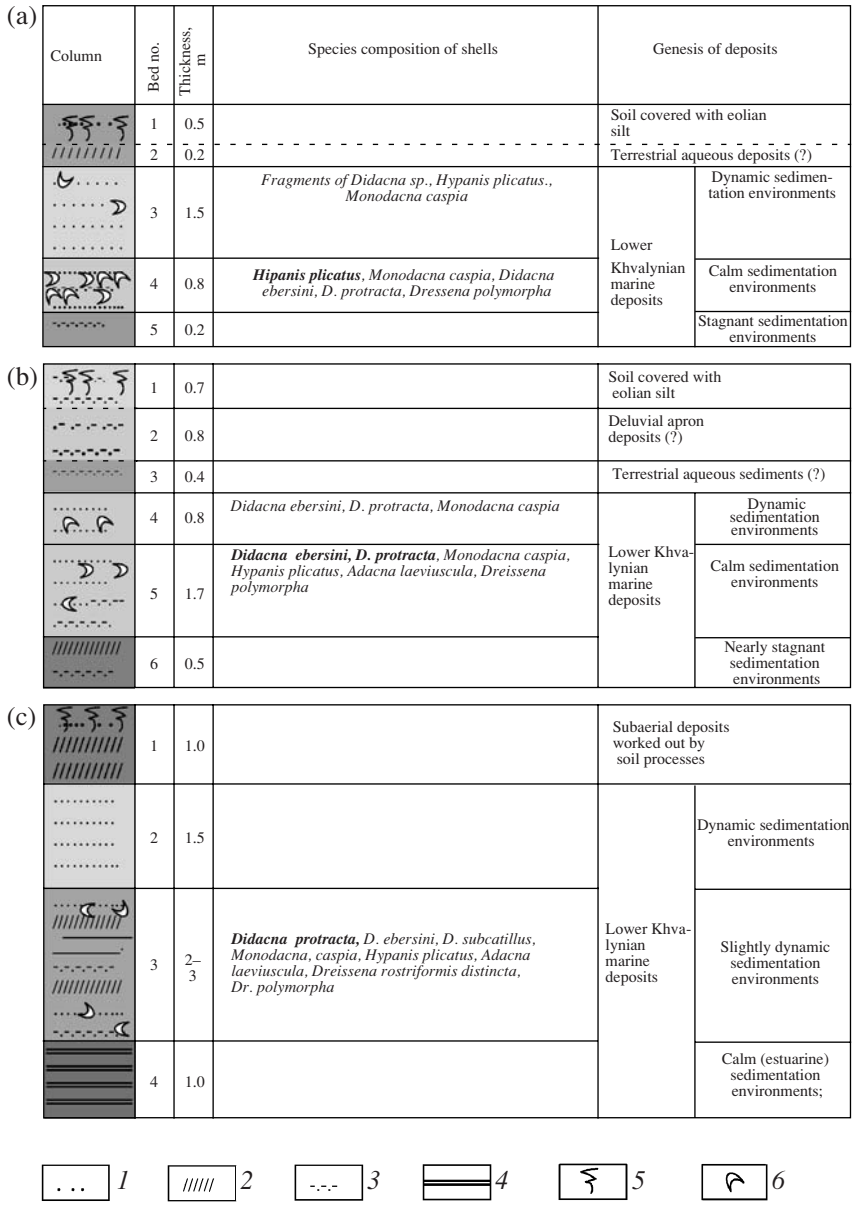

Fig. 2. The structure of Khvalynian malacofauna localities. (a) Chograi dam; (b) Zunda–Tolga; (c) Levyi Island; (*1*) sand; (*2*) loam; (*3*) sandy loam; (*4*) clay; (*5*) soil; (*6*) mollusk shells. Predominating mollusk species are given in bold.

shells. *Monodacna caspia* (Eichw.) and *Didacna ebersini* Fed. (*D. trigonoides chvalynica* Svit.) are abundant. *D. protracta* (Eichw.) and *Dreissena polymorpha* Pall. shells are rare. Shells of Khazarian species with traces of redeposition are solitary. Transition to the underlying bed is gradual. The thickness is 0.7–0.8 m.

(Bed 5) Muddy brown-gray silt with thin laminas of ferruginized sand. The apparent thickness is 0.2 m.

Beds 3–5 represent lower Khvalynian deposits characterized by a mollusk community with early Khvalynian index species *Didacna ebersini* Fed. and *D. protracta* (Eichw.). Judging from their facies characteristics, sedimentation proceeded under stagnant (Bed 5), calm (Bed 4), and rather dynamic (Bed 3) conditions.

(Locality B) The Zunda–Tolga area. The structure of the slightly southward inclined Khvalynian plain (altitude 50–30 m) is exposed in the abrasion scarp on the northern shore of the Chograi reservoir (Fig. 2B). The eolian silt and soil sequence (Beds 1–2) is underlain by the following beds:

(Bed 3) Brown-gray sand and silt with spots of ferrugination and obscure horizontal bedding in the lower part. The boundary is distinct. The thickness is 0.4 m (terrestrial aqueous sediments similar in structure and position to Bed 2 in Section A).

(Bed 4) Yellow-gray and yellow, well-graded sand with a very thin horizontal-wavy and banded bedding related to layer-by-layer ferrugination. The bed contains rare shells of Khvalynian mollusks *Didacna ebersini* Fed., *D. protracta* (Eichw.), and *Monodacna caspia* (Eichw.). The apparent thickness is 0.6 m.

The highest part of the Khvalynian plain exposed 1.5 km eastward shows the following underlying beds:

(Bed 5) Gray, graded, fine-grained, wavy and diagonally bedded sand with shells of mollusks mainly represented by *Didacna ebersini* Fed. and small *D. protracta* (Eichw.). Representatives of the *Monodacna caspia* (Eichw.) and *Dreissena polymorpha* Pall. species are rare. *Hypanis plicatus* (Eichw.), *Adacna laeviuscula* (Eichw.), and *Sphaerium* sp. are sporadic. The lower boundary is distinct. The thickness is 1.7 m.

(Bed 6) Muddy brown-gray sand and sandy loam (more rarely loam). The sand is more washed and yellow with thin horizontal and wavy bedding. The apparent thickness is 0.5 m.

The Zunda–Tolga section exposes the following three lithological members of lower Khvalynian deposits, which reflect different sedimentation conditions. The upper member (Bed 4) is represented by washed laminated sand, which characterizes dynamic sedimentation conditions. The middle member (Bed 5), which is the main locality of the early Khvalynian microfauna, is made up of sand and sandy loam with diverse bedding that indicates more calm sedimentation conditions. The lower member (Bed 6) is composed of muddy sand and sandy loam reflecting calm (nearly stagnant) conditions of the basin.

(Locality C) The western edge of Levyi Island on Lake Manych. The abrasion scarp exposes the Khvalynian terrace (altitude 25–27 m) overlapped by a thin cover of subaerial deposits and well-reworked steppe soil at the top (Bed 1). The terrace is underlain by the following beds (Fig. 2c):

(Bed 2) Yellow-gray sand with thin horizontal and oblique bedding. The thickness is 1.5 m.

(Bed 3) Yellow–gray sand and sandy loam alternating with silt and chocolate-like clay. Mollusk shells are abundant and dominated by *Didacna protracta* (Eichw.) (relatively large forms). *D. ebersini* Fed. (small forms), *Monodacna caspia* (Eichw.), and *Dreissena polymorpha* Pall. are subordinate. *Didacna subcatillus* Andrus. (small shells), *Hypanis plicatus* (Eichw.), *Adacna laeviuscula* (Eichw.), and *Dreissena rostriformis distincta* (Andrus.) are sporadic. The thickness is 2–3 m.

(Bed 4) Chocolatelike clay with thin interlayers of silt, slab jointing, and a manganese film. The apparent thickness is 1.0 m.

The Lower Khvalynian deposits are represented by Beds 2–4. Their lithological composition suggests the replacement of calm-stagnant (estuarine) sedimentation conditions (chocolatelike clay of Bed 4) by less calm (Bed 3) and dynamic (Bed 2) conditions.

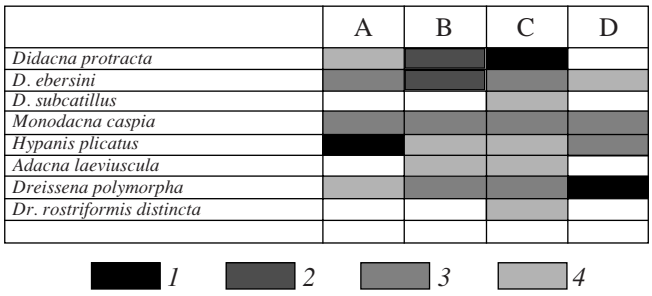

Fig. 3. The species composition of the Khvalynian fauna in different localities: (A) Chograi dam, (B) Zunda–Tolga, (C) Levyi Island, (D) Manych–Balabino. Relative abundance of species shells: (*1*) abundant, (*2*) numerous; (*3*) rare; (*4*) sporadic specimens.

(Locality D). The Manych–Balabino area situated in the western part of the Manych Depression has been described repeatedly in the literature [3, 7, 8, 11]. We analyzed previously the malacofauna found in the deposits [8, 11]. Marine sediments are represented by sandy loam and poorly graded sand. The sediments comprise abundant mollusk shells with different degrees of preservation. They have a mixed ecological and age compositions indicating the relation to different paleobasins. Only the depleted Khvalynian assemblage is found in situ. It is composed of rare representatives of the *Didacna ebersini* Fed. species, abundant *Dreissena polymorpha* Pall. and *Dr. rostriformis distincta* Andrus., and subordinate *Monodacna* and *Adacna*.

The Khvalynian malacofauna from the studied localities comprises representatives of three cardioid genera (*Didacna* Eichw., *Monodacna* (Eichw.), and *Adacna* Eichw.) and the *Dreissena* van Beneden genus of the Dreissena family. The *Didacna protracta* Eichw., *D. eberseni* Fed., and *D. subcatillus* Andrus. species are typical representatives of the Khvalynian malacofauna of the Caspian Sea. The first and second species represent the index species for the early Khvalynian basin. Judging from the ecological characteristics of Didacna forms, they are typical Caspian brackish-water species. *D. protracta* and *D. subcatillus* belong to relatively salinophilic species preferring conditions of salinity within 11–13‰. Salinity within 7–11‰ represents optimum conditions for the *Didacna trigonoides* group, which includes the *D. ebersini* species.

The species composition of mollusk shells (Figs. 3, 4) from localities of the early Khvalynian fauna (the presence of abundant *Didacna protracta*) indicates that salinity of the early Khvalynian transgression water flowing into the Manych Strait was similar to that of the present-day central Caspian region. Water in the western part of the strait was substantially desalinated by the water of its tributaries. This is evidenced by abundant *Dreissena* and rare representatives of *Didacna trigonoides* in the Manych–Balabino locality.

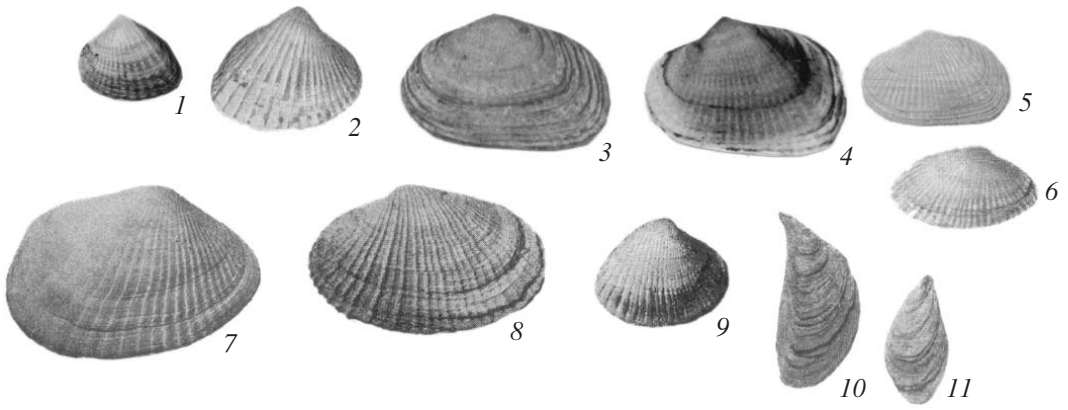

Fig. 4. Khvalynian malacofauna of the Manych Depression. (*1, 2*) *Didacna ebersini*, (*3–5*) *D. protracta*, (*6*) *D. subcatillus*, (*7*) *Adacna laeviuscula*, (*8*) *Hypanis plicatus*, (*9*) *Monodacna caspia*, (*10*) *Dreissena polymorpha*, (*11*) *Dr. rostriformis distincta*.

Localities of the Khvalynian fauna in the eastern part of the paleostrait occur at different hypsometric levels and exhibit different quantitative compositions of species at a similar taxonomic composition. Hence, their distribution reflects different stages of the Khvalynian water overflow through the strait to the Azov–Black Sea basin. Judging from the geomorphological position, the locality near the Chograi dam is likely to be the oldest one reflecting conditions of the initial functioning of the Manych strait. The predominance of *Monodacna* and *Adacna* representatives suggests that the conditions were very calm (similar to estuarine and lacustrine conditions) with the salinity within 7–9‰.

The Zunda–Tolga and Levyi Island localities belong to the main epoch of the strait functioning when the salinity of Khvalynian water could reach 11–12‰, as evidenced by abundant *Didacna protracta*. This is also indicated by the similarity of malacofauna communities of these localities and mollusks characterizing the epoch of maximal development of the early Khvalynian transgression [6]. Dating of the *Didacna ebersini* shell from Bed 5 in the Zunda–Tolga section by the AMS method at Groningen University (the Netherlands) yielded a ^{14}C age of 12740 ± 50 yr BP (GrA-33717), which corresponds to the calibrated age of 14 030–14 670 yr BP. This date confirms the inference suggested previously [8 and others] about a "young" age of the early Khvalynian transgression of the Caspian Sea.

CONCLUSIONS

(1) The Khvalynian malacofauna from new localities in the East Manych Depression is characterized by the prevalence of brackish-water didacnas. Their two species (*Didacna protracta* and *D. ebersini*) serve as index species for the early Khvalynian fauna complex of the Caspian Sea.

(2) The species composition of fauna communities from localities of the East Manych Depression reflects conditions of strait salinity within 10–12‰. In the West Manych Depression at the exit from the strait, its water was substantially desalinated.

(3) Localities of malacofauna in the East Manych Depression characterize different stages of early Khvalynian transgression water outflow into the Neoeuxinian basin. The earliest stage is recorded in the locality near the Chograi dam. The later (maximum) stage is recorded in the Zunda–Tonga and Levyi Island localities. They indicate that salinity of the strait water was approximately 12‰.

(4) The geological structure of the localities indicates a successive replacement of hydrological conditions in the strait from a calm (stagnant) regime to a shallow-water and dynamic (not stagnant) regime.

(5) Taphocoenoses of the Khvalynian fauna in the East Manych Depression are compositionally similar to mollusk communities from the northwestern Caspian region during the epoch of maximal early Khvalynian transgression.

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