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The Khvalynian transgressions and early human settlement in the Caspian basin

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ABSTRACT

Radiocarbon dates for both Lower and Upper Khavalynian transgressions fall in the timespan between 10 and 17 ka BP, with 13.6–11.8 ka BP, as the most probable age. This transgression supposedly proceeded as a rapid succession of sea-level fluctuations. The initial emergence of Mousterian industries in the Caspian basin as indicated by the Volgograd site, might be correlated with a mild interval preceding the Atelian regression, which was broadly contemporaneous with the Last Glacial maximum (25–18 ka BP). The subsequent expansion of Mousterian sites was largely coeval with the Khvalynian transgression. Supposedly, specific environments that arose in the Caspian basin favoured a prolonged conservation of the Mousterian technique, and, possibly, a survival of Neanderthal populations. A possible factor is a 'cascade' of Eurasian basins that included the Caspian-Black Sea 'spillway', which effectively isolated the Caucasian-Central-Asian area.

1. Introduction

The land-locked Caspian Sea that now stands at −27 m below oceanic sea level (Fig. 1) experienced repeated sea-level changes during the course of Late Pleistocene and Holocene. These changes, which directly affected the early human settlements in the Caspian Sea basin, are now the subject of multidisciplinary international studies (Kroonenberg and RusakovSvitoch, 1997, Kroonenberg et al., 2000, Leroy et al., 2000). Notwithstanding considerable progress recently attained, numerous problems remain unresolved and hotly debated.

One of the major controversial issues concerns the Khvalynian transgression. This transgression was first recognised in the late 19th century (Andrusov, 1888, 1900) and subsequently was studied by Russian geologists with the use of geomorphic, geological and micro-palaeontological (molluscan) evidence (Pravoslavlev, 1926; Leontjev, 1961; Svitoch, 1991 and many others).

The Khvalynian transgression was preceded by the Atelian regression. In its course, considerable shelf areas in the northern part of the Caspian Sea were exposed and the brackish water mollusc assemblages with *Didacna trigonoides* became dominant (Svitoch, 1991, 64). Mainly based on geomorphic criteria, two major phases of the Khvalynian transgression were recognised. The coastal landforms and corresponding deposits situated above 0 m asl are classified as the Early Khvalynian, whereas those between 0 and −17 m are viewed as the Late Khvalynian (Svitoch, 1991, 65).

The Early Khvalynian transgression featured the maximum rise of the Caspian Sea level during the entire Pleistocene. Sea-level reached the altitude of 48–50 m and attained the Zhiguli Height on the Volga River at 53°N (Leonov et al., 2002). Although many aspects of the palaeogeographical environments of the Khvalynian transgression are by now satisfactorily studied, its detailed chronology and the correlation with global climatic events remain controversial. Rychagov (e.g. 1997), based mostly on TL dates, suggested the age of the Early Khvalynian transgression as 70–40 ka BP, and that of the Late Khvalynian as 20–10 ka BP. Kvasov (1975) concluded that these transgressions were broadly coeval with MIS 4–2. An opposite point of view based on ^{14}C and U-Th dates was advanced by Svitoch (1991), Kaplin et al. (1993), and others, who argue for a much younger age, falling within the range of 20–7 ka BP. AMS dates in the order of 16–10 ka BP have been obtained for the samples of the transgressive phase of Early Khvalynian transgression from the sequences of the Lower Volga (Leonov et al., 2002).

Serious problems relate to the age of archaeological sites, particularly, the Mousterian ones on Khvalynian coastal landforms. The Mousterian industries, which feature complex stone-working technology, are often reliably associated with Neanderthal hominids. Both Mousterian and Neanderthal sites are found in a large areas of Eurasia stretching from the Atlantic coast of France and Iberian Peninsula and encompassing the greater part of Europe, Western Asia, Caucasus, central Asia, and, possibly, southern Siberia. In most cases the 'classical' Neanderthal and Mousterian sites are dated to the early stages of the Last Ice Age, *c.* 110–35 ka BP (MIS 5.1–4). At several sites in North-Western Europe Neanderthal skeletal remains in association with Mousterian stone industries

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Fig. 1. Caspian Sea Basin. Key: 1 – Krasnovodsk (Tuirkmen Bashi) Peninsula; 2 – Dagestan Coast; 3 – Mangyshlak; 4 – Volgograd; 5 – Kumo-Manych.

were found in the deposits dated to 170–250 ka BP (MIS 7–6) (Tuffreau and Sommé, 1988; Bringmans, 2007).

Numerous Mousterian sites were found in the Caucasus and the Pamiro–Alay mountains in Central Asia. The ages of these sites in the Caucasus range from 250 to 29 ka BP (Golovanova et al., 1999; Lyubin and Belyaeva, 2006). The complete skeleton of a child in the Mousterian cultural context, found at the Teshik-Tash rock shelter on the south-eastern extension of the Ghissar Ridge in Central Asia, has been recently confirmed by mtDNA evidence as Neanderthal, demonstrating its genetic affinity to European and Caucasian Neanderthals (Krause et al., 2007).

Available evidence suggests prolonged survival of Neanderthal populations in several areas of north-western Eurasia: until *c.* 30 ka BP in France (Gravina et al., 2005), and until 28–29 ka BP in Croatia (Smith et al., 1999). Similar ages were established for the remains of late Neanderthals in the Crimea (Chabai, 2007), and Northern Caucasus (Mezmaiskaya Cave); (Golovanova et al., 1999). Consequently, the present paper is focused on three interrelated problems:

1. The assessment of exact chronology of the Khvalynian transgressions and related landforms;
2. The correlation of Mousterian sites with Khvalynian coastal landforms; and
3. The assessment of the impact of environment on the expansion of early humans.

2. Methods of investigation

The principal method of investigations was primarily based on the correlation of the coastal landforms and sediments with archaeological layers of investigated sites with the use of GIS

Table 1
Radiocarbon dates of Khvalynian deposits on the Daghestani Coast and the Lower Volga area (after Svitoch, 1991; Rychagov, 1997; and Leonov et al., 2002).

Stage	Lab index	C-14 dates BP uncalibrated
Upper Khvalynian	MГУ-796	07330 ± 500
	MGU-794	07700 ± 250
	LU-842	08850 ± 700
	MGU-95	09700 ± 190
	LU-479A	11210 ± 850
	LU-479B	11340 ± 160
	MGU-130	11300 ± 400
	LU-193A	11750 ± 120
	LU-193B	12480 ± 150
	MGU-IOAN-34(A + B)	12200 ± 240
	MGU-IOAN-39	12800 ± 200
	LU-423B	12330 ± 140
	MO-460	12350 ± 150
	LU-424A	13110 ± 490
	LU-424B	12720 ± 400
	LU-192A	13140 ± 150
	LU-192B	13200 ± 250
	LU-1409	13540 ± 130
	LU-1361	13920 ± 740
	IOAN-129	14430 ± 230
	IOAN-130	14240 ± 640
	GIN-187	14030 ± 250
	MO-457	14400 ± 230
	LU-460A	14600 ± 210
	LU-179	14700 ± 130
	LU-73	15020 ± 500
	LG-118	15020 ± 140
	MGU-97	15500 ± 350
	MGU-IOAN-33	15100 ± 300
	IVP-226	5130 ± 400
	IVP-211	20500 ± 1200
	IVP-229	20000 ± 1500
	IVP-213	21590 ± 1200
	IVP-222	22400 ± 900
Lower Khvalynian	LG-147	08680 ± 170
	MGU-1042	09500 ± 700
	MGU-1044	09700 ± 330
	MGU-1039	10770 ± 330
	MGU-1037	11280 ± 700
	LU-425B	11740 ± 180
	MGU-98	11600 ± 140
	MGU1034	11290 ± 380
	LU-1358	11390 ± 200
	LU-841	11490 ± 380
	LU-426B	11600 ± 1000
	MGU-792	11760 ± 200
	LU-864A	11830 ± 200
	MGU-793	11820 ± 250
	MGU-IOAN-38	12150 ± 200
	GIN-66	12500 ± 140
	LU-1359	12010 ± 340
	LU-1357	12210 ± 150
	MGU-99	12050 ± 090
	AA37204	12060 ± 130
	AA37366	12120 ± 180
	AA37203	12445 ± 075
	AA37365	12470 ± 080
	LU-490A	12520 ± 140
	AA37363	12580 ± 070
	MGU-19	12600 ± 240
	LU-1353	12690 ± 100
	AA37201	13070 ± 100
	MGU-25	13100 ± 300
	AA37202	13170 ± 085
	AA37368	13240 ± 045
	MGU-1491	14300 ± 680
	LG-93	14080 ± 100
	MGU-18	15500 ± 300
	MGU-18	15600 ± 350
	MGU-97	16000 ± 330
	LU-828	16700 ± 550
	IOAN-90	17000 ± 350

(*continued on next page*)

Table 1 (*continued*)

Stage	Lab index	C-14 dates BP uncalibrated
	MGU-22	18460 ± 220
	IOAN-91	21500 ± 300
	IOAN-93	22100 ± 730
	IOAN-94	23450
	IOAN-92	23400 ± 500
	IOAN-132	24000 ± 1300
	LU-826	24200 ± 700
	LG-149	24830 ± 170
	MGU-23	30700 ± 1500

technology in four key areas in the northern and eastern Caspian basin. The age of both geological and archaeological sites was based on palaeontological evidence and radiometric techniques.

Radiocarbon measurements were obtained for the samples of mollusc shells from the Khvalynian coastal sediments (Rychagov, 1997; Leonov et al., 2002; Svitoch, 2003) (Table 1). These radiocarbon measurements were statistically processed and their frequencies evaluated. The reliability of the latter incurs serious problems. To minimise the effect of contamination by recent carbon, exclusively thick-walled molluscs (predominantly *Didacna praetrigonoides*) were selected (Chepalyga et al., 2008).

The radiocarbon reservoir effect, the offset in ^{14}C age between contemporaneous organisms from the terrestrial environment and organisms that derive their carbon from the marine environment, is no less significant. Recent investigation in the North Atlantic Ocean (Ascough, 2005) show the global average marine reservoir age of surface waters, R(t), to be *c.* 400 radiocarbon years, with regional values deviating from this as a function of climate and oceanic circulation systems. The comparison of marine and terrestrial records for the Late Glacial period show a discrepancy of about 1000 ^{14}C years with large uncertainties (Björck et al., 2003). The reservoir effect for Late Pleistocene – early Holocene sediments of Chalko Salt Lake in north-western China is assessed as 1700 radiocarbon years (Xangqi et al., 2008). In view of absence of reliable investigations focused on the radiocarbon reservoir effect in direct relation to Caspian marine molluscs, quantification was not attempted, as the reported measurements might exhibit greater reservoir ages ($\delta R = c.$ +400 to +800 ^{14}C a). As the above cited discrepancies may considerably affect the existing calibration techniques, all measurements in this paper are reported as uncalibrated BP.

The temperature and salinity of sea water were estimated based on the combined use of oxygen isotope O^{18}/O^{16}) analyses, and the measurement of Ca/Mg ratio in the aragonite extracted from *Didacna surachanica*, *Didacna crassa nalivkini* and *Didacna protracta protrac* shells, which are discussed in greater detail elsewhere (Dorefeyeva et al., 1996; Dolukhanov et al., 2008).

3. Results

3.1. Northern Caspian Lowland and the lower Volga

Intensive field studies conducted over the last decennia show the wide occurrence of landforms indicative of land-locked basins

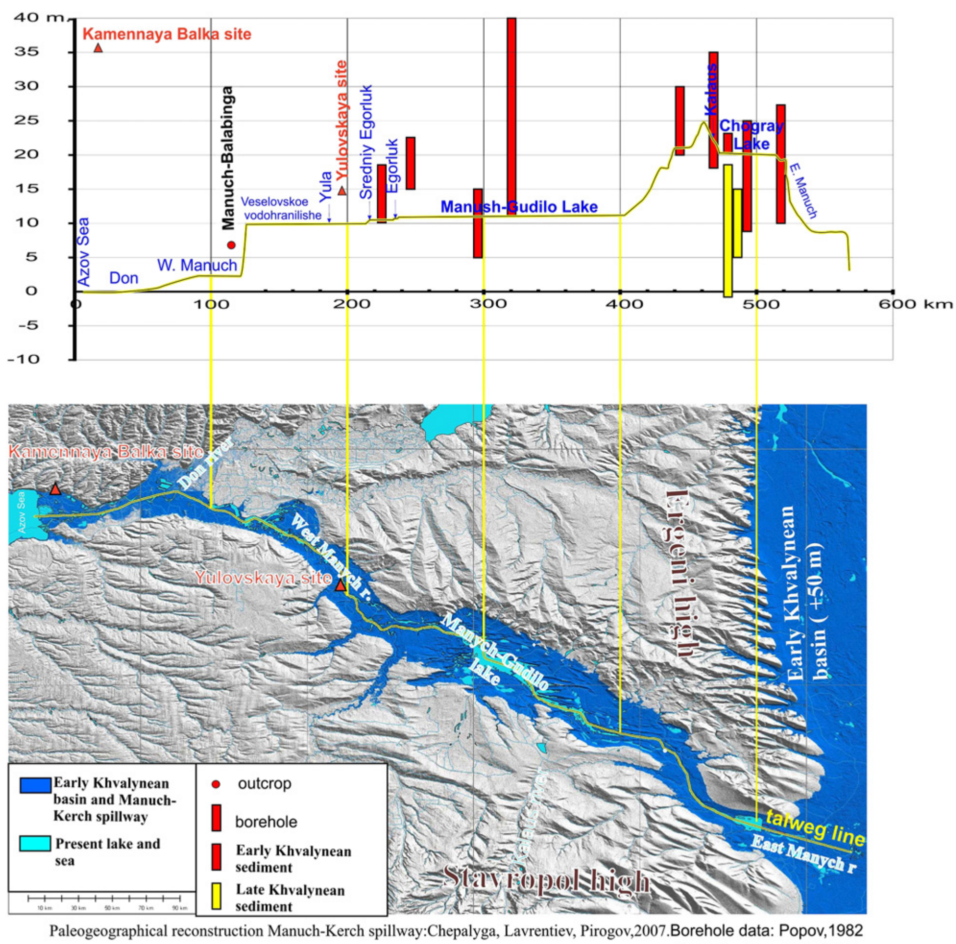

Fig. 2. Kumo-Manych Strait (GIS reconstruction).

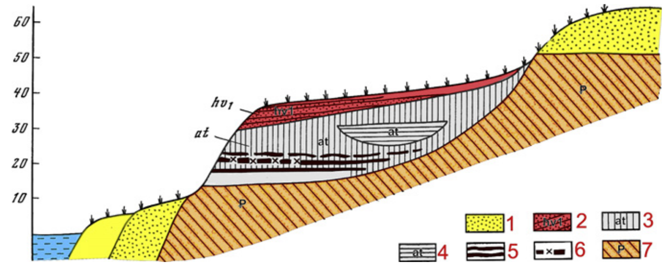

Fig. 3. The Volgograd site sequence (after Moskvitin, 1962): *Key*: 1 – sand; 2 – laminated sand (Khvalynian); 3 – Atelian loam; 4 – Atelian lake sediments; 5 – palaeosol; 6 – archaeological deposits; 7 – Palaeogene sandstone.

and lagoons within the Northern Caspian Lowland. These landforms at the altitude of about 0 m were allegedly formed by intensive flood flows in the course of the Khvalynian transgression (Badyukova, 2002, 2004). The related sediments include 'chocolate' clay, rich in hydrous ferric oxides, which Badyukova (2002) views as lagoonal-estuarine sediment formed during the Early Khvalynian transgression. Along the Lower Volga sequences (Shkatova, 1973), the Upper Khazarian sediments were usually found overlying the Lower Khvalynian sands and 'chocolate' clays. The coastal sediments at Kopanovka site included the mammal fauna: a skull of a small cave bear (*Ursus rossicus* Boris) as well as bones of small mammals: water vole (*Arvicola terrestris* L and shrew *(Sorex sp.*) (identifications made by G.F. Baryshnikov, Institute of Zoology, St. Petersburg).

As demonstrated by the isotopic data (Dorefeyeva et al., 1996; Dolukhanov et al., 2008), during the Early Khvalynian transgression the maximum summer temperatures were close to the present-day values, with both the temperature and salinity reaching their all-time Pleistocene maximums. As high spring temperatures contributed to intense snow melting, and reduced salinity, the water became isotopically 'lighter' by 3–4‰ as compared to its summer values while the total oxygen isotopic composition was 1–2‰ 'heavier' than at the initial transgression phase. During the Late Khvalynian regression both the spring and summer seawater temperatures were 5 °C lower than at its transgression phase. The isotopic composition of water oxygen was the most 'lightened' for the entire period of the Khvalynian Sea.

3.2. Kuma-Manuch strait

The Kuma-Manych valley is located along the tectonic depression of NW-SE direction in an area of Karpinsky Swell, on the southern margin of the Scythian platform. Its highest point, forming the Caspian-Black Sea watershed, is located near Zunda-Tolga village, at 25 m above the Ocean level in the mouths of Kalaus and Western Manych rivers. Its widest section, 50–55 km wide and 180 km long, is presently taken up by Manych Gudilo Lake (Popov, 1983).

The Khvalynian sediments with the typical Khvalynian mollusc fauna are recognizable all along the valley, consisting of clay and silt and, less frequently, sand. In both their texture and composition, these sediments are similar to the 'chocolate' clay of the Lower Volga. Khvalynian sediments form a row of parallel ridges on the bottom of Manych Gudilo Lake, 10–25 km long, 20–30 m high, with their width ranging from a few hundred metres to 1–2 km.

Based on geologic and paleontologic evidence, several writers (Badyukova, 2001, 2004; Chepalyga, 2007) suggest the occurrence of the "Kuma-Manych strait', via which the Caspian water was spilled into the Pont. The total length of this spillway was 950–1000 km (depending on sea-level), its width varying between 50–55 and 10 km, and the depth of about 30–50 m (Fig. 2) Taking into account the differences in the levels of the Caspian (+50 m) and the Black Sea (−80 to −100 m), the spillway bottom gradient is estimated be in the order of 0.0001, the stream velocity as ~0.2 m per s, the maximum discharge, as 40,000–50,000 m^3 per s, and the total runoff as exceeding 1000 km^3 per annum, six times greater than that of the Volga River and thrice that of the Mississippi River.

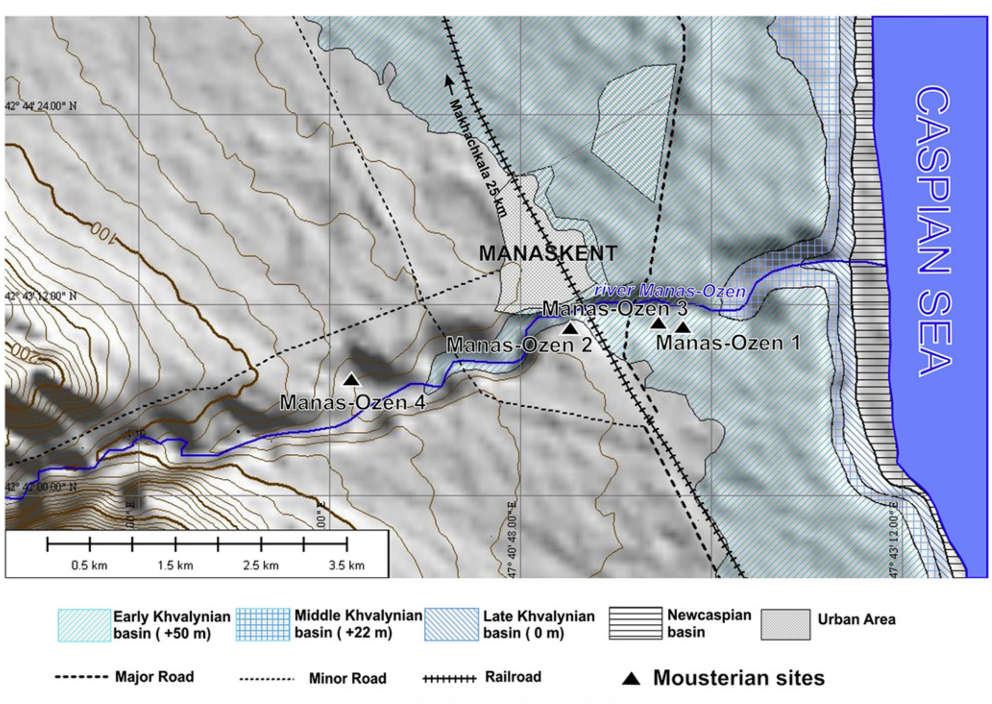

Fig. 4. Manas-Ozen' sites, Dagestan (GIS reconstruction).

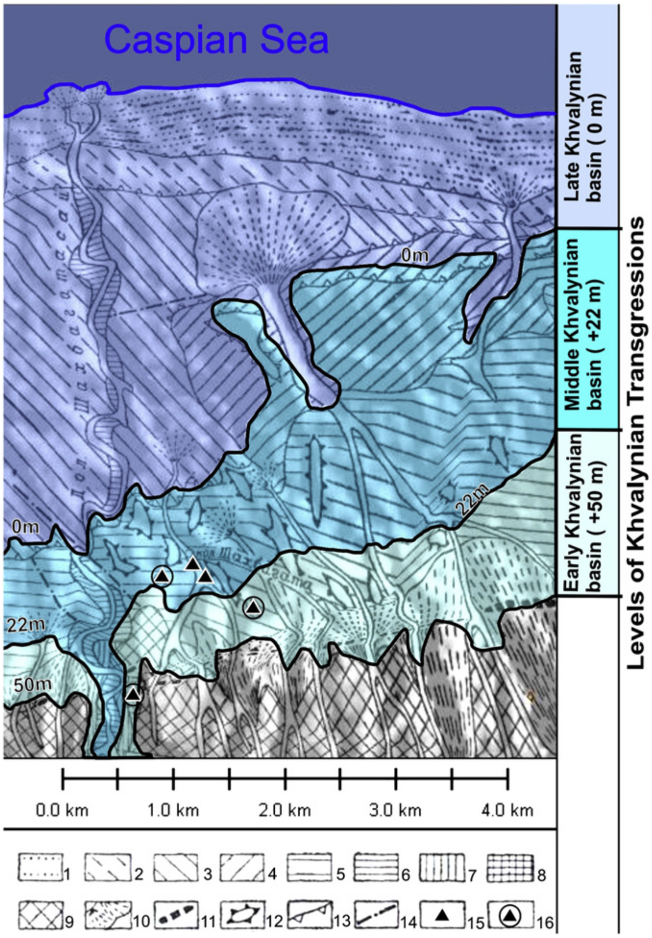

Fig. 5. Saratysh Bay sites, Mangyshlak Peninsula, after Medoev (1982) with modifications; *Key*: Marine terraces: 1 – Neocaspian; 2 – Late Khvalynian; 3 – Early Khvalynian; 4 – Bakunian abrasion terrace; 5 –Neogenic (?) aggradation terrace. River terraces: 6 – flood-plain; 7 – 1st terrace; 8 – 2nd – 4th terrace; 9 – Tyubkaragan plateau; 10 – alluvial fans and rock trains; 11 – Early Khvalynian sand barrier; 12 – residual islands; 13 – wave-cut cliff; 14 – fault-line; 15 – surface Palaeolithic sites; 16 – excavated Palaeolithic site.

3.3. *Sukhaya Mechetka (Volgograd)*

The Palaeolithic site in the northern suburb of Volgograd had been discovered in 1951 and excavated in 1952 by S.N. Zamyatin. The site was located in a deep ravine of Sukhaya Mechetka stream. According to Moskvitin (1962), two terraces of Khvalynian age are distinguishable in that area: the upper (50–45 m) and the lower ones (25–34 m). Both terraces are formed by the circumlittoral sediments: sand transforming upwards into the ‘chocolate’ clay. Both contain similar mollusc fauna which include *Didacna* ex gr. *ebersini* Fed., *D. parallela* Bog., *Adacna plicata* Eichenw., and *Dreissenia polymorpha* Pall.

The Palaeolithic site lies at the inner edge of the Khvalynian coastal sediments at depths ranging from 20 to 25–38 m, beneath c. 4 m thick Khvalynian strand sand with *D. polymorpha* and c. 1.5 m thick ‘Atelian loam’. Palaeolithic artefacts and animal bones were encountered on the surface and partly inside the palaeosol at the bottom of the ‘Atelian loam’. This palaeosol is viewed by Vasil’ev (1961) as of the ‘meadow–palustrine type’ (Fig. 3). The pollen analysis of the samples of palaeosol shows the prevalence of herbs with *Artemisia* and Chenopodiaceae and limited spruce, denoting cold-resistant steppe and semi-desert vegetation. Similar pollen spectra were discovered in the overlying ‘Atelian loam’.

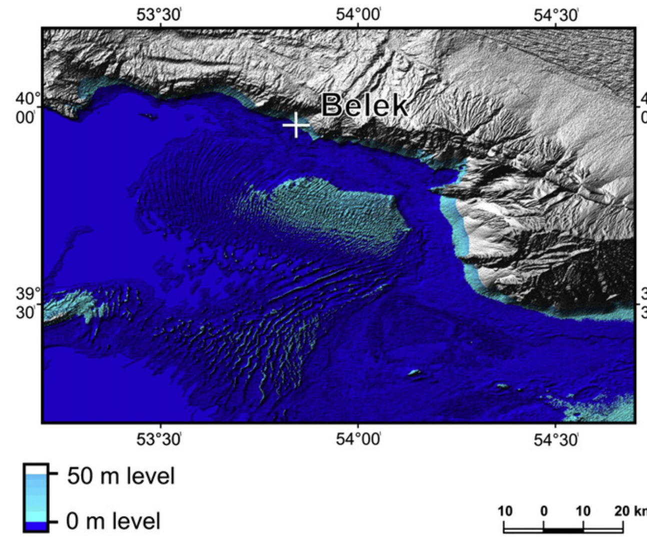

Fig. 6. Belek sites, Krasnovodsk Peninsula (GIS reconstruction).

The archaeological inventory is dominated by side-scrapers, and includes bifacial foliate points, knives, including a specific Volgograd-type knife, and a variety of bifacial tools (Zamyatin, 1961; Praslov, 1984; Vybornov et al., 2000). This industry is viewed as belonging to the Eastern Micoque Mousterian facies, stemming from Central Europe (Lyubin and Belyaeva, 2006).

Animal bones recovered from the archaeological layer include mammoth, red deer (*Cervus elaphus*), wolf (*Canis lupus*), saiga antelope (*Saiga tatarica*), and aurochs (*Bos primigenius*). The overlaying Atelian loam contained the bones of wild horse (*Equus ferus*), and reindeer (*Rangifer tarandus*) (Moskvitin, 1962).

3.4. *Dagestan coast*

The Dagestan coastal area forms the southern extension of the Caspian Lowland facing the anticline heights of the Greater Caucasus’ outer ridges. All cover deposits are formed by predominantly marine Quaternary deposits, 1000 m thick along the axis of the Terek-Sulad Delta. Nine Khvalynian marine terraces are distinguishable in the coastal area at the altitudes of 48, +35, +22, +16, +6, −5, ± 0, −6, and −12 m (Chepalyga, 2002, 2007).

Amirkhanov (1986) discovered and studied seven Mousterian sites in the lower stretches of the Manas-Ozen’ River, three of which are located below the maximum level of the Khvalynian transgression. The Manas-Ozen’ I site is located on the relic of the first terrace on the right bank of the river southeast of Manaskent village.

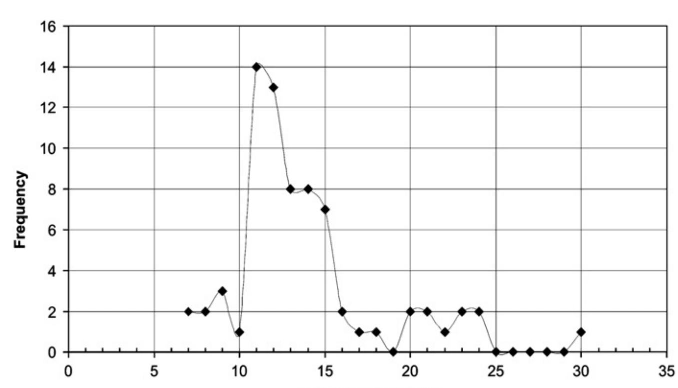

Fig. 7. Frequencies of radiocarbon dates of Khvalynian mollusc samples.

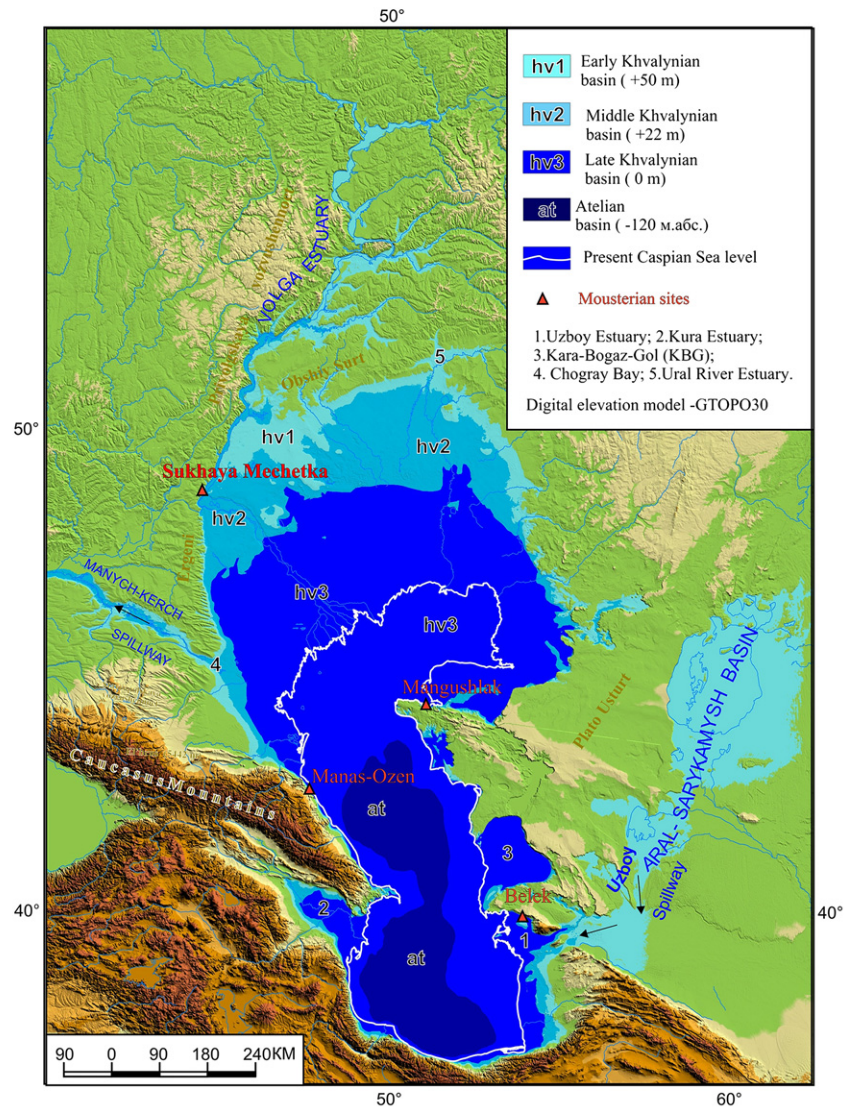

Fig. 8. The Khvalynian Sea and Mousterian sites.

The lithic inventory includes five objects, including a side-scraper on a small flake, a biface reduction flake, and two flakes, all of them with a strong patina. The assemblage is deemed to be of Mousterian age.

The Manas-Ozen' 2 site was found on the terrace of the river right bank, east of the railway line (Amirkhanov, 1986). The 26 objects include four Levallois-type flakes, one fragment of a massive polyhedral core, and numerous flakes.

The Manas-Ozen' 3 site lies on a promontory of the upper terrace extending into the flood-plain on the outskirts of Manaskent village (Amirkhanov, 1986). The lithic inventory includes three thick flakes of sub-rectangular shape with broad butts, and large percussion bulbs. All three sites include identical raw material and are stylistically similar. Hence, they may be considered as belonging to the Mousterian. The scarcity of the finds and the apparent lack of archaeological layers suggest that these were temporal short-lived sites. Inspection of these sites has shown that these sites lie on the surface of the Khvalynian terraces at the altitude of 35–45 m (Fig. 4).

3.5. Manyshlak (Tupqaraghan) Peninsula

The Mangyshlak is an oil and gas rich peninsula in the north-eastern part of the Caspian basin. Limestones of Sarmatian age form a huge tableland lying at the altitude between 70 and 132 m asl. This plateau is separated by steep escarpments ('chinks') from the coastal plain, where a system of aggradational and wave-cut terraces is evident. Several allegedly Early Palaeolithic sites were reported by Medoev (1982) from the area of Saratysh Bay on the Mangyshlak Peninsula. They included different types of hand-axes and cores of pseudo-Levallois type. Vishnyatskii (1996, 36), who had an opportunity to study these collections, argues that they are of a more recent age. Comparison of the geomorphic map published by Medoev (compiled by Potapova) with Google Earth satellite imagery shows that the sites on the Saratysh Bay are situated on the marine terrace at the altitude 45–50 m, which corresponds to the level of the Early Khvalynian transgression (Fig. 5).

3.6. Krasnovodsk (Turkmenbashi) Peninsula

The low-lying area between the Krasnovodsk plateau and the Greater Balkhan, the westernmost extension of the Kopel-Gag Mountains is a terraced plain, consisting of marine coastal landforms. Several open-air sites containing Mousterian-type bifacial tools were discovered in 1976 during archaeological surveys near Belek Station, west of the town of Djebel in western Turkmenistan (Dolukhanov, 1977).

The archaeological collection includes several bifacial tools of apparently Mousterian age, similar to those which had been found further west on the Krasnovodsk Peninsula. These tools were found on the surface of a barrier beach at the altitude of −5 m asl (Fig. 6), correlated with the Late Khavalynian transgression. This age was further substantiated by a lens of marine shells below the barrier bar containing typical Upper Khavalynian molluscs: *Didacna trigonoides praetrigoboides*; *D. baeri*; *D. pyramidata*; *D. parallela* (as identified by Dr. Ya. I. Starobogatov, Institute of Zoology, Russian Academy of Sciences, St. Petersburg).

3.7. Radiocarbon measurements

^{14}C dates were obtained for the mollusc samples stemming from clearly stratified sequences of Khvalynian deposits in the Dagestan coastal area and the Lower Volga (Rychagov, 1997; Leonov et al., 2002; Svitoch, 2003) (Table 1) The frequencies of radiocarbon dates per 200 years show a unimodal distribution, with no distinction between the Lower and Upper Khvalynian samples (Fig. 7). Most of the dates lie in the timespan between 10 and 17 ka BP, whereas the remaining dates (both the younger and the older ones) appear to be outliers which can be reasonably ignored. The highest frequencies are observable in a narrow range between 13.6 and 11.8 ka BP, accepted as the most probable age of the Khvalynian transgression.

4. Discussion

The suggested age of the Khvalynian transgression maximum (13.6–11.8 ka BP) should be seen as a rough estimate based on the uncalibrated radiocarbon dates without taking into account the reservoir effect. If accepted, this transgression was basically coeval with the Late Glacial ice recession in the higher latitudes. This conclusion is further substantiated by the proxy evidence. The stable isotope data suggest sufficiently high temperature values of the Khvalynian sea and its 'lighter' oxygen isotopic composition. On the other hand, palaeoclimate modelling (Kislov and Toporov, 2006, 2007) strongly suggests that both the Caspian and Black Seas regressions corresponded to the decreased river runoff as established during the colder and drier climate episodes and notably the Last Glacial maximum (LGM, 25–18 ka BP).

From this perspective, the Atelian regression may be viewed as corresponding to the LGM. As shown by the pollen and stable isotope records, the climate at that time was cold and continental, with mean annual temperature at least 2–3° below the present one (Shkatova, 1979).

During the course of Khvalynian transgression the volume of the Caspian basin increasing 6.5-fold, as compared to the preceding Atelian stage. The transgression proceeded in a quick succession of sea-level fluctuations, by means of 'flood flows' resulting in the emergence of large shallow basins with numerous lagoons and estuaries (Badyukova, 2002). Over c. 2000 years the sea-level rose by no less than 130 m. This implies the rate of sea-level rise of about 6.5 cm/year, which does not look unrealistic. Beginning in 1978, the Caspian level rose at the rate of about 35 cm/year. The rise of the sea-level above the Caspian-Pontic sill triggered flow of the excessive water into the Black Sea via the Kuma-Manych strait.

The data indicate a considerably younger age for Mousterian sites in the Caspian basin. The initial emergence of Mousterian industries in the Caspian basin, as indicated by the Volgograd site, occurred during a mild interval preceding the Atelian regression, which was broadly contemporaneous with the LGM. The subsequent expansion of Mousterian sites was largely coeval with the Khvalynian transgression (Fig. 8).

Significantly, very few authentic Upper Palaeolithic sites older than 12 ka BP are known either in the central or eastern Caucasus and Central Asia. Obi-Rakhmat, the multi-layered Palaeolithic rock shelter in the western extension of the Tien Shan, yielded a series of ^{14}C in the range of 54–56 to 19 ka BP. Several writers (Suleimanov 1972; Derevianko et al., 2001; Krivoshapkin and Brantingham, 2004) based on the high rate of laminar blanks and lame-based tools combined with the low percentage of Levallois forms, consider the site as corresponding to the Middle- to Upper Palaeolithic transition. Vishnyatsky (1996, 2004) provides typological and statistical arguments suggesting that this industry lies within the Mousterian technical variability.

In all probability, during the course of the Khvalynian transgression specific environments arose in the Caspian basin that favoured a prolonged conservation of the Mousterian technique, and, possibly, a survival of Neanderthal populations. One of the factors might be a 'cascade' of basins, including the Caspian-Black Sea spillway across the Kumo-Manych Valley (Chepalyga, 2007), that effectively isolated the Caucasian-Central-Asian area. The spread of Upper Palaeolithic technology in that area became possible only after the maximum of the Upper Khvalynian transgression, 12.5–12 ka BP.

Acknowledgements

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Regrettably, Professor Dolukhanov passed away in December 2009, prior to the final editing of this paper. He will be greatly missed, both for his insights into Quaternary history and archaeology, and as a colleague and friend.

–Norm Catto, Editor-in-Chief, *Quaternary International*.

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