



HAL
open science

Exploring Hypotheses on Early Holocene Caspian Seafaring Through Personal Ornaments: A Study of Changing Styles and Symbols in Western Central Asia

Solange Rigaud, Alain Queffelec, François-Xavier Le Bourdonnec, Saltanat Alisher Kyzy, Stanley H. Ambrose, Ronan Ledevin, Redzhep Kurbanov, Alexandra Buzhilova, Natalia Berezina, Rustam H. Ziganshin, et al.

► To cite this version:

Solange Rigaud, Alain Queffelec, François-Xavier Le Bourdonnec, Saltanat Alisher Kyzy, Stanley H. Ambrose, et al.. Exploring Hypotheses on Early Holocene Caspian Seafaring Through Personal Ornaments: A Study of Changing Styles and Symbols in Western Central Asia. *Open Archaeology*, 2023, 9 (1), pp.20220289. 10.1515/opar-2022-0289 . hal-04096960

HAL Id: hal-04096960

<https://hal.science/hal-04096960>

Submitted on 14 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



Research Article

Solange Rigaud*, Alain Queffelec, François-Xavier Le Bourdonnec, Saltanat Alisher kyzy, Stanley H. Ambrose, Ronan Ledevin, Redzhep Kurbanov, Alexandra Buzhilova, Natalia Berezina, Rustam H. Ziganshin, Svetlana Shnaider

Exploring Hypotheses on Early Holocene Caspian Seafaring Through Personal Ornaments: A Study of Changing Styles and Symbols in Western Central Asia

<https://doi.org/10.1515/opar-2022-0289>

received January 7, 2023; accepted April 14, 2023

Abstract: This article studies the discoid *Didacna* sp. shell beads discovered at Kaylu, a Middle Holocene burial site located in Southern Turkmenistan. Microscopic, morphometric, spectrometric, and SEM analyses were carried out on the material to identify how the beads were manufactured and used. New radiocarbon dating and bioanthropological data to age and sex the two skeletons discovered in the burials are provided. A regional synthesis shows that personal ornaments from the Caspian region were diversified through time and that a stylistic shift between the last foragers and the first farmers occurred. We also observed strong correspondences between the personal ornaments documented in the northern, eastern, and western Caspian Sea during the Neolithic, with no evidence of similar symbolic production in Northern Iran. We propose that a northern route may have allowed the diffusion of common ornamental traditions in the Caspian region to the exclusion of the southern Caspian. Alternatively, discontinuities in material culture diffusion in coastal areas could be evidence of maritime voyaging. Seafaring may have granted the fast and spatially erratic diffusion of specific bead types, people, information, knowledge, and symbols from both sides of the Caspian Sea, by long maritime voyages or by leapfrog diffusion during the Neolithic.

Keywords: Neolithic, Caspian Mesolithic, bead, Raman spectroscopy, SEM

* **Corresponding author: Solange Rigaud**, CNRS, UMR 5199 – PACEA, Université de Bordeaux, Bâtiment B8, Allée Geoffroy Saint Hilaire, 33615 Pessac, France, e-mail: solange.rigaud@cnrs.fr

Alain Queffelec, Ronan Ledevin: CNRS, UMR 5199 – PACEA, Université de Bordeaux, Bâtiment B8, Allée Geoffroy Saint Hilaire, 33615 Pessac, France

François-Xavier Le Bourdonnec: Université Bordeaux Montaigne, Archéosciences Bordeaux, UMR 6034 CNRS, Maison de l'Archéologie, Esplanade des Antilles, F-33607 Pessac, France

Saltanat Alisher kyzy, Svetlana Shnaider: Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences, 17, Acad. Lavrentiev Avenue, Novosibirsk, 630090, Russia

Stanley H. Ambrose: Department of Anthropology, University of Illinois, 607 South Mathews Avenue, Urbana, IL 61801, USA

Redzhep Kurbanov: Research Institute and Museum of Anthropology, M. V. Lomonosov Moscow State University, Mokhovaya 11, Moscow, 125009, Russia; Institute of Geography RAS, Moscow, Russia, Leninskie Gory Str.1, 119017, Moscow, Russia

Alexandra Buzhilova, Natalia Berezina: Research Institute and Museum of Anthropology, M. V. Lomonosov Moscow State University, Mokhovaya 11, Moscow, 125009, Russia

Rustam H. Ziganshin: Shemyakin-Ovchinnikov Institute of Bioorganic Chemistry, Miklukho-Maklaya Str., 16/10, Moscow 117997, Russia

1 The Early Holocene in Western Central Asia

The questions of why and how hunter-gatherers living in Southwest Asia 10 ky ago began to cultivate crops and raise domestic herd animals has puzzled archeologists since the early 19th century. In the Near East, archeobotanical and zooarcheological data show that initial domestication started circa. 11,500 years ago and emerged independently in different parts of the Fertile Crescent (Fuller *et al.*, 2011a and 2011b; Zeder, 2012). Farming technologies and domesticated plant and animal species then diffused westward across Europe circa. 8 ky ago (Zeder, 2008, 2012) and then eastward through the northern Zagros region and beyond, circa. 9 ky ago (Daly *et al.*, 2018; Naderi *et al.*, 2007). While Central Asia constitutes one of the main migration routes for early peoples moving into North and East Asia, it is far less explored than its European counterpart and the processes of Neolithization are therefore much less understood. Evidence of early farming technologies in Western Central Asia, however, can be inferred from Eastern Iran and Turkmenistan. At the Pre-Pottery Neolithic (PPN) site of Sang-e Chakhmaq, Iran, strong correspondences with the PPN from Zagros have been observed (Roustaei, Mashkour, & Tengberg, 2015). Early villagers are also attested later in Southwestern Turkmenistan at the Early Neolithic site Jeitun, where domestic cereal crops and animal herds were not locally domesticated but rather introduced from the southern Taurus and western Zagros circa. 10 ky ago (Harris *et al.*, 2010). The Caspian Seashore played a key role in this Neolithic diffusion. The apparently rapid movement of farmers to Northeastern Iran and Central Asia was most likely facilitated by a geographic corridor running from the northern Zagros, south of the Caspian Sea, Northeastern Iran, and Southwestern Turkmenistan (Harris, Damania, Valkoun, Wilcox, & Qualset, 1998; Harris *et al.*, 2010; Vahdati Nasab, Shirvani, & Rigaud, 2019). Though the diffusion pattern of farming technologies beyond this region is more difficult to model it seems to have slowed down, while foraging communities persisted for several centuries in Northwestern Turkmenistan.

Kaylu, close to the Caspian Sea (Figure 1), is one of three sites presently known in Turkmenistan with stratified deposits encompassing the transition from the Mesolithic to the Neolithic (Okladnikov, 1951). Stone tools discovered at Kaylu, Jebel, and Dam-Dam-Cheshme 1 and 2 have been intensively studied since the 1950s (Harris *et al.*, 2010; Shnaider *et al.*, 2018); however, non-lithic, ornamental and potentially symbolic artifacts that may reflect other aspects of past cultural identity and group membership are mostly unpublished and unknown to the scientific community. Seven decades have passed since Okladnikov's (1949, 1951) site reports on the eastern Caspian region, and our knowledge of the diverse facets of cultural processes that may have played a role in the diffusion of the Neolithic way of life in the region, potential contacts and interactions with neighboring communities, and their influences on variation in local material culture and practices during this transition remains restricted.

As part of our investigation into the economic, technological, and social organization of the Early Holocene communities in Western Turkmenistan, we briefly present the initial analyses of ceramic and lithic artifacts, as well as the first radiocarbon dates on the human burials. We also present detailed microscopic analysis of natural surface modifications, production and use-wear traces, and the geochemical analysis of the residue composition on the shell beads associated with the dated burials from the Kaylu rockshelter. Finally, we discuss the implications of this site for the Mesolithic–Neolithic transition in the eastern Caspian Sea region of Turkmenistan.

New chronological data, detailed archeometric analyses of shell beads, and regional comparisons provide new insights on the sharing of common stylistic standards between neighboring communities around the Caspian area.

1.1 Kaylu Rockshelter

Previous investigations into the Final Pleistocene/Early Holocene transition in Western Turkmenistan were conducted during the mid-20th century by A.P. Okladnikov, who discovered dozens of sites in the Krasnovodsk peninsula in 1947 (Okladnikov, 1949, 1951). The Kaylu rockshelter (Figure 1) is important

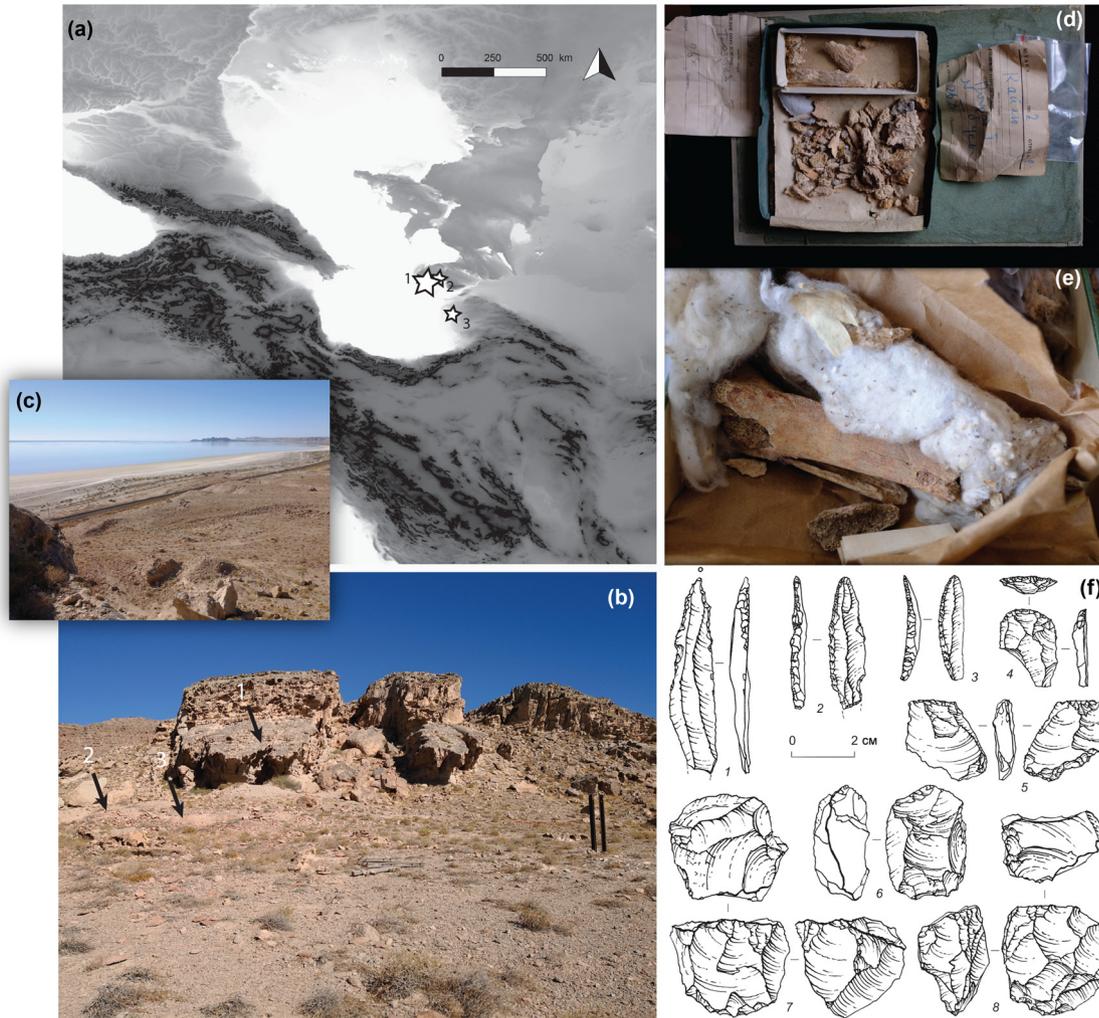


Figure 1: Location of Kaylu archeological site (a no 1), Jebel (a no 2), and Dam-Dam-Cheshme 1 and 2 (a no 3); view of the rockshelter (b1); location of the two burials (b2 and b3); Caspian Sea view from the site (c); human remains state of preservation (d and e); lithic industry from layer 7 of Kaylu (f) – point (1), lunates (2, 3), end-scraper (4), splinted pieces (5, 6), cores (7, 8).

because it preserves stratified deposits spanning the late Mesolithic and Neolithic. Since its discovery, the site has not been comprehensively reassessed or directly dated (Shnaider et al., 2018, 2021).

The Kaylu rockshelter is located at the eastern end of Kubadag, 20 km east of Krasnovodsk, at an altitude of 23 m above the current Caspian Sea level. During excavations conducted in 1952, Okladnikov recorded 4 m of stratified deposits. Seven cultural layers were identified, with the first six upper layers attributed to the Neolithic. The absence of pottery remains in layer 7 led Okladnikov to attribute this layer to the Mesolithic (Okladnikov, 1953, 1966). Kaylu was rediscovered during fieldwork in 2018, and surface artifact assemblages were subjected to a preliminary study (Shnaider et al., 2018). Until now, excavated lithic, pottery, and faunal remains had been poorly described. Pottery is present in layers 1–6, but more frequent in layers 3 and 4 (Table 1). Their analysis is still ongoing. No faunal data are available for these layers.

No precise spatial field records were taken during Okladnikov's excavation. The absence of systematic sediment sieving has most likely introduced a bias toward larger artifacts. The stone tool assemblages in layers 1–6 comprise debris, flakes, flat cores for flake production, volumetric cores for bladelet production, and retouched flake tools (Table 2). The absence of bladelets may result from the transport of finished tools away from the site, or from the poor field methods.

Table 1: Number of pottery remains in each layer identified at Kaylu rockshelter

Ceramic fragments	
Layer number	<i>N</i>
Layer 1	23
Layer 2	6
Layer 3	119
Layer 4	110
Layer 5	15
Layer 6	14
Layer 7	—
Surface	15
Total	302

Table 2: Composition of the lithic industry from Kaylu rockshelter

Debitage	Layer 1 <i>N</i>	Layer 2 <i>N</i>	Layer 3 <i>N</i>	Layer 4 <i>N</i>	Layer 5 <i>N</i>	Layer 7 <i>N</i>	Surface <i>N</i>
Cores	—	2	3	1		2	4
Pebbles	—	4	2		3		
Core trimming elements	—	—	2	2		29	1
Flakes	—	2	16	20	9	79	8
Blades	1	1	5			29	13
Bladelets/microbladelets	—	—	3			45	
Total, without debris	1	9	31	23	12	184	26
Debris (chunks, chips, flakes less than 20 mm)	1	2	9	6		35	
Total	2	11	40	29	12	219	26

The lithic assemblage from layer 7 comprises 219 artifacts. Bladelet cores are semi-cylindrical with one striking platform (Table 2 and Figure 1). Core preparation includes semi-tablets, corner and lateral flakes, and front core-trimming. Thedebitage includes 79 flakes, 29 blades, and 45 bladelets. The retouched tool assemblage totals 17 artifacts, including end-scrapers, notches, splintered pieces, awls, and backed lunates.

Two burials were discovered at the site, just a few meters from the entrance of the rockshelter (Figure 1). The skeletons were not deeply buried and showed many alterations, including a high level of breakage, cracks, decalcification, and concretion. Some remains were cemented in a very hard breccia, which was probably responsible for the high level of material breakage during excavation. The individual from burial 1 had postcranial bones with fused epiphyses (Figure S2). Wear patterns on the two upper premolars suggest that it was a young adult. The skeleton from burial 2 was almost exclusively represented by small upper body bone fragments, one premolar, and one lower incisor (Figure S2). The wear pattern of the incisor suggests that this individual was an adult. Sex determination was performed using peptides in the tooth enamel, following the method of Stewart *et al.* (2017) (Supplementary Text A). The young adult was identified as a male and the adult as a female (Tables S1 and S2). No photographs or drawings showing the position of the bodies were kept with the collection, but descriptions of the burials in Okladnikov's field report indicate that the skeletons were supine, with the head orientated north-west and the feet south-east, and their two arms were joined on the pelvic area. Both the bodies had been covered with ochre and were accompanied by dozens of discoid shell beads. Some lithic tools, similar to the material from layer 7 of the rockshelter, were found during the burials' excavation (Okladnikov, 1951). However, the lack of spatial information regarding the association of the lithic material and the human remains does not secure their strict contemporaneity, and the presence of lithic material within the filling sediment of the graves cannot be excluded.

2 Materials and Methods

2.1 Taxonomic Identification of Shells

Taxonomic identification of the shells involved two steps: the characterization of the shell's general shape for class determination (e.g. Scaphopoda, Gastropoda, Bivalvia) followed by an examination of the number of whorls (shape of the aperture, lip, ventral and dorsal sides) and ornamentation to determine the genus or species (Harasewych & Moretzsohn, 2010; Poppe & Goto, 1993). The nomenclature employed adopted classifications from the Caspian Sea Biodiversity Project (Checklist for Caspian Sea mollusks by P. Kijashko https://www.zin.ru/projects/caspdiv/caspian_molluscs.html, search performed on April 2018) and the WoRMS database (World Register of Marine Species <http://www.marinespecies.org/index.php>, search performed April 2018). A consideration of the configuration and distribution of the regional biotopes particular to each shell species and fossil outcrop revealed their probable procurement location(s) (Bar-Yosef Mayer, Gümüs, & Islamoglu, 2010; Rasilla et al., 2020; Rigaud, O'Hara, Charles, Man-Estier, & Paillet, 2022; Rigaud, 2013; Vanhaeren, 2002).

2.2 Functional and Morphometric Analyses of the Shells

A Motic SMZ-168 microscope equipped with a Canon 1100 D digital camera was used to document the surface modifications of each shell. The surfaces show microscopic alterations testifying to events that occurred either during the life of the mollusk or post mortem. In the case of shells collected and/or modified by prehistoric groups, microscopic analyses provided information relevant to the environment in which the shells were collected, as well as subsequent taphonomic and anthropogenic modifications (d'Errico, Henshilwood, Vanhaeren, & Van Niekerk, 2005; Dupont, 2006; Taborin, 1998; Vanhaeren, d'Errico, van Niekerk, Henshilwood, & Erasmus, 2013). The presence, location, and degree of natural modifications impeding microscopic analysis (calcite deposits, cracks) were recorded for each specimen, along with the degree of preservation of the shell's original shape and features. Anthropogenic modifications such as fractures, use-wear, or those produced by suspension (e.g. perforations, residues, incisions) were also systematically recorded.

Morphometric variables (shell maximum and minimum diameter, maximum and minimum diameter of the perforation and thickness of the shell) were recorded to characterize size selection and shaping standardization. The K-means Cluster Analysis (KCA) was used to explore the size variation of the beads and to partition data into relatively homogeneous groups. Because the primary role of personal ornamentation is to be seen, to transmit symbolic messages (Erikson, 1969; Meisch, 1998), the most important characteristics of the beads are those related to their visual impact (Beck, 1926; Kassam, 1988). We therefore chose the number of groups used for the K-mean clustering based on macroscopic observations performed on the full bead assemblage. PAST software (Hammer, Harper, & Ryan, 2001) was used for the analysis, performed with $K = 3$ and 1,000 iterations.

2.3 Residue Analysis

The location, color, and microscopic features of the shell bead residues were systematically recorded. Their mineralogical composition was subsequently explored with Raman Spectroscopy and SEM microprobe analyses. Raman spectra were obtained on six samples with a SENTERRA confocal microspectrometer (Bruker Optics, Ettlingen, Germany) equipped with a 532 nm excitation line. The spectra, acquired with a 5 mW laser power, 50 co-additions of 5 s excitation, were compared with the RRUFF™ database (Lafuente et al., 2015). Four samples were characterized using a JEOL JMS 6460 LV scanning electron microscope, operating at an accelerated voltage of 20 kV, coupled with an Oxford X-Max EDS Silicon Drift Detector in a 20 mm² active area and a 125 eV resolution for the Mn K α emission line (Le Bourdonnec et al., 2010; Mulazzani et al., 2010).

Table 3: Scanning conditions of the three sets of beads maintained in carbonate concretions investigated using X-ray microtomography (voxel size, beam tension, and intensity)

Beads	Voxel size (μm)	Tension (kV)	Intensity (μA)
KAL1	13	100	180
KAL2	15	100	180
KAL3	27	120	250

2.4 3D Characterization of the Beads

Beads embedded in carbonate concretions were 3D scanned using a General Electric (GE) Vtome x|s microtomograph. For each scan (length = 90 mn), the cubic voxel size and beam parameters were adapted to fit the sample characteristics (Table 3). A copper filter of 0.1 mm was used and 2,550 projections were taken at 360°. Reconstruction of the volumes was performed using the Datos | Acq software, GE. 3D visualizations of the beads were then performed within the Avizo 9.1 (FEI) workspace.

2.5 Radiocarbon Dating

One premolar from burial 2 at Kaylu was directly dated by enamel carbonate radiocarbon (^{14}C) dating. Tooth enamel samples were leached under vacuum with acetic acid in the Environmental Isotope Paleobiogeochemistry Laboratory at the University of Illinois to remove exogenous soil carbonate, using a protocol based on the Vacuum Milling technique of Krueger (1991). At the Keck Carbon Cycle AMS (KCCAMS) laboratory, University of California, Irvine, the tooth enamel was further purified with 0.1M HCl to remove 10% of the sample weight, prior to hydrolysis with 85% phosphoric acid to generate CO_2 for conversion to AMS targets. Sample preparation backgrounds were subtracted, based on measurements of ^{14}C -free calcite. All results have been corrected for isotopic fractionation according to the conventions of Stuiver and Polach (1977), with $\delta^{13}\text{C}$ values measured on prepared graphite using the UCIAMS spectrometer at the KCCAMS laboratory, University of California, Irvine. However, as these can differ from the $\delta^{13}\text{C}$ of the original material they are not reported. Radiocarbon concentrations are given as fractions of the modern standard, D14C, and radiocarbon years before present (RCYBP), following the conventions of Stuiver and Polach (1977) (Table 4).

Table 4: Information on the tooth sample selected for radiocarbon dating

UCIAMS #	ISGS #	Sample #	Material	Fraction of MC \pm	D^{14}C \pm	RCYBP \pm
228529	A4880	SA-818, Kaylu cave, Turkmenistan	Tooth Enamel	0.5033	0.0010	-496.7 1.0 5,515 20

3 Results

3.1 Identification and Sourcing of the Shells

Forty-six shells were discovered within the stratigraphic layers of the rockshelter, including three bivalve species and two gastropod species (Table 5, Figure 2). Six unmodified shells, attributed to four different species, were also present in the material from the burials (Table 5). Four shells were not clearly attributed to any of the site's sectors.

Table 5: List of the shell material discovered within the cave site and the burials

Sector	Layer/burial	Shell species	Description	N
Burial	1	cf. <i>Didacna</i> sp.	Small beads	85
Burial	1	cf. <i>Didacna</i> sp.	Mid-sized beads	38
Burial	1	cf. <i>Didacna</i> sp.	Large beads	25
Burial	1	<i>Dreissena polymorpha</i>	Unmodified	3
Burial	1	<i>Turricaspia</i> sp.	Unmodified	1
Burial	1	<i>Theodoxus pallasii</i>	Unmodified	1
Burial	1	<i>Didacna</i> sp.	Unmodified	1
Burial	2	cf. <i>Didacna</i> sp.	Mid-sized beads	1
Burial	?	cf. <i>Didacna</i> sp.	Mid-sized beads	30
Burial	?	cf. <i>Didacna</i> sp.	Small beads	10
Rockshelter	?	<i>Didacna</i> sp.	Unmodified	20
Rockshelter	?	<i>Dreissena polymorpha</i>	Unmodified	1
Rockshelter	I	<i>Didacna</i> sp.	Unmodified	1
Rockshelter	III	<i>Didacna</i> sp.	Unmodified	5
Rockshelter	III	<i>Dreissena polymorpha</i>	Unmodified	1
Rockshelter	III	<i>Theodoxus pallasii</i>	Unmodified	1
Rockshelter	III	Unionidae	Unmodified	2
Rockshelter	IV	cf. <i>Didacna</i> sp.	Unmodified	1
Rockshelter	IV	<i>Didacna</i> sp.	Unmodified	7
Rockshelter	IV	<i>Dreissena polymorpha</i>	Unmodified	3
Rockshelter	VI	<i>Didacna</i> sp.	Unmodified	1
Rockshelter	VI	<i>Theodoxus pallasii</i>	Unmodified	1
Rockshelter	VI	Unionidae	Unmodified	1
Rockshelter	VII	<i>Theodoxus pallasii</i>	Unmodified	1
?	?	<i>Dreissena polymorpha</i>	Unmodified	1
?	?	<i>Theodoxus pallasii</i>	Unmodified	2
?	?	<i>Didacna</i> sp.	Unmodified	1

'?' indicates that the location of the discovery within the site is not known.

Personal ornaments discovered in the burials included 189 discoid shell beads. Parallel and straight large ribs – naturally present on the dorsal side of many bivalve species – are present on the convex side of all these beads. Some also present shorter ribs on the concave side corresponding to the natural ribs present in the inner part of bivalves.

The evolution of the cardiid bivalves of the Ponto-Caspian region remains unclear because of stratigraphic gaps, unsettled taxonomy, and the unclear status of bivalve groups. Due to these issues, the shell beads have not been taxonomically attributed, but the thickness of the shells and the morphology of the ribs suggest the genus *Didacna* belonging to the Cardiidae family.

3.2 Taphonomic and Functional Analyses of the Shells

The bivalves from the rockshelter (*Unionidae*, *Didacna* sp., and *Dreissena polymorpha*) do not show any anthropic modification, though a dorsal perforation is observable on one *Theodoxus pallasii*. The perforation is irregular and the edge of the hole shows fresh breakages not covered with patina, indicating the perforation is post-depositional, recent, and most likely occurred during excavation. The six complete shells from the burial do not show any anthropic modifications.

Several sets of discoid beads were cemented in their original association by calcite concretions. The position of the beads shows that at least some of the ornaments were aligned and suspended by a string through the central perforation at the time of their deposit (Figure 3).



Figure 2: Material discovered in the rockshelter (a) and the two burials (b and c): fragments of discoid beads (b) and intact discoid beads (c).

Fragmentation prevented the measurement of metric variables on many bead specimens; however, 64 well-preserved beads and their perforations were measured (thickness, maximum and minimum diameter) and showed patterns in size variation, with three main size classes being clearly visible to the naked eye (Figure 2). The KCA performed on the minimum and maximum diameter confirms the presence of three statistically different groups of shell bead diameters (Mann–Whitney U test $p < 0.01$). A scatterplot of the minimum and maximum diameters clearly differentiates the three groups identified by KCA with the larger beads clearly separated from the small and mid-sized beads (Figure 4).



Figure 3: Discoid shell beads maintained in their original configuration by calcite concretions (a–d). μ CT-based three-dimensional visualization of the beads: (e and f) 3D-CT of cemented beads (b); (g) 3D-CT of cemented beads (c); (h and i) 3D-CT of cemented beads (d).

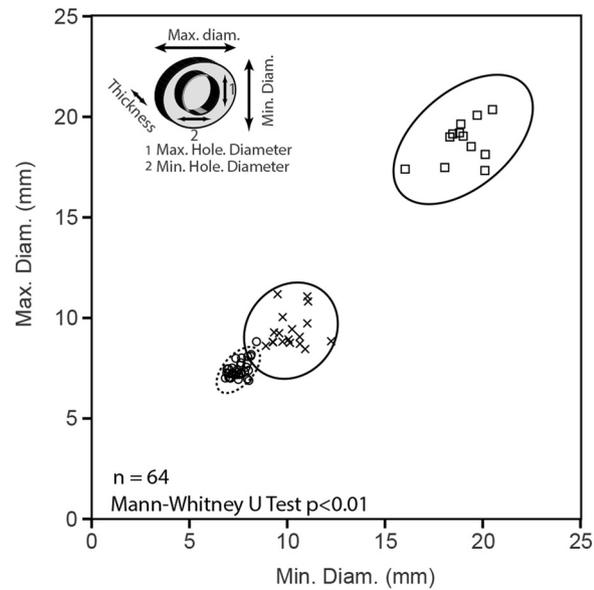


Figure 4: Scatterplot of the maximum and minimum diameters of the discoid shell beads. Confidence ellipse 95%. Each ellipse corresponds to one of the groups identified by the K-mean cluster analysis.

The technological analysis was limited by the multiple alterations present on the shells' surface. Several post-depositional processes including dissolution, breakages, and concretions have contributed to the destruction of anthropic modifications.

Natural ribs are visible on both sides of the large discoid beads (Figure 5). Ribs on the concave side are short, do not extend across the full surface of the beads, and correspond to natural ribs located at the shells'

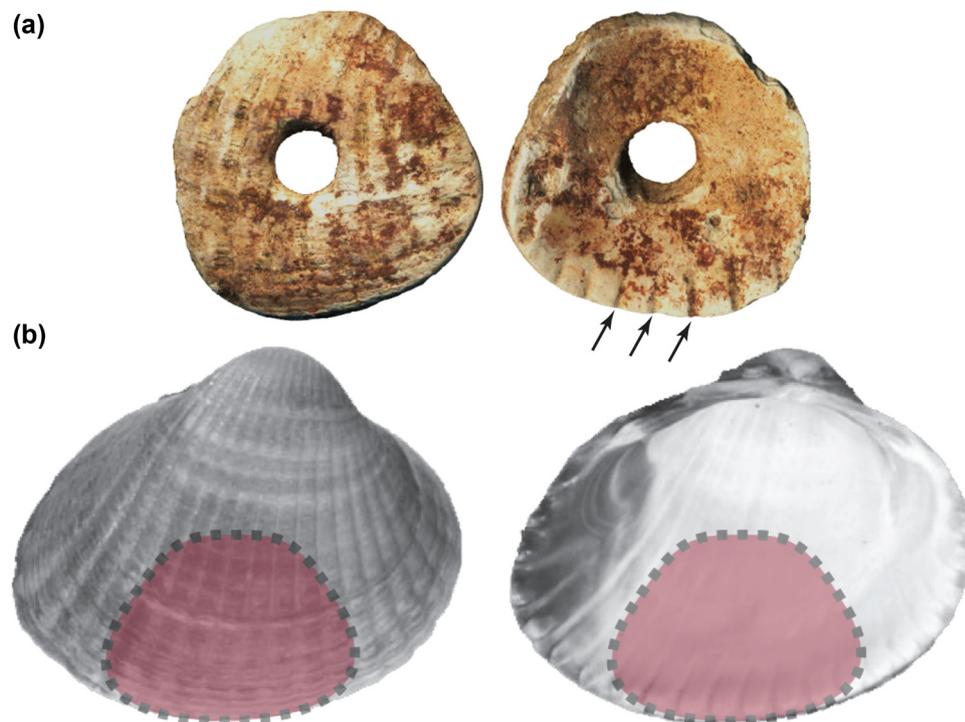


Figure 5: View of the natural ribs on the surface of the bivalves. (a) Dorsal and ventral side of an archeological shell bead and (b) location of the anatomical portion of the bivalve used for the discoid bead manufacture in red.

ventral margin. The presence of short ventral ribs on the large archeological specimens indicates that the beads were shaped from a portion of the shell located near the ventral margin. Natural ribs still visible on the discoid beads suggest that the surface of the large beads was not regularized by grinding (Figure 6). The absence of short ribs on one side of the mid-sized and small beads may be due to the removal of the ventral margin during manufacture. No other clear technological features were observed on the mid-sized or large beads.

Many small and mid-sized beads were affected by exfoliation, resulting in a laminated breakage pattern (Figures 2b and 3). The thickness of the foliated beads was not recorded. The measurements recorded on the unbroken beads show that the large beads have a mean thickness of 3.24 mm ($n = 15$), mid-sized beads a mean thickness of 2.37 mm ($n = 17$), and small beads a mean thickness of 2.36 mm ($n = 53$). Thickness differences between the large and the mid-sized/small beads and an absence of grinding evidence on the ventral and distal sides of all the shell beads suggest the use of two different raw shell materials.

Circular striations on the perforations of the small beads indicate that the shells were perforated by the rotation of a lithic point (Figure 7c–g). The perforations are biconic, suggesting that the rotation was performed from both sides of the bivalves (Figure 7i and j). The edge between the two perforation cones

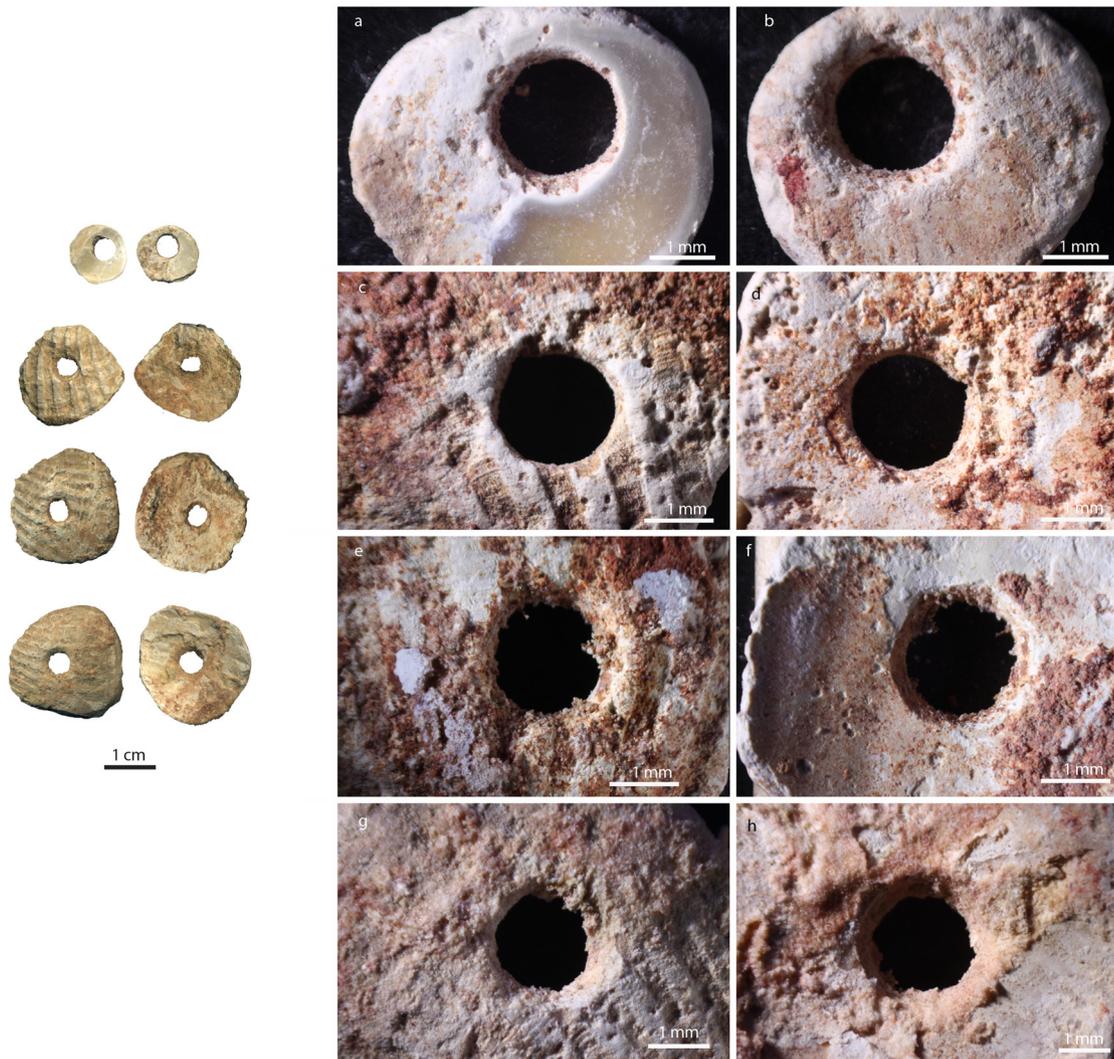


Figure 6: Modifications on the ventral and dorsal side of the mid-sized (a and b) and large discoid beads (c–f). Taphonomic alterations: exfoliation (a, b, d, e, and f), concretion (c, g, and h); anthropic modifications: red residue (b–h).

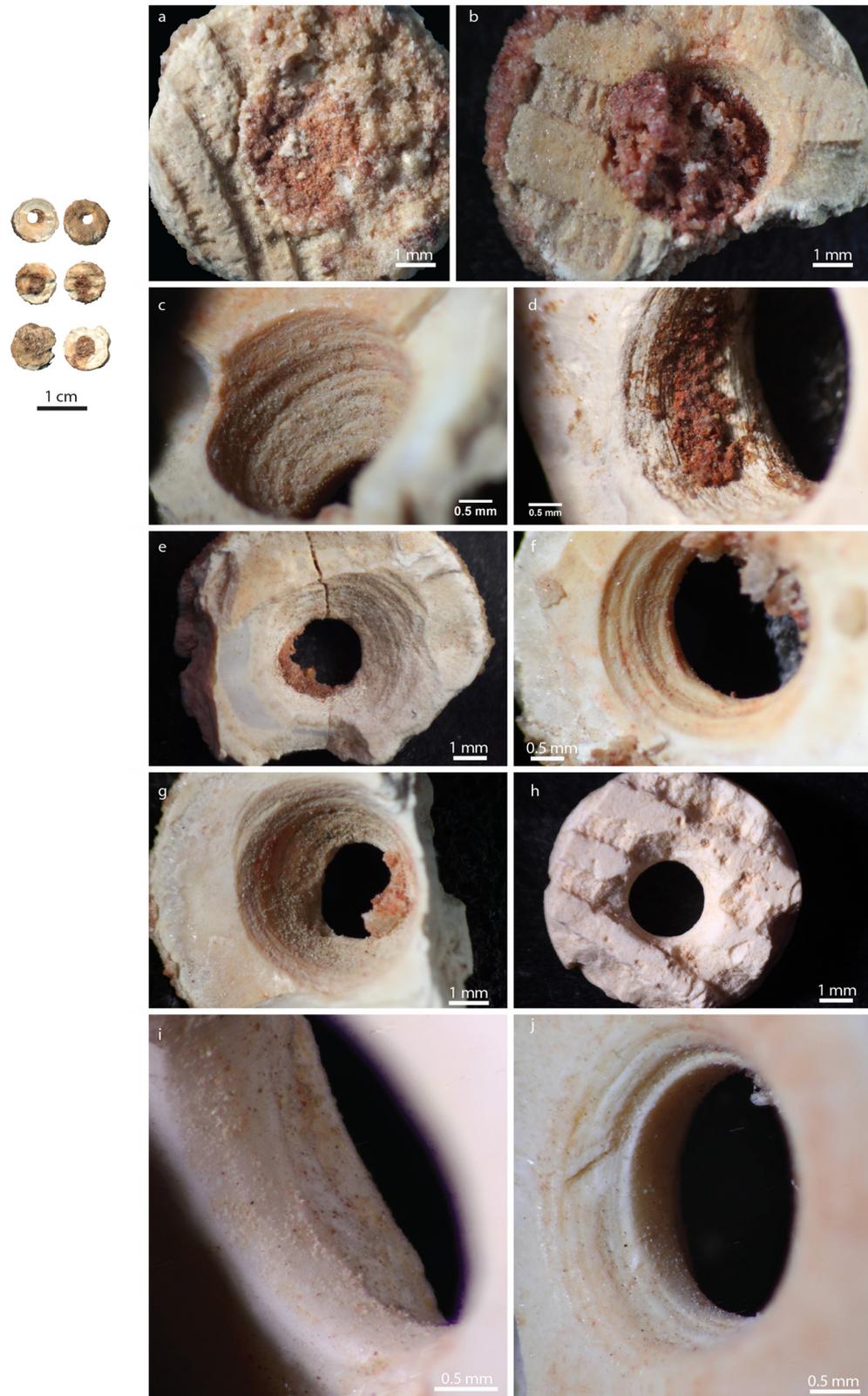


Figure 7: Taphonomic and anthropic modifications observed on the small discoid beads. (a, b, d, e, and g) Red residue in the perforations embedded in calcite concretions; (c–g) circular striations resulting from perforation by the rotation of a lithic point; (h) discoid bead altered by dissolution process; and (i and j) sharp edge on the biconic perforation showing that the circular motions were made from both sides of the shell.

is closer to the dorsal side of the valve, evidencing that the perforation was processed first from the ventral side and the opening was subsequently enlarged from the dorsal side. Considering the natural convexity of the valves, this process may have limited accidental breakages by applying rudimentary pressure on the dorsal convex side during the final stage of perforation manufacture. Use-wear analysis was not conclusive due to the poor preservation of the material (Figures 6a–h and 7h).

3.3 Residue Analysis

Microscopic analysis identifies a red residue concentration within the perforation of the small and mid-sized shell beads and at the surface of both sides of the large beads (Figures 6b–f and 7a, b, d, e, and g). Raman spectroscopy and SEM analyses were performed on specimens from each bead size category (Figures 8 and 9, Figures S5 and S6). Analysis of the red compound revealed fragments and fine particles of iron oxide, explaining the residue's red coloration. Hematite (Fe_2O_3) was present as finely grained powder; no particular variation in structure or orientation was visible in the samples, besides the presence of rare, shiny and larger fragments in one sample (Figure 9, Figures S5 and S6). With regards the ochre particles, analyses identified calcite (CaCO_3), gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), quartz (SiO_2), and halite (NaCl). The proximity of the site to the Caspian Sea, and the local dry sandy environment, suggests that quartz, gypsum, and halite were part of the surrounding sediment. Calcite corresponds to the shells' composition; therefore, its presence within the residue itself may also result from the post-depositional carbonate

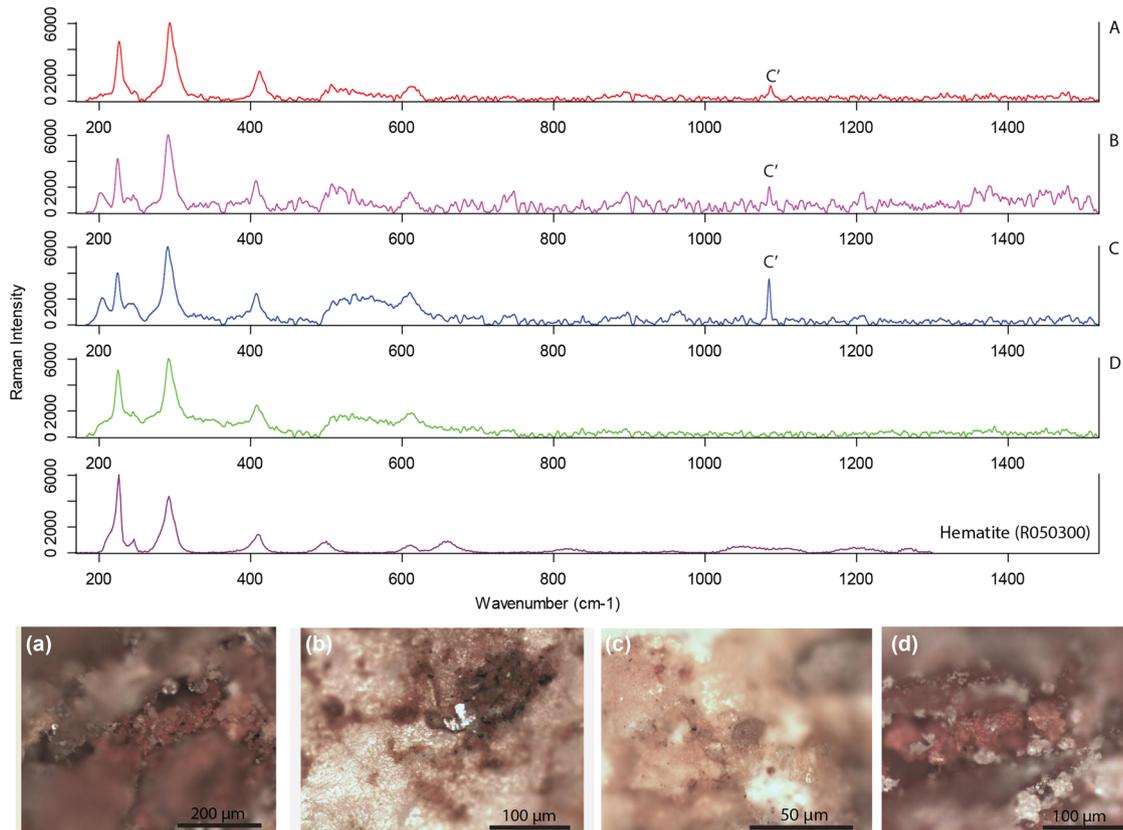


Figure 8: Raman spectra obtained for the red residue present on the beads: (a) small bead from burial 1, (b) mid-sized bead from burial 2, (c) mid-sized bead from burial 1, and (d) large bead from burial 1. *C'* labeled peak corresponds to calcite/ aragonite.

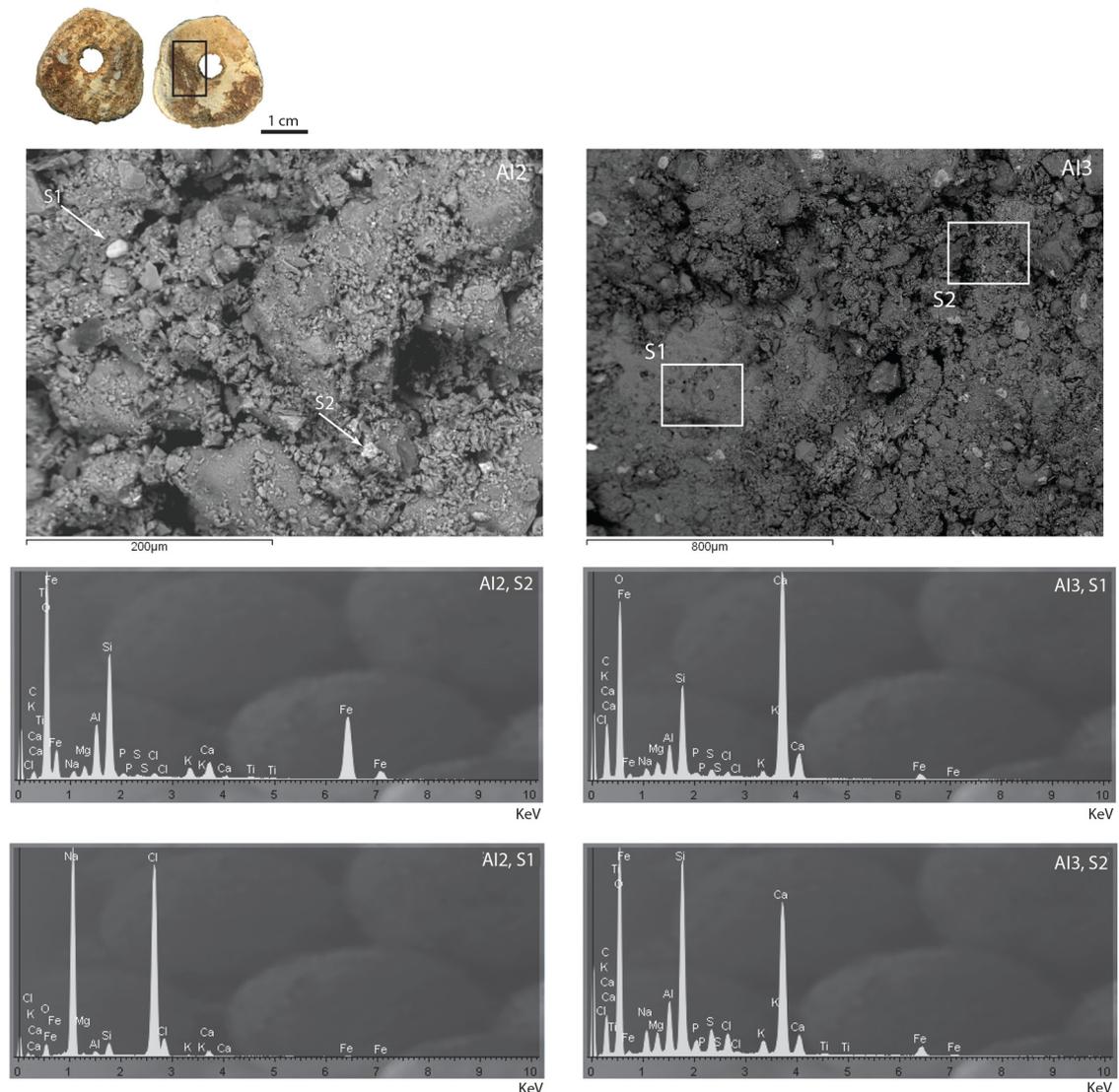


Figure 9: SEM-EDS analysis performed on one large bead. AI: area of interest; S: spectrum. AI2-S2: ochre (iron-rich and aluminosilicate-rich material); AI2-S1: halite; AI3-S1: calcite; AI3-S2: ochre and calcite concretion and/or aragonite from the shell.

formation that contributed to cementing some of the beads together and to preserving and hardening the residue (Figure 3).

3.4 New Chronological Data

Recent data obtained on the Late Quaternary Caspian Sea Khvalynian transgression (Kurbanov *et al.*, 2021; Yanina *et al.*, 2017) show that between 13 and 15 ky ago the Caspian Sea level was 76 m above the modern sea level and that part of the Kubadag cliff, including the Kaylu site, was underwater (Kurbanov, Svitoch, & Yanina, 2014). The Kaylu rockshelter was presumably formed during one particular sea-level stabilization phase attributed to the Late Khvalynian period (Kumskaya stage). The rockshelter then became accessible for settlement after the beginning of the Mangyshlak regression, about 9–10 ka BP (Svitoch, 2012). These geomorphological data provide an approximate terminus ante quem for possible early human occupations of the site.

The results of the radiocarbon dating of burial 2 indicates a median age of 6300 ± 27 cal BP (Table 6).

Table 6: Radiocarbon age obtained from the premolar from burial 2. The date was calibrated using OxCal v4.3.2 Bronk Ramsey (2017); r:5 IntCal13 atmospheric curve (Reimer et al. 2013)

Site/sample	ISGS-SA #	RYCBP	Plus or minus	1 s.d. Cal	%	2 s.d. Cal	%
Kaylu burial 2	A4880–SA818	5,515	20	6309–6287 Cal Yr BP	68.2	6392–6366 Cal BP	9.9
						6345–6334 Cal BP	2.1
						6322–6279 Cal BP	83.4

4 Discussion

4.1 Acquisition Selection, Transformation, and Use of the Shells

The shell species identified in the rockshelter and the burials are naturally present in the Ponto-Caspian area. The *Didacna* sp. bivalves are an endemic marine species currently present in the Caspian Sea and are widely distributed in local fossil outcrops (Albrecht, von Rintelen, Sereda, & Riedel, 2014). They are classically used as a paleontological marker of the different Caspian Sea transgressive and regressive episodes (Yanina, 2005). The *D. polymorpha* bivalve is present in the Caspian Sea and also in freshwater rivers and brackish water estuaries (Son, 2007). Unionidae shells are freshwater bivalves (Graf, 2007). *Turricaspia* sp. gastropods are mostly marine shells, but some rare species can be found in brackish water (Vinarskij, & Kantor, 2016). The *T. pallasi* gastropod is a freshwater species present in the region and is also observable in the brackish environment near Caspian estuaries (Anistratenko, Zettler, & Anistratenko, 2017; Neubauer, van de Velde, Yanina, & Wesselingh, 2018). The location, about 500 m from today's Caspian shore, and less than 20 m during the transgression some 13 ky ago, suggests that the raw shell materials used for bead manufacture were collected locally.

The shells present in the archeological layers of the rockshelter do not show any anthropic modifications, are diversified, and not abundant in each layer. The field methods used during the Okladnikov excavation did not include sieving and have therefore affected the collection of small items. Regional comparisons show that a perforated umbo fragment, attributed to *Didacna* sp., has been documented as a bead in one Epipaleolithic layer at Altappéh (Iran), located in the southern Caspian Sea (Manca, Mashkour, Shidrang, Averbouh, & Biglari, 2018). Perforated *T. pallasi* were also present in Caspian Mesolithic layer V of Dam-Dam Cheshme 2 (Figure 10, personal data, eastern Caspian region, Turkmenistan).

Beads made from *Didacna* sp. and *T. pallasi* from two contemporaneous sites in the southern Caspian region suggest that these same shell species may have been brought to the Kaylu rockshelter for the same purpose, sometime during the Caspian Mesolithic. The other shell species found at Kaylu were not documented as beads, although they were unlikely to have been used for consumption. The lack of geoarchaeological data concerning the impact of the Caspian Sea regression/transgression episodes on the estuary and river systems, surrounding the rockshelter and on the layers formed within the site, prohibits further discussion on the origins of the shell accumulation, though a natural origin cannot be excluded.

The three *D. polymorpha*, the *Didacna* sp. valve, the *Turricaspia* sp., and the *Theodoxus pallisi*, present in burial 1 show no anthropic modifications, and no data are available regarding their location in the burial or their relation to the body (Okladnikov, 1951). This lack of spatial information renders their strict contemporaneity with the skeleton inconclusive, and their presence within the filling sediment of the grave is a possibility.

The discoid shell beads from burials 1 and 2 were shaped on bivalves attributed to the *Didacna* genus. The difference in shell thickness between the shell beads, the thinner *Didacna* sp. from the rockshelter, and

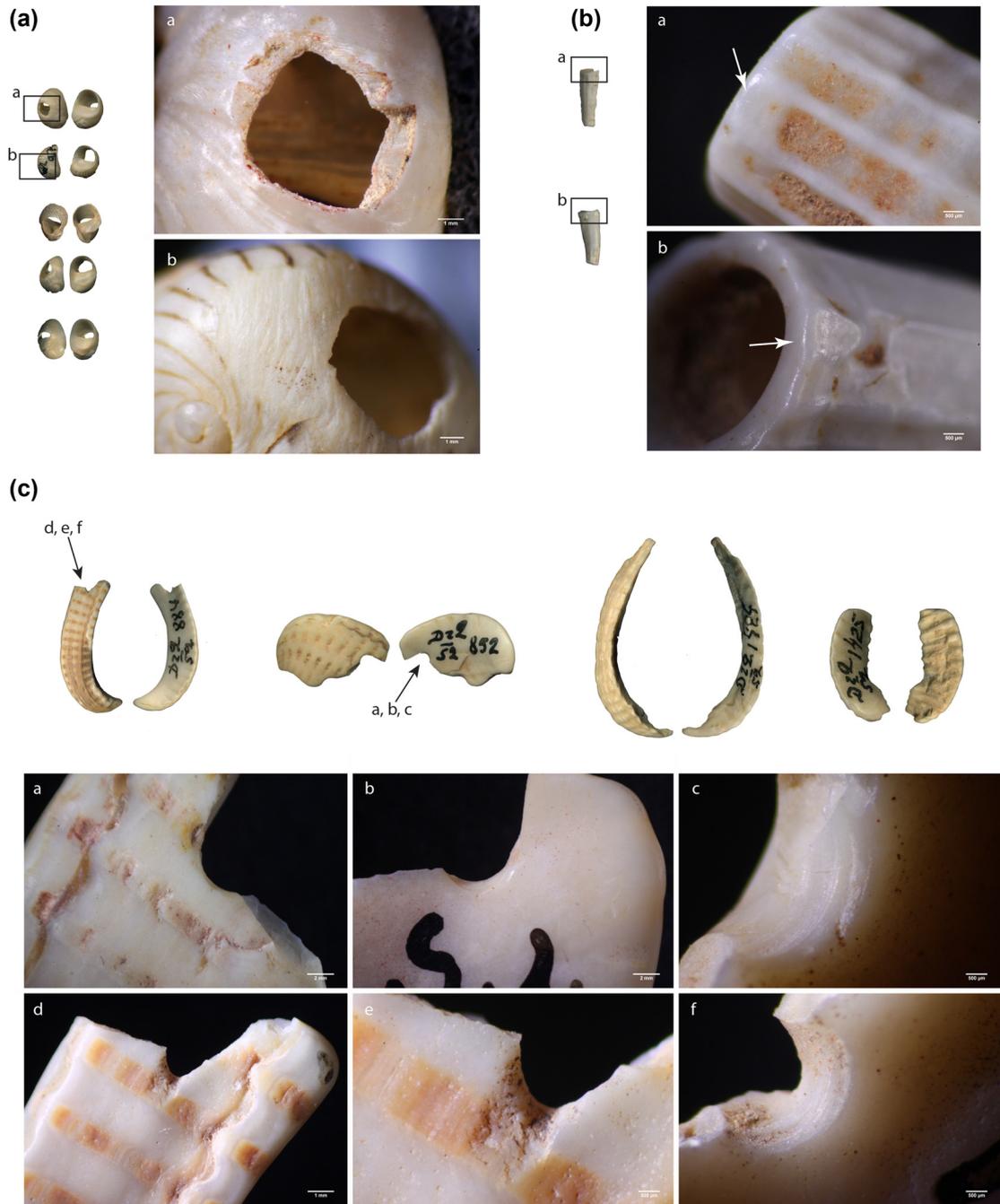


Figure 10: Shell beads documented within the Epipaleolithic layers of Dam-Dam Cheshme 2 (Turkmenistan): (a[a]) *T. pallasi* perforated by percussion on the dorsal side of the last spire whorl; (a[b]) *T. pallasi* perforated by abrasion on the dorsal side of the last spire whorl; (b) *Dentalium* sp. with use-wear on the distal and proximal extremities; (c[a–c]) anthropic perforation and use-wear on a fragment of *Didacna* sp. naturally eroded by surf action; and (c[d–f]) anthropic perforation and use-wear on a marginal fragment of *Didacna* sp. naturally eroded by surf action.

the unmodified valve unclearly associated with burial 1 may be due to their various states of maturation (juvenile versus adult specimen) or their collection from differing environments, an external factor well known to impact shell size, or to the presence of different *Didacna* shell species in the material (Fisher, Rhile, Liu, & Petraitis, 2009; Reimchen, 1982). The thickness of the large shell beads compared to the mid-/small-sized beads may also reflect similar factors.

Our results show that the portion of the shell dedicated to be perforated was not randomly selected and was made using a precise percussion process. After perforation, the shell flake was shaped into a disc corresponding to one of the three size categories identified in the collection. The nearly complete absence of overlap between the various size categories indicates that the shaping of these distinct sets of beads was performed separately to obtain a highly standardized morphology and size (Figure 11). The abrasion of shell flakes assembled on a string would have allowed for such standardization.

The presence of three size categories suggests that the beads may have been suspended in many different configurations. However, preservation of the beads maintained in the concretion hull shows homogeneous sets exclusively composed of beads attributed to the same size categories (Figure 3). This result echoes observations made by the excavators in the field who identified three types of beads: some big and flat and some smaller and thicker of two different sizes. Many of the smallest beads were observed located next to the skulls and interpreted as part of a headdress. The biggest ones were mainly observed on the right side of the skeletons next to the pelvis and right femur (Okladnikov, 1951). No indication is available concerning the mid-sized beads. Our morphometric results also show that the large beads are the thickest, indicating that the field observations were somewhat inaccurate.

The presence of a red sediment covering the skeletons was reported during excavation, suggesting that ochre was spread on the bodies during the funerary rites (Okladnikov, 1951). Observation of the human

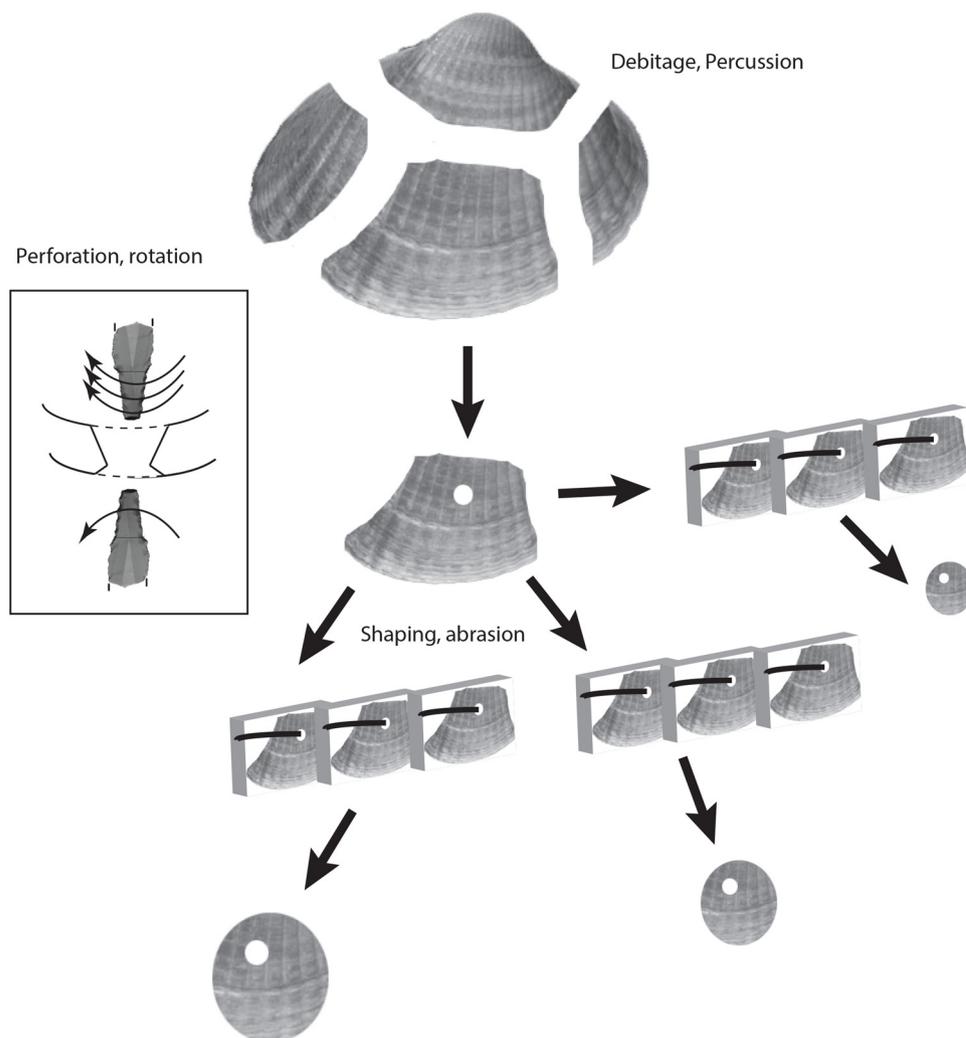


Figure 11: Manufacturing process of the discoid shell beads from the Kalyu burials.

remains shows the presence of a red compound on the surface of the two skeletons, particularly visible through the slightly red coloration of the skull, hand and long bones (Figures S1 and S2). The residual sediment present in the storage boxes shows that the deposit surrounding the bones was also reddish and rich in iron oxide. The residue observed on the beads adheres more firmly and is redder and probably richer in hematite. Discrepancies between the sediment and light-red coloration of the bones and the residue observed on the beads support two different uses of ochre – the intentional use of a hematite compound for the beadwork and the use of another red pigment for the funerary rites.

The red compound on the beads may result from the use of a pigment to change the natural color of the beads, the use of hematite as a fine-grained abrasive during bead manufacture (Rigaud *et al.*, 2014), or the use of iron oxide as part of an adhesive compound used to attach the beads (Dayet, Erasmus, Val, Feyfant, & Porraz, 2017; d’Errico *et al.*, 2005; Orton, 2008; Rigaud *et al.*, 2014). However, the high concentration and the thickness of the red residue on the beads from the two burials does not plea for the use of hematite solely as an abrasive during bead manufacture. The location of the residue strictly distributed on the ventral and dorsal sides of the large beads and its near complete absence from the perforations suggest that both sides of the beads were coated. The disposition of the beads aligned on a single string indicate that they may have been tightly attached to each other with an adhesive. The pattern is different for the small- and mid-sized beads that show a high concentration of red residue cemented within the perforations. The location of the residue supports the hypothesis that a red pigment was used to deliberately stain the strings used to attach the beads. The presence of large beads near the pelvis and small beads near the skull indicates that two different systems of suspension (applying glue or using red string) were used for two different parts of the body to create disparate visual effects.

4.2 Regional Comparisons

Movius (1953) described Okladnikov’s (1949) excavated finds of early Neolithic *Didacna* sp. shell beads in several stages of manufacture at Cape Kuba-Sengir, located approximately 8 km ESE of the Kaylu rock-shelter. Movius reports that Okladnikov (1949) considered this site to be a Neolithic workshop and that it “suggests a stage of industrial specialization in the production of ornaments that probably indicates trade relations over a fairly wide area.” Analysis of the 843 shell beads from the Okladnikov collection shows significant differences with the material from Kaylu (Figure 12 and Table 7). At Kuba-Sengir, the beads are represented by perforated *Didacna* sp. valves naturally eroded by sand (Figure 12a–c) and commonly found within thanatocenoses (Rogalla, Amler, & München, 2007). Perforations were made by bifacial rotation (Figure 12c–i) and the natural shape of the eroded valves does not show any anthropic modification. The presence of unperforated eroded valves in the material (Figure 12b) supports the workshop hypothesis previously mentioned by Okladnikov.

Didacna sp. discoid shell beads documented at sites in the Caspian Sea region, Uzboi, Ustyurt, and the lower reaches of the Amu Darya are dated from the late 5th to the late 3rd millennia BC (Vinogradov, Itina, & Yablonsky, 1986). Small discoid shell beads, similar to the small beads recovered from the Kaylu burials, are documented at the Chalcolithic burial site Tokmak, located near the Caspian Sea in the Mangyshlak peninsula (Asta’ev, 2014). At Tokmak, the discoid beads were found associated to *Dentalium* sp. shells, discoid stone beads, several small clay cylinders, and perforated *Theodoxus* sp. (Table 7 and Figure 14). Similar shell beads were discovered at Aktau 1 and Koskuduk 1 and 2, all sites belonging to the Oyukly culture (Asta’ev, 2014). The discoid shell beads recovered from the Kaylu burials also show correspondences with those documented at the northern Caspian Chalcolithic cemetery, Khvalynsk (Kirillova *et al.*, 2018), which had been shaped from Pleistocene fossil species of *Didacnoides* cf. *caucasicus* and belong to one size category (Kirillova *et al.*, 2018). The location of the fossil outcrops indicates contact with the southeastern Caspian region near the Buzachi peninsula, currently in Kazakhstan (Kirillova *et al.*, 2018). Okladnikov found some analogies between the material from the Kaylu burials and the Late Neolithic Mariupol cemetery located in North Azov sea (Okladnikov, 1966). One Early Neolithic site located in the



Figure 12: Shell beads documented at Kunda-Sungir: (a) *Didacna* sp. shell bead from the Okladnikov collection, (b) intact, naturally eroded *Didacna* sp. valves discovered at the site, (c) perforated *Didacna* sp. valves, and (d–i) perforations made by bifacial rotation.

southwestern Caspian area, MPS 4 (Azerbaijan, Heit, 2014), also shows similarities with Kaylu. The presence of *Didacna* sp. shells, fragments, blanks, and finished beads indicates the production of discoid shell beads at the site (Heit, 2014). The morphometric data available in the literature indicate that only one bead size category was present at MPS 4 (Heit, 2017), probably corresponding to the small beads identified in the Kaylu burials. The large discoid shell beads from Kaylu also echo the bead material from the Tuzovskiye Bugry-1 burials in Altai (Kiryushin, Kiryushin, Schmidt, Kuzmenkin, & Abduganeyev, 2011). These discoid beads are made from *Colletopterum* sp. bivalve fragments, originating from the Ob Basin (Kiryushin et al., 2011). The presence of *Dentalium* sp. and *Corbicula* sp. shell beads suggests contact between Tuzovskiye Bugry-1 and the southern areas of Western Central Asia (Kiryushin, Kiryushin, Schmidt, & Abduganeyev, 2012). Large and small discoid shell beads were also documented at the Tumek-Kichidjik cemetery (Northern Turkmenistan, Vinogradov et al., 1986). Stone beads and pendants, clay plugs, bone beads,

Table 7: List of the bead types and sites mentioned in the text

Site	Location	Cultural attribution	Chronology	Bead types	Ref.
Kaylu Rockshelter	Krasnovodsk peninsula, West Caspian Sea, Turkmenistan	na	8000–4300 cal BC?	*	Okladnikov, 1951, personal data
Kaylu burials	Krasnovodsk peninsula, West Caspian Sea, Turkmenistan	na	4300 cal BC?	Large, mid-size and small <i>Didacna</i> sp. shell discoid beads	Okladnikov, 1951, personal data
Kunda-Sungir	Krasnovodsk peninsula, West Caspian Sea, Turkmenistan	Neolithic	na	<i>Perforated naturally eroded Didacna</i> sp. valves	Okladnikov, 1951, personal data
Dam-Dam Cheshme 2	Krasnovodsk peninsula, West Caspian Sea, Turkmenistan	Layer V, Epipaleolithic	na	<i>Theodoxus pallasi</i> , <i>Dentalium</i> sp., perforated marginal fragment of <i>Didacna</i> sp.	Okladnikov, 1951, personal data
Jeitun	Kara Kum desert, South Turkmenistan	Early Neolithic	c. 7200–6300 cal BC	Limestone and calcite pendants, calcite and clay plugs, green stone and chalcedony tubular beads, discoid calcite beads, tubular bird/small carnivorous bone beads, <i>Cypraea</i> sp. shell beads, <i>Mitrella</i> cf. <i>agatha</i> , Cardiidae	Harris et al., 2010, personal data from Masson excavation material
Jebel	Great Balhans, Turkmenistan	Neolithic	c. ~5000 cal BC	Perforated, naturally eroded <i>Didacna</i> sp. valves, small-sized <i>Didacna</i> sp. shell discoid beads, decorated bones, stone beads, decorated tortoise shell	Personal data and Okladnikov, 1956
Tumek-kichidjik	North Turkmenistan	Late Neolithic	na	<i>Dentalium</i> sp., <i>Maetra Vitaliana</i> , <i>Didacna</i> sp., large and small discoid shell beads	Vinogradov et al. 1986
Tokmak	Mangyshlak peninsula, West Caspian Sea, Kazakhstan	Hvalyn culture – Chalcolithic	c. 4500–4500 cal BC	Small discoid shell beads, <i>Dentalium</i> sp., discoid stone beads, clay cylinders, perforated <i>Theodoxus</i> sp.	Astaf'ev, 2014
Aktau 1	Mangyshlak peninsula (Aktau), West Caspian Sea, Kazakhstan	Oyukly culture (Neolithic)	c. 5000 cal BC	Large, mid-sized and small <i>Didacna</i> sp. shell discoid beads	Astaf'ev, 2014
Koskuduk 1	Mangyshlak peninsula (Aktau), West Caspian Sea, Kazakhstan	Oyukly culture (Neolithic)	c. 5000 cal BC	Large, mid-sized and small <i>Didacna</i> sp. shell discoid beads, large-sized blanks <i>Didacna</i> sp. shell discoid bead blanks, round red pebble beads, cylindrical slate pendant	Astaf'ev, 2014
Koskuduk 2		Oyukly culture (Neolithic)	c. 5000 cal BC	Large, mid-sized and small <i>Didacna</i> sp. shell discoid beads, discoidal slate beads	Astaf'ev, 2014

(Continued)

Table 7: Continued

Site	Location	Cultural attribution	Chronology	Bead types	Ref.
Khvalynsk	Mangyshlak peninsula (Aktau), West Caspian Sea, Kazakhstan Saratov region, North Caspian Sea	Khvalynsk culture – Chalcolithic	c. 5500–4500 cal BC	Small discoid <i>Didacnoides</i> cf. <i>caucasicus</i> shell beads, <i>Dentalium</i> sp., perforated <i>Corbicula fluminalis</i> , perforated <i>Didacnoides</i> cf. <i>caucasicus</i>	Kirillova et al., 2018
Tuzovskiy Bugry-1	Altai	Chalcolithic	c. 3000–2000 cal BC	Large discoid <i>Colleopterum</i> sp. shell beads, <i>Dentalium</i> sp., <i>Corbicula</i> sp. shell beads, red deer canines, elk incisors, badger canine, musk deer incisors and canines, marmot incisors, fox canine	Kiryushin et al., 2011, 2012
Altappéh	Alborz Mountains, South Caspian Sea, Iran	Layers 3, 10, 12, 13, 14a, 20a, Epipaleolithic	c. 13600–12000 cal BP	Perforated marginal <i>Didacna</i> sp. fragment, perforated <i>Didacna</i> sp.	Manca et al., 2018
Belt - Kamarband	Alborz Mountains, South Caspian Sea, Iran	Layers 11–28, Mesolithic	c. 13400 cal BP	Perforated carnivorous teeth, perforated <i>Didacna</i> sp., land snails (probably used as personal ornaments), perforated marine bivalve	Coon, 1951
Tappeh Sang-e Chakhmaq	Alborz Mountains, South Caspian Sea, Iran	East Mound, layers 182–173, phase 5, Early Neolithic	c. 6200–5300 cal BC	Small stone beads (shale, marble, turquoise), <i>Didacna</i> sp. bead	Roustaei et al., 2015
MPS 4	Mil Plain, East Caspian Sea, Azerbaijan	Late Neolithic	c. 6000 cal BC	Small <i>Didacna</i> sp. discoid shell beads	Heit, 2014
Mariupol cemetery (Mariupolskii mogilnik)	Kalmius River, Donetsk district, Donetsk region, North Azov Sea	Late Neolithic – Chalcolithic	c. 5400–5100 cal BC	Stone, shell and bone beads, decorated wild boar canine	Kotova, 2010

* This study.



Figure 13: Material from Jeitun (Turkmenistan, Masson excavations): 1–5 limestone pendants, 6–8 calcite pendants, 9–16 clay plugs, 17–18 calcite plugs, 19 green stone tubular bead, 20 and 22–25 discoid calcite beads, 21 chalcedony tubular bead, 29–39 tubular bird/small carnivorous bone beads, 40–43 *Cypraea* sp. shell beads, 44–48 *Mitrella* cf. *agatha*, and 49–50 *Cardiidae*.

bivalves, and gastropods originating from the Persian Gulf or the Red Sea have been documented in the Early Neolithic village of Jeitun (Southwest Turkmenistan, Figure 13), but no discoid shell beads have been reported so far (Harris *et al.*, 2010). At the Jebel Neolithic site (Great Balkan Turkmenistan), naturally eroded *Didacna* sp. shell valves were documented, but discoid shell beads are absent from the material (personal data and Okladnikov, 1956). Near the southern Caspian Sea, in Iran, perforated *Didacna* sp. associated with various stone beads are documented in the Early Neolithic Tappeh Sang-e Chakhmaq East Mound (Roustaei *et al.*, 2015); however, no discoid shell beads have as yet been documented in the Early Neolithic occupations (Table 7 and Figure 14).

No discoid shell beads were found in the Caspian Mesolithic layers from the Kaylu rockshelter (Okladnikov, 1951). Only the presence of the freshwater gastropod *T. pallasi* echoes another Caspian Mesolithic occupation at Dam-Dam-Cheshme 2, where the same species was perforated and used (personal data, eastern Caspian region, Turkmenistan, Figure 10). Other pendants present in the Caspian Mesolithic

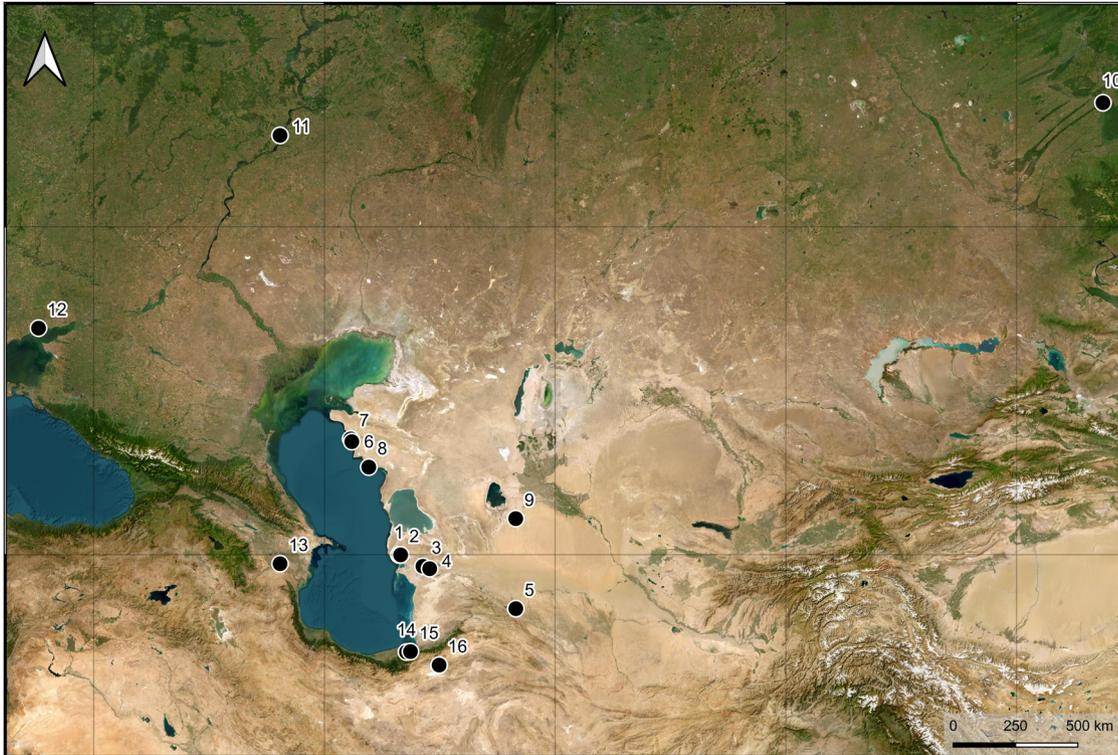


Figure 14: Map of the sites mentioned in the text: (1) Kaylu; (2) Kuba-Sengir; (3) Jebel; (4) Dam-Dam Chesme-2; (5) Jeitun; (6) Aktau-1; (7) Koskuduk-1, 2; (8) Tokmak; (9) Tumek-kichidjik; (10) Tuzovskiye Bugry-1; (11) Khvalynsk; (12) Mariupol cemetery; (13) MPS-4; (14) Belt-Kamarband; (15) Altappeh; and (16) Tappeh Sang-e Chakhmaq.

layers of Dam-Dam-Cheshme 2 include *Dentalium* sp. and the perforated vestigial marginal edge of *Didacna* sp. valves. Similar bivalve fragments are commonly found within thanatocenoses and result from extreme sand abrasion by surf action (Rogalla et al., 2007). Broken perforations with use-wear have been observed on two eroded marginal shell fragments at Dam-Dam-Cheshme 2. Similar shell pendants are documented within the Epipaleolithic occupation of Altappeh (Iran) located in the southern Caspian Sea (Manca et al., 2018). Personal ornaments, including one perforated fragment of *Didacna* sp., were documented in the Mesolithic layers of the Belt Kamarband cave (Coon, 1951).

The shell beads associated with the Kaylu burials do not correspond with the material from the rockshelter, or with other Epipaleolithic/Caspian Mesolithic occupations documented in the southern Caspian region. Differences between the Neolithic shell beads of the regions, including the Early Neolithic material from the two burials documented at Kaylu and the Epipaleolithic/Caspian Mesolithic ornaments documented in the southern Caspian, indicate a sharp typo-stylistic discontinuity between the two periods.

5 Conclusion

Reassessment of the material from the Kaylu burials and rockshelter provides the first regional synthesis of the personal ornaments used by the last foragers and the first farmers who occupied the southern Caspian Sea region. Diachronic comparisons show that personal ornaments from this area were diversified through time and that a stylistic shift between both communities occurred. Data for the Epipaleolithic from Northern Iran and the Caspian Mesolithic from the eastern Caspian Sea region indicates similarities in raw shell material selection and use for personal ornaments. This large-scale, common symbolic production was not maintained at the beginning of the Neolithic, with eastern Caspian Neolithic sites corresponding more with

northern and western Caspian sites. Northern Iran is considered a corridor for the diffusion of farming technologies toward Western Central Asia (Fuller, Willcox, & Allaby, 2011a; Harris *et al.*, 2010; Roustaei & Nokandeh, 2017; Roustaei *et al.*, 2015; Zeder, 2011). The strong similarities observed between the personal ornaments documented in the northern, eastern, and western Caspian Sea at a later stage of the Neolithic diffusion, with no evidence of corresponding symbolic production in Northern Iran, suggest a different pattern of diffusion. A late, northern route of dispersal may have allowed the movement of common ornamental traditions in the Caspian region, to the exclusion of the southern Caspian, as a result of evolutionary mechanisms that still need to be explored. Alternatively, discontinuities in material culture diffusion in coastal areas could be interpreted as evidence of maritime voyaging (Fort, Pujol, & Linden, 2012; Isern, Zilhão, Fort, & Ammerman, 2017; Zilhao, 2001); indeed, the oldest evidence of complex and mastered seafaring is documented circa. 13–11 ky ago in the Eastern Mediterranean at the end of the Epipaleolithic and the Early Neolithic (Vigne & Cucchi, 2005; Vigne, Carrère, Briois, & Guilaine, 2011; Vigne, Zazzo, Cucchi, Briois, & Guilaine, 2014).

The use of Caspian Sea marine resources for consumption, technical, and symbolic productions during the Epipaleolithic and the Early Neolithic (Heit, 2017; Manca *et al.*, 2018; Mashkour, Fontugne, & Hatte, 1999; Mashkour, Chahoud, & Mahforouzi, 2010; Okladnikov, 1951), shows the interest of the Caspian people in their maritime environment. Seafaring contacts between these communities may have granted the fast and spatially discontinuous circulation of specific bead-types, along with people, information, knowledge, and symbols from either side of the Caspian Sea, by long maritime voyages or by leapfrog diffusion during the Neolithic. Indirect evidence of Caspian seafaring has been documented for the Gobustan coastal area in Azerbaijan – rock art, including several boat representations. With all the uncertainties related to engraved rock art dating (Aubry, Dimuccio, Bergadà, Sampaio, & Sellami, 2010; Rodríguez-Vidal *et al.*, 2014), data on the regression/transgression episodes of the Caspian Sea and the location of the engravings on the various terraces suggest that some of the boat depictions may date as far back as 14 ky ago (Sigari, 2020). The diffusion of styles and symbols by land or by sea remains debatable, but the discontinuities observed in the Caspian cultural geography are congruent with maritime voyage, as suggested for other cultural contexts, and as already attested in the region by open-air representations.

Acknowledgements: We are indebted to Dr. Alexey Furasiev for providing access to the Jeitun collection curated at the Hermitage Museum, St. Petersburg. The material from Kaylu and Dam-Dam-Cheshme 2 is currently curated at the Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk. We thank Jill Cucchi for her help in editing this article.

Funding information: This work was supported by the French National Research Agency under the IDEX Bordeaux NETAWA Emergence project No ANR-10-IDEX-03-02 “Out of the Core: Exploring social NETWORKS at the dawn of Agriculture in Western Asia 10,000 years ago,” the French-Russian CNRS International Laboratory “Multidisciplinary Research on Prehistoric Art in Eurasia – ARTEMIR” and the Grand Programme de Recherche “Human Past” of the University of Bordeaux; the analysis of Okladnikov’s archive materials was supported by RSF #19-78-10053 “The emergence of food-producing economies in the high mountains of interior Central Asia” (Saltanat Alisher kyzy, Svetlana Shnaider); analysis of the anthropological collection and sex determination were supported by project # AAAA-A19-119013090163-20 (Natalia Berezina).

Author contributions: Solange Rigaud conceived and designed the analysis. All authors contributed to collecting/analyzing the data and writing the paper.

Conflict of interest: All the authors declare that they have no conflict of interest.

References

- Albrecht, C., von Rintelen, T., Sereda, S., & Riedel, F. (2014). Evolution of ancient lake bivalves: The Lymnocardinae (Cardiidae) of the Caspian Sea. *Hydrobiologia*, 739(1), 85–94. doi: 10.1007/s10750-014-1908-3.
- Anistratenko, V. V., Zettler, M. L., & Anistratenko, O. Y. (2017). On the taxonomic relationship between *Theodoxus pallasi* and *T. astrachanicus* (Gastropoda: Neritidae) from the Ponto-Caspian region. *Archiv für Molluskenkunde International Journal of Malacology*, 146(2), 213–226. doi: 10.1127/arch.moll/146/213-226.
- Asta'ev, A. E. (2014). *Neolit i Eneolit poluostrova Mangyshlak*. (Vol. VI. pp.360, 6 p. of plates). Astana: A. Kh. MargulanInstitute of Archaeology, Astana branch. (in Kazakh, Russian and English).
- Aubry, T., Dimuccio, L. A., Bergadà, M. M., Sampaio, J. D., & Sellami, F. (2010). Palaeolithic engravings and sedimentary environments in the Côa River Valley (Portugal): Implications for the detection, interpretation and dating of open-air rock art. *Journal of Archaeological Science*, 37(12), 3306–3319. doi: 10.1016/j.jas.2010.07.033.
- Bar-Yosef Mayer, D. E., Gümüş, B. A., & Islamoglu, Y. (2010). Fossil Hunting in the Neolithic: Shells from the Taurus Mountains at Çatalhöyük, Turkey. *Geoarchaeology*, 25(3), 375–392.
- Beck, C. H. (1926). *Classification and nomenclature of beads and pendants*. London: Society of Antiquaries of London.
- Bronk Ramsey, C. B. (2017). Methods for summarizing radiocarbon datasets. *Radiocarbon*, 59(6), 1809–1833. BAR Publishing. doi: 10.1017/RDC.2017.108.
- Coon, C. S. (1951). *Cave Explorations in Iran 1949*. University Museum. Philadelphia (PA): University of Pennsylvania.
- Daly, K. G., Maisano Delser, P., Mullin, V. E., Scheu, A., Mattiangeli, V., Teasdale, M. D., ... Bradley, D. G. (2018). Ancient goat genomes reveal mosaic domestication in the Fertile Crescent. *Science*, 361(6397), 85. doi: 10.1126/science.aas9411.
- Dayet, L., Erasmus, R., Val, A., Feyfant, L., & Porraz, G. (2017). Beads, pigments and early Holocene ornamental traditions at Bushman Rock Shelter, South Africa. *Journal of Archaeological Science: Reports*, 13, 635–651. doi: 10.1016/j.jasrep.2017.05.015.
- d'Errico, F., Henshilwood, C., Vanhaeren, M., & Van Niekerk, K. (2005). Nassarius kraussianus shell beads from Blombos Cave: Evidence for symbolic behaviour in the Middle Stone Age. *Journal of Human Evolution*, 48, 3–24.
- Dupont, C. (2006). *La malacofaune de sites mésolithiques et néolithiques de la façade atlantique de la France: Contribution à l'économie et à l'identité culturelle des groupes concernés*. BAR Publishing.
- Erikson, J. M. (1969). *The Universal Bead*. New York: W.W. Norton.
- Fisher, J. A. D., Rhile, E. C., Liu, H., & Petraitis, P. S. (2009). An intertidal snail shows a dramatic size increase over the past century. *Proceedings of the National Academy of Sciences*, 106(13), 5209–5212. doi: 10.1073/pnas.0812137106.
- Fort, J., Pujol, T., & Linden, M. V. (2012). Modelling the Neolithic transition in the Near East and Europe. *American Antiquity*, 77(2), 203–219.
- Fuller, D. Q., Willcox, G., & Allaby, R. G. (2011a). Early agricultural pathways: Moving outside the 'core area' hypothesis in Southwest Asia. *Journal of Experimental Botany*, 63(2), 617–633. doi: 10.1093/jxb/err307.
- Fuller, D. Q., Willcox, G., & Allaby, R. G. (2011b). Cultivation and domestication had multiple origins: Arguments against the core area hypothesis for the origins of agriculture in the Near East. *World Archaeology*, 43(4), 628–652. doi: 10.1080/00438243.2011.624747.
- Graf, D. L. (2007). Palearctic freshwater mussel (Mollusca: Bivalvia: Unionoidea) diversity and the Comparative Method as a species concept. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 156(1), 71–89.
- Hammer, O., Harper, D., & Ryan, P. D. (2001). Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1), 1–9.
- Harasewych, J., & Moretzsohn, F. (2010). *The book of shells: A life-size guide to identifying and classifying six hundred sea-shells*. Chicago: University of Chicago Press.
- Harris, D. R., Asouti, E., Bogaard, A., Charles, M., Conolly, J., Coolidge, J., ... Wilkinson, K. (2010). *Origins of agriculture in Western Central Asia*. Philadelphia: University of Pennsylvania Press. <http://www.jstor.org/stable/j.ctt3fj6gz>.
- Harris, D. R., Damania, A. B., Valkoun, J., Wilcox, G., & Qualset, C. O. (1998). The spread of Neolithic agriculture from the Levant to western Central Asia. In A. B. Damania, J. Valkoun, G. Wilcox, & C. O. Qualset (Eds.), *The origins of agriculture and crop domestication: Proceedings of the Harlan Symposium, 10–14 May 1997, Aleppo, Syria* (pp. 65–82). International Center for Agricultural Research in the Dry Areas.
- Heit, I. (2014). The bead workshop at site MPS4, Mil Plain, Azerbaijan: Craft specialization and the manufacture of shell jewelry in the Neolithic. *Polish Archaeology in the Mediterranean*, 23(2), 21–40.
- Heit, I. (2017). Die neolithische Muschelperlenwerkstatt aus Fundstelle MPS 4. Archäologische und technologische Untersuchungen. In B. Helwing, A. Tevekkül, B. Lyonnet, F. Guliyev, S. Hansen, & M. Guram (Eds.), *The Kura Projects. New Research on the Later Prehistory of the Southern Caucasus* (Vol. 16, pp. 73–123). Berlin: Dietrich Reim.
- Isern, N., Zilhão, J., Fort, J., & Ammerman, A. J. (2017). Modeling the role of voyaging in the coastal spread of the Early Neolithic in the West Mediterranean. *Proceedings of the National Academy of Sciences*, 114(5), 897–902.
- Kassam, A. (1988). Traditional ornament: Some general observations. *Kenya Past and Present*, 20(1), 11–16.

- Kirillova, I. V., Levchenko, V. A., Ippolitov, A. P., Pokrovsky, B. G., Shishlina, N. I., & Yanina, T. A. (2018). The origin of objects of invertebrate descent from the Khvalynsk Eneolithic cemeteries (Northern Caspian region). *IGCP 610 Second Special Volume of Quaternary International*, 465, 142–151. doi: 10.1016/j.quaint.2017.08.037.
- Kiryushin, Y. F., Kiryushin, K. Y., Schmidt, A. V., & Abdulganev, M. T. (2012). Ornaments made from animal teeth in human burials at Tuzovskiy bugry-1 and their relevance to ethnic processes in the Altai, 3rd millennium BC. *Archaeology, Ethnology and Anthropology of Eurasia*, 40(3), 59–66. doi: 10.1016/j.aee.2012.11.007.
- Kiryushin, Y. F., Kiryushin, K. Y., Schmidt, A. V., Kuzmenkin, D. V., & Abdulganev, M. T. (2011). Mollusk shells from burials of tuzovskiy bugry-1 As indicators of ethno-cultural processes In southern siberia and western central asia In the 3rd millennium bc. *Archaeology, Ethnology and Anthropology of Eurasia*, 39(2), 37–45. doi: 10.1016/j.aee.2011.08.004.
- Kotova, N. V. (2010). Burial clothing in Neolithic cemeteries of the Ukrainian steppe. *Documenta Praehistorica*, XXXVII, 167–177.
- Krueger, H. W. (1991). Exchange of carbon with biological apatite. *Journal of Archaeological Science*, 18(3), 355–361. doi: 10.1016/0305-4403(91)90071-V.
- Kurbanov, R. N., Murray, A., Thompson, W., Svistunov, M., Taratunina, N. Y., & Yanina, T. (2021). First reliable chronology for the Early Khvalynian Caspian Sea transgression in the Lower Volga River valley. *Boreas*, 50, 134–146.
- Kurbanov, R. N., Svitoch, A. A., & Yanina, T. A. (2014). New data on marine Pleistocene stratigraphy of the Western Cheleken peninsula. *Doklady Earth Sciences*, 459(2), 1623–1626.
- Lafuente, B., Downs, R. T., Yang, H., & Stone, N. (2015). The power of databases: The RRUFF project. In T. Armbruster & R. M. Danisi (Eds.), *Highlights in Mineralogical Crystallography* (pp. 1–30).
- Le Bourdonnec, F.-X., Bontempi, J.-M., Marini, N., Mazet, S., Neuville, P. F., Poupeau, G., & Sicurani, J. (2010). SEM-EDS characterization of western Mediterranean obsidians and the Neolithic site of A Fuata (Corsica). *Journal of Archaeological Science*, 37(1), 92–106. doi: 10.1016/j.jas.2009.09.016.
- Manca, L., Mashkour, M., Shidrang, S., Averbouh, A., & Biglari, F. (2018). Bone, shell tools and ornaments from the Epipalaeolithic site of Ali Tappeh, East of Alborz Range, Iran. *Journal of Archaeological Science: Reports*, 21, 137–157. doi: 10.1016/j.jasrep.2018.06.023.
- Mashkour, M., Chahoud, J., & Mahforouzi, A. (2010). Faunal remains from the Epipalaeolithic site of Komishan Cave And its dating, preliminary results. *Iranian Archaeology*, 1, 32–37.
- Mashkour, M., Fontugne, M., & Hatte, C. (1999). Investigations on the evolution of subsistence economy in the Qazvin Plain (Iran) from the Neolithic to the Iron Age. *Antiquity*, 73(279), 65–76. doi: 10.1017/S0003598X00087846
- Meisch, L. A. (1998). Why do they like red? Beads, ethnicity and gender in Ecuador. In L. D. Sciamia & J. B. Eicher (Eds.), *Beads and beadmakers: Gender, material culture and meaning* (pp. 147–177). Oxford: Berg.
- Movius, H. L. (1953). Paleolithic and Mesolithic sites in Soviet central Asia. *Proceedings of the American Philosophical Society*, 97(4), 383–421.
- Mulazzani, S., Le Bourdonnec, F.-X., Belhouchet, L., Poupeau, G., Zoughlami, J., Dubernet, S., ... Khedhaier, R. (2010). Obsidian from the Epipalaeolithic and Neolithic eastern Maghreb. A view from the Hergla context (Tunisia). *Journal of Archaeological Science*, 37(10), 2529–2537. doi: 10.1016/j.jas.2010.05.013.
- Naderi, S., Rezaei, H.-R., Taberlet, P., Zundel, S., Rafat, S.-A., Naghash, H.-R., ... Econogene Consortium. (2007). Large-scale mitochondrial DNA analysis of the domestic goat reveals six haplogroups with high diversity. *PLoS one*, 2(10), e1012. doi: 10.1371/journal.pone.0001012.
- Neubauer, T. A., van de Velde, S., Yanina, T., & Wesselingh, F. P. (2018). A late Pleistocene gastropod fauna from the northern Caspian Sea with implications for Pontocaspian gastropod taxonomy. *ZooKeys*, 770, 43–103. doi: 10.3897/zookeys.770.25365.
- Okladnikov, A. P. (1949). Izuchenie drevneishikh arheologicheskikh pamyatnikov Turkmenii. *Kratkiye Soobshcheniya Instituta Istorii i Materialnoy Kultury*, 28, 67–71. (in Russian).
- Okladnikov, A. P. (1951). Drevneishie arheologicheskie pamyatniki Krasnovodskogo poluostrova (otchet o polevykh rabot 1947). In M. E. Masson (Ed.), *Trudy JuzhnoTurkmenskoj arheologicheskoy ekspedicii, Ashgabat 2* (pp. 73–104). Barnaul: Altai University Press. (in Russian).
- Okladnikov, A. P. (1953). Izuchenie pamyatnikov kamennogo veka v Turkmenii (po dannym rabot IX otryada YuTAKE v 1952 g.). *Izvestia AN TSSR*, 2, 3–22. (in Russian).
- Okladnikov, A. P. (1956). “The Djebel Cave – a Monument of Ancient Culture of the Caspian Tribes of Turkmenistan.” In *Proceedings of the Joint Turkestan Archaeological Expedition (Trudy YUTAKE)* (Vol. 7). Ashgabat. (in Russian).
- Okladnikov, A. P. (1966). Paleolit i mezolit Srednej Azii. In V.M. Masson (Ed.), *Srednjaja Azija v epohu kamnja i bronzy* (pp. 11–75). Moscow-Leningrad: Nauka.
- Orton, J. (2008). Later Stone Age ostrich eggshell bead manufacture in the Northern Cape, South Africa. *Journal of Archaeological Science*, 35(7), 1765–1775. doi: 10.1016/j.jas.2007.11.014.
- Poppe, G. T., & Goto, Y. (1993). *European Seashells (Scaphopoda, Bivalvia, Cephalopoda)*. Wiesbaden: Hemmen.
- Rasilla, M., de la Duarte, E., Sanchis, A., Carrión, Y., Cañaveras, J. C., Marín-Arroyo, A. B., ... Santos, G. (2020). Environment and subsistence strategies at La Viña rock shelter and Llonin cave (Asturias, Spain) during MIS3. *Journal of Archaeological Science: Reports*, 30, 102198. doi: 10.1016/j.jasrep.2020.102198.
- Reimchen, T. E. (1982). Shell size divergence in *Littorina mariae* and *L. obtusata* and predation by crabs. *Canadian Journal of Zoology*, 60, 687–695.

- Reimer, P., Bard, E., Bayliss, A., Beck, J. W., Bronk Ramsey, C., Blackwell, P. G., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hafliðason, H., Hajdas, I., Hatté, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., Hughen, K. A., Kaiser, K. F., ... van der Plicht, J. (2013). IntCal13 and Marine13 Radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon*, 55(4), 1869–1887. doi: 10.2458/azu_js_rc.55.16947.
- Rigaud, S. (2013). Les objets de Parure associés au dépôt funéraire mésolithique de GroBe Ofnet: Implications pour la compréhension de l'organisation sociale des dernières sociétés de chasseurs-cueilleurs du Jura Souabe. *Anthropozoologica*, 48(2), 207–230. doi: 10.5252/az2013n2a2.
- Rigaud, S., O'Hara, J., Charles, L., Man-Estier, E., & Paillet, P. (2022). The management of symbolic raw materials in the Late Upper Paleolithic of South-Western France: A shell ornaments perspective. *Peer Community Journal*, 2, e65. doi: 10.24072/pcjournal.185.
- Rigaud, S., Roussel, M., Rendu, W., Primault, J., Renou, S., Hublin, J. J., & Soressi, M. (2014). Les pratiques ornementales à l'Aurignacien ancien dans le Centre-Ouest de la France. L'apport des fouilles récentes aux Cottés (Vienne). *Bulletin de la Société Préhistorique Française*, 111(1), 19–38.
- Rigaud, S., Vanhaeren, M., Queffelec, A., Bourdon, G., & d'Errico, F. (2014). The way we wear makes the difference: residue analysis applied to Mesolithic personal ornaments from Hohlenstein-Stadel (Germany). *Archaeological and Anthropological Sciences*, 6, 133–144. doi: 10.1007/s12520-013-0169-9.
- Rodríguez-Vidal, J., d'Errico, F., Pacheco, F. G., Blasco, R., Rosell, J., Jennings, R. P., ... Finlayson, C. (2014). A rock engraving made by Neanderthals in Gibraltar. *Proceedings of the National Academy of Sciences*, 111(37), 13301–13306.
- Rogalla, N. S., Amler, D. M., & München, M. (2007). Statistic approach on taphonomic phenomena in shells of *Glycymeris glycymeris* (Bivalvia: Glycymerididae) and its significance in the fossil record. *Paläontologische Zeitschrift*, 81(3), 334–355.
- Roustaei, K., Mashkour, M., & Tengberg, M. (2015). Tappeh Sang-e Chakhmaq and the beginning of the Neolithic in north-east Iran. *Antiquity*, 89(345), 573–595. doi: 10.15184/aqy.2015.26.
- Roustaei, K., & Nokandeh, J. (2017). Neolithic developments in the Gorgan Plain, south-east of the Caspian Sea. *Antiquity*, 91(358), e3. doi: 10.15184/aqy.2017.124.
- Shnaider, S., Alisher kyzy, S., Yanina, T. A., Bujilova, N., Berezina, N., & Rigaud, S. (2021). The human cultures in South-Eastern Caspian region in final Pleistocene – Holocene period. *Archaeological Research in Asia*, 28, 100318. doi: 10.1016/j.ara.2021.100318.
- Shnaider, S. V., Kurbanov, R. N., Alisher kyzy, S., Rigaud, S., Shangina, M. V., & Krivoshapkin, A. I. (2018). The Results of Kaylu and Kuba-Sengir Sites Preliminary Study (Eastern Caspian, Turkmenistan). *Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories*, XXIV, 184–189. doi: 10.17746/2658-6193.2018.24.184-189.
- Sigari, D. (2020). The sea on the rocks. Sailing in the rock art of Gobustan. In F. Biglari, J. Nokandeh, A. N. Beni, & A. Hozhabri (Eds.), *Human and the Sea. A review of thousands of years of relationship between humans and the sea in Iran* (pp. 173–194). Teheran: National Museum of Iran. <https://hal.science/hal-03836212>.
- Son, M. A. (2007). Native range of the zebra mussel and quagga mussel and new data on their invasions within the Ponto-Caspian Region. *Aquatic Invasions*, 2(3), 174–184.
- Stewart, N. A., Gerlach, R. F., Gowland, R. L., Gron, K. J., & Montgomery, J. (2017). Sex determination of human remains from peptides in tooth enamel. *Proceedings of the National Academy of Sciences*, 114(52), 13649. doi: 10.1073/pnas.1714926115.
- Stuiver, M., & Polach, H. A. (1977). Discussion reporting of 14C data. *Radiocarbon*, 19(3), 355–363. doi: 10.1017/S003822200003672.
- Svitoch, A. A. (2012). The Caspian Sea shelf during the pleistocene regressive epochs. *Oceanology*, 52, 526–539. doi: 10.1134/S0001437012030113.
- Taborin, Y. (1998). *La parure en coquillage au Paléolithique* (C. Editions, Éd.). Broché.
- Vahdati Nasab, H., Shirvani, S., & Rigaud, S. (2019). The Northern Iranian Central Plateau at the end of the Pleistocene and Early Holocene: The emergence of domestication. *Journal of World Prehistory*, 32(3), 287–310. doi: 10.1007/s10963-019-09133-0.
- Vanhaeren, M. (2002). *Les fonctions de la parure au Paléolithique supérieur: De l'individu à l'unité culturelle*. Bordeaux: Université de Bordeaux.
- Vanhaeren, M., d'Errico, F., van Niekerk, K. L., Henshilwood, C. S., & Erasmus, R. M. (2013). Thinking strings: Additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa. *Journal of Human Evolution*, 64(6), 500–517. doi: 10.1016/j.jhevol.2013.02.001.
- Vigne, J. D., & Cucchi, T. (2005). Premières navigations au Proche-Orient: Les informations indirectes de Chypre. *Paléorient*, 31, 186–194.
- Vigne, J.-D., Carrère, I., Briois, F., & Guilaine, J. (2011). The early process of mammal domestication in the Near East: New evidence from the Pre-Neolithic and Pre-Pottery Neolithic in Cyprus. *Current Anthropology*, 52(S4), S255–S271. doi: 10.1086/659306.
- Vigne, J.-D., Zazzo, A., Cucchi, T., Briois, F., & Guilaine, J. (2014). The transportation of mammals to Cyprus shed light on early voyaging and boats in the mediterranean sea. *Eurasian Prehistory*, 10(1–2), 157–176.
- Vinarskij, M. V., & Kantor, J. I. (2016). *Analytical catalogue of fresh and brackish water molluscs of Russia and adjacent countries*. Moscow: Institut problem ékologii i évoljucii A. N. Severtcova Rossijskoj Akademii Nauk.

- Vinogradov, A. V., Itina, M. A., & Yablonsky, L. T. (1986). *Drevneisheye naseleniye nizovii Amudari: Arkheologopaleoantropologicheskoye issledovaniye* (Vol. 15). Nauka.
- Yanina, T. A. (2005). *Didakny Ponto-Kaspiya [Didacna of the Ponto-Caspian]*. Madzhenta.
- Yanina, T. A., Svitoch, A. A., Kurbanov, R. N., Murray, M. S., Tkach, N. T., & Sychev, N. V. (2017). Opyt datirovaniya pleystotsenovykh otlozheniy Nizhnego Povolzh'ya metodom opticheski stimulirovannoy lyuminestsentsii (Paleogeographic analysis of the results of optically stimulated luminescence dating of Pleistocene deposits of the Lower Volga area). *Vestnik MSU, Seriya 5 Geografiya*, 1, 21–29.
- Zeder, M. A. (2008). Domestication and early agriculture in the Mediterranean Basin: Origins, diffusion, and impact. *Proceedings of the National Academy of Sciences*, 105(33), 11597–11604. doi: 10.1073/pnas.0801317105.
- Zeder, M. A. (2011). The origins of agriculture in the Near East. *Current Anthropology*, 52(S4), S221–S235. doi: 10.1086/659307.
- Zeder, M. A. (2012). Pathways to animal domestication. In A. B. Damania, C. O. Qualset, P. E. McGuire, P. Gepts, R. L. Bettinger, S. B. Brush, & T. R. Famula (Eds.), *Biodiversity in agriculture: Domestication, evolution, and sustainability* (pp. 227–259). Cambridge: Cambridge University Press. doi: 10.1017/CBO9781139019514.013.
- Zilhao, J. (2001). Radiocarbon evidence for maritime pioneer colonization at the origins of farming in west Mediterranean Europe. *Proceedings of the National Academy of Science*, 98(24), 14180–14185.