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NEOLITHIC CERAMICS OF THE CHOKH SETTLEMENT IN THE CONTEXT OF CERAMIC TECHNOLOGICAL TRADITIONS OF THE EASTERN CAUCASUS

Abstract. The purpose of this article is to study the place of Neolithic ceramics of the Chokh settlement among the cultural and technological traditions of the Neolithic ceramics of the Caucasus, as well as its role in the formation of ceramic production of Central Dagestan. In this regard, in the course of this work, using technological, photographic, XRD and spherulite analyzes, a comparative study of Neolithic ceramics from Chokh settlement was carried out with products from the closest Neolithic settlement of Transcaucasia – Göytepe, located in the middle reaches of the Kura River, as well as with later ceramic materials from the Chalcolitic and Bronse Age periods of Central Dagestan. The analysis of Neolithic ceramics from the Chokh settlement, on the one hand, showed that it is entirely an item of local production, which is determined by the characteristics of the raw materials, and the admixture of grog in the pottery paste. On the other hand, connections with one of the types of Transcaucasian ceramics from the settlements of the early 6-th millennium BCE, Haci Elamxanli Tepe and Gadachrili Gora – products with mineral admixture and, possibly, dung in the pottery paste, fired mostly in reducing atmosphere with applique buttons on the surface are presumably recorded. This type continued to exist in later Göytepe materials with some changes. Further, in the pottery production of Central Dagestan during the Chalcolitic – Bronze Age period, on the one hand, we can talk about the gradual development – the replacement of mineral admixtures, the appearance of polishing tradition and improvement of firing conditions.

Keywords: Chokh; Neolithic of the Caucasus; Central Dagestan; Chalcolithic of Dagestan; Bronze Age of Dagestan; Transcaucasia; Göytepe; ceramics

АРХЕОЛОГИЯ

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Исследовательская статья

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НЕОЛИТИЧЕСКАЯ КЕРАМИКА ПОСЕЛЕНИЯ ЧОХ В КРУГУ КЕРАМИЧЕСКИХ ТЕХНОЛОГИЧЕСКИХ ТРАДИЦИЙ ВОСТОЧНОГО КАВКАЗА

Аннотация. Целью исследования является определение места неолитической керамики поселения Чох среди культурных технологических традиций керамики неолита Кавказа, а также ее роли в становлении керамического производства Центрального Дагестана. В связи с этим в ходе данной работы с помощью технико-технологического, петрографического, рентгенофазового и сферулитного анализов было проведено сравнительное изучение неолитической керамики поселения Чох с изделиями наиболее близкого ей территориально неолитического поселения Закавказья – Геой-тепе, расположенного в среднем течении реки Куры, а также с более поздними керамическими материалами периода энеолита и бронзового века Центрального Дагестана. Анализ неолитической керамики поселения Чох, с одной стороны, показал, что она полностью является продуктом местного производства, что фиксируется по особенностям сырья, а также по примеси шамота. С другой стороны, предположительно отмечены связи с одним из типов керамики Закавказья, присутствующем на поселениях начала VI тыс. до н.э. Хаджи Эламханлы Тепе и Гадачрили Гора – изделий с минеральной примесью и, возможно, навозом в формовочной массе, обожженными преимущественно в восстановительной атмосфере с налепами-кнопками на поверхности. Этот тип продолжил свое существование в более поздних материалах Геой-тепе с некоторыми изменениями. Далее в гончарном производстве Горного Дагестана в течении периода энеолита – эпохи бронзы с одной стороны мы можем говорить о преемственности традиций (использование шамота и навоза в качестве искусственной примеси), а с другой – о постепенно развитии – замещении минеральной примеси, появлении лощения и улучшении условий обжига.

Ключевые слова: Чох; неолит Кавказа; Центральный Дагестан; энеолит Дагестана; эпоха бронзы Дагестана; Закавказье; Геой-тепе; керамика.

Introduction

The emergence of pottery in the Caucasus dates back to the early 6th millennium BCE. It spread into the South Caucasus region along with advancements in agriculture and animal husbandry, and is associated with vast territories of the Near East: from the Eastern Taurus and its foothills, through the eastern part of Upper Mesopotamia, to the adjacent northern areas of the Zagros Mountains and the Iranian Plateau [1; 2; 3; 4; 5, p. 55–82; 6, p. 15–28]. Ceramics extended throughout the territory of Transcaucasia, but local variants can be distinguished in the middle reaches of the Kura River valley, including settlements such as Hacı Elamxanlı Tepe [7], Shomutepe [2], Göytepe [8], Mentesh-tepe [9], Gadachrili Gora [10], Shulaveris-Gora [11], Imiris Gora [12], Khiramis Didi-Gora [13], and Arukhlo [14]. Additional pottery settlements have been identified in the Ararat Valley (Tekhut [15], Aknashen [16; 17], Aratashen [16]), in Nakhichevan (Kultepe [18]), and the Mil steppe (Kamil-Tepe [19]). Furthermore, pottery has been found beyond the Great Caucasian Ridge, with the Chokh settlement [20] in Central Dagestan being the only known site thus far.

This study aims to determine the place of Neolithic ceramics from the Chokh settlement within the cultural and technological traditions of Neolithic ceramics in the Caucasus, as well as its role in the formation of ceramic production in Central Dagestan. In this regard, we conduct a comparative analysis with ceramics from the closely related Neolithic settlement in Transcaucasia – Göytepe, located in the middle course of the Kura River – as well as with later ceramic materials from the Chalcolithic and Bronze Age periods of Central Dagestan (Fig. 1; 2, *1–4*).

Pottery making traditions in Neolithic Transcaucasia (Based on materials from the middle reaches of the Kura River)

The traditions of pottery making will be considered further using materials from the following sites: Hacı Elamxanlı Tepe [21, p. 133–152], Shomu-Tepe [22, p. 53; 2], Göytepe [23, p. 22–31; 24, p. 1–11; 25, p. 166–169; 26, p. 261–286], Aruhlo, Gadachrili Gora [27], Mentesh-tepe, [27; 9] (fig. 1).

The earliest pottery in the region has been identified at the settlements of Hacı Elamxanlı Tepe (5950–5800 cal BCE) [28, p. 290] and Gadachrili Gora (5920–5720 cal BCE) [10]. Some of the ceramics from the Hacı Elamxanlı Tepe settlement is represented by thin-walled ceramic fragments with paintings, indicating connections with Upper Mesopotamia of the Standard Hassuna period and is characterized by the absence of admixture and coating with a greyish-yellowish slip. There is also ceramics with mineral and organic admixtures with an orange and grey-yellowish-brown surface. According to the researchers, all the ceramics are made using coils [21, p. 133–152].

The pottery of the Gadachrili Gora settlement is made of sanded clay. Basalt and rare plant material were recorded as artificial admixtures. It is also assumed that the most common method of construction was coiling. The surface treatment was simple smoothing. Appliqués

are limited to protruding knobs; polishing was rarely used. Both reducing and oxidizing conditions were used for firing [27, p. 8, 12–13, 41. Tabl. 13].

Later, in the settlements of the region under consideration, researchers identified two main types of pottery[1], which could also be mixed. The first is vessels with plant admixture associated with straw [23, p. 23; 22, p. 53; 2], or sometimes interpreted as a fine organic admixture [26, p. 262; 27, p. 35–36]. In some cases, imprints of grains can be observed. In the Göytepe settlement, it is assumed that this type of pottery was made using clay bands, but short coils and slabs are also mentioned [23, p. 23–25]. The vessels could be painted, including with the use of bitumen (separate bands), slipped (red or light slip) and were fired in both oxidizing and reducing conditions.

The second, predominant variety of pottery contained mineral impurities which were most likely intentionally added. These impurities included crushed basalt, obsidian, sand, and grog. The use of molds for the lower part of the vessel and the finishing with bands for the upper part are observed in Göytepe ceramics [23, p. 23–25]. The vessels were often coated with a thick layer of clay and could feature appliqué buttons, bitumen stripes, and light and red slip. Firing occurred in both oxidizing and reducing conditions.

In addition, for both types of pottery of the Arukhlo settlement, it was found that using coils was the most common method of pottery constructions. One study mentioned mixed coils and slabs for the ceramics of the Mentesh-tepe settlement [27, p. 12–13], while another mentioned bands and slabs [9, p. 179]. In any case, this situation indicates the presence of a variety of construction methods. Weaving imprints are also regularly found on the outside of the base [22; 2; 27, p. 1–48; 22, p. 22–31 etc.].

The tradition of pottery making in Central Dagestan in the Neolithic-Bronze Age

In the North Caucasus, Chokh is the only known settlement where pottery has been discovered in Neolithic layers. This settlement is situated in Central Dagestan, near the Great Caucasian Ridge. According to several researchers, the pottery from this settlement is linked to the traditions of the South Caucasus [29; 30, p. 14; 3, etc.]. The development of pottery making in the region during the Chalcolithic period remains largely unexplored. However, two key sites from this period in Central Dagestan have yielded pottery: the Ginchi settlement [31, pp. 28–87] and the Rugudzha sites of Malin-Karat, Muchu-Bahil-Bakli, and Arkhinda [32]. This is due both to the difficulty of finding sites and settlements of the early period in mountainous areas, and, probably, to the small number of them in this inaccessible area during the period in question. The ceramic material from the Rugudzha sites is very insignificant. Two forms were partially restored, and it was noted that the surface colour was pinkish and brown [31, p. 75–76]. Little is known about the pottery of the Ginchi settlement, but the existing collections are quite extensive and should be the subject of a separate study in the future.

The real spread of pottery in the region is associated with the Early Bronze Age and with the emergence of sites belonging to the North-Eastern Caucasian local version

1. Researchers also offer more detailed descriptions of varieties of pottery

of the Kura-Araxes cultural and historical community – in the middle of the 4th millennium BCE. The settlements of Mekegi, Galgalatli I, Andi and the burial grounds of Shchebokha and Gono are known from this period [31, p. 140–151]. Bronze Age layers have also been recorded at the Chokh settlement [20]. In addition, the burial ground of the Middle Bronze Age Nokhola-ad [33, p. 41–52], belonging to the Ginchinsky-Gatynkalinsky culture, was located near the settlement (fig. 1). In the Middle Bronze Age, potters used ferruginous clay with low and medium sand content as the basic raw material for pottery paste. The main recipes for pottery pastes were: clay + grog + organic materials (dung, organic solution). The presence of shale in the pottery pastes was also recorded, but it is not always clear whether it is of natural or artificial origin [34, p. 278–293].

Materials and research methods

The main object of study was ceramics from the Neolithic layer of the Chokh settlement, located in the Gunib region of the Republic of Dagestan. The settlement was explored three times: in 1955–1957 by V.G. Kotovich [32], in 1981–1982 and in 2021–2022 by H.A. Amirkhanov [20; 35; 36]. According to the definition of H.A. Amirkhanov, the settlement contained layers dating back to the Mesolithic, Neolithic and Bronze Age. The ceramics contained a Neolithic layer, dated by the author of the excavations in early 6th millennium BCE, and a Bronze Age layer [20; 30; 35; 36].

In the excavated area of the Neolithic layer, about 900 mostly very small ceramics fragments were found. The morphology of the vessels was reconstructed by the author of the excavation on the basis of two items: a bowl (height about – 5 cm, rim diameter – 11.8 cm, bottom – 8 cm, wall thickness – 6 cm) and a pot-shaped vessels (height approximately – 20 cm, rim diameter – 15. 5 cm, bottom – 12 cm, widest part – 20 cm). The pottery was made of slightly sandy clay mixed with finely crushed ceramics. One characteristic of the pottery is the presence of a small protrusion along the rim [20, p. 130]. An important feature indicating a link with the Neolithic of Transcaucasia is the presence of appliqué on one fragment (fig. 3. *1*, *3*), in the form of protruding buttons [20; 30, p. 14, fig. 3]. In our study, we examined 15 fragments of rims, walls, and bottoms from different vessels, with a varying thickness of 6–9 cm. (fig. 3. *4–9*).[2]

The Bronze Age layer of the Chokh settlement contained very few small-sized pottery, and therefore only two fragments of vessel walls about 7–8 cm thick were studied. In addition, pottery from the Rauf M. Munchaev's excavations at the Middle Bronze Age cemetery of Nokhola-ad, adjacent to the Chokh settlement were studied [33, p. 41–52]. All available material from crypt № 1 and №2 was selected for this purpose. [3] A total of thirteen fragments of the rims, bases and walls of different vessels were used in the study. Morphologically, these are pot-shaped vessels and bowls with a truncated cone with a wall thickness of 0.8-1.1 cm, and miniature vessels with a wall thickness of up to 0.5 cm (fig. 4).

2. Storage of the Institute of Archeology Russian Academy of Science, Moscow
3. Storage of the National Museum of the Republic of Dagestan named after A. Takho-Godi, Makhachkala (Scientific and Auxiliary Fund. #7868).

For comparison with the above-mentioned materials, individual pottery samples were also selected from other earliest sites of Mountain Dagestan – Ginchi and the Rugudzha site of Malinkarat, 2-3 cm in size, dating back to the Chalcolithic period [31, p. 75–76].[4]

Ceramics from the settlement served as comparative material from the South Caucasus Göytepe area, located in the middle reaches of the Kura River in Western Azerbaijan, and the closest of the known Neolithic settlements of the South Caucasus to the Chokh settlement. The ceramic materials used in this work belong to the upper 2–4 horizons of the site,[5] dating to the middle of the 6th millennium BCE [37, p. 3–16; 37]. Materials from horizon 4 have already been published [23, p. 22–31]. These are fragments of rims, walls and bottoms of vessels of various morphology.

To achieve the set goals, the authors of this paper carried out technical and technological (for all materials), petrographic, X-ray structural and spherulite analyses (for selected materials from the Chokh and Göytepe settlements).

Technological analysis

Technological research of ceramics was carried out according to the method of Alexander A. Bobrinsky, which includes traceological and microscopic analysis of cross-sections and surfaces of the investigated objects, as well as experimental modelling of individual stages of pottery production and comparison them with archaeological materials [38; 39]. Microscopic analysis was carried out using a Carl Zeiss Stemi 2000C stereomicroscope.[6]

Ceramics from the Chokh settlement from the Neolithic layer. The Neolithic ceramics of the Chokh settlement were made from ferruginous, slightly sandy clay raw materials with an artificial admixture of grog of different colours (both identical to the main colour of the ceramics – grey, and warmer beige tones) ranging in size from 1 to 7 mm in various concentrations (from 1:10 to 1: 4) (fig. 4. *1–4*). Individual small plant remains were noted in the pottery paste (fig. 4. *1*). On the basis of some samples, it was possible to establish the application of the slabs construction. This can be seen from the layering of cross-sections, especially the fragments of the bases (fig. 3. *8–9*). The surface treatment was simple smoothing. The pottery were fired mainly in a reducing atmosphere (without oxygen), but there are fragments that have been in an oxidizing atmosphere. The latter is probably due to the imperfection of the firing device (fire pit) and the unintentional access of oxygen.

Ceramics of the Chalcolithic period from Central Dagestan. The very small fragments of ceramics studied provide limited information. Presumably, the raw material was ferruginous medium sandy clay. In the ceramics from the Rugudzha site of Malinkarat, grog with a polished surface was observed (fig. 5, *5*). Firing typically occurred in an oxidizing atmosphere (fig. 4, *1–2*). The ceramics from the Ginchi settlement contain a significant admixture of what is presumably clay shale, with a high concentration estimated at a ratio of 1:3 or 1:4 (fig. 5, *6*). Most vessel surfaces were covered with an additional layer of clay (fig. 4, *3–5*), as evidenced

4. Storage of the Institute of History, Archeology and Ethnography, Dagestan Federal Research Center RAS
5. Storage of the Institute of Ethnography, Archeology and Anthropology of ANAS, Baku.
6. The samples were studied using the equipment of the Center for Collective Use at the Institute of Archaeology of the Russian Academy of Sciences (Moscow).

by cracks and chipping in this layer, as evidenced by the cracks and chipping of this additional layer (fig. 4, *5*). However, there are also fragments without this additional coating, where a high concentration of crushed stone is visible on the surface (fig. 4, *6*).

Bronze Age ceramics from the Middle Bronze Age burial ground Nokhola-ad and Chokh settlement. Vessels originating from the burial ground were made from ferruginous clays with medium and high sand content. Organic matter (dung, organic solution) was used as an admixture in the production of vessels. Artificial mineral impurities included in the pottery paste are grog (fig. 5, *7*) and, in one case, quartz grit (fig. 5, *8*), which distinguishes this pottery from other materials of the Middle Bronze Age. The grog is identical to the main raw material of the vessels. The vessels were constructed using clay slabs. The surfaces of the vessels were treated only by mechanical means: smoothing and polishing, in most cases, from the inside. The vessels were fired in an oxidizing atmosphere in primitive devices or fire pits, as evidenced by the pinkish, light brown and mottled surface (fig. 4, *7-8*). However, there are also instances of firing in a reducing atmosphere, particularly this applies to miniature pots with wall thickness of up to 0.5 mm. (fig. 4, *9*). In general, as already mentioned, the pottery-making technology from the Chokh burial ground is characteristic for the ceramics of the Middle Bronze Age in the region and belongs to the Ginchinskaya-Gatynkalinskaya culture.

Bronze Age ceramics from the Chokh settlement were made from medium-sandy raw materials (probably with an admixture of clay shale). Grog and an organic solution were used as an artificial admixture, identified by the characteristic porous voids in the fracture and small plant residues, presumably associated with dung. The surface of the fragments is either simply smoothed or polished. The ceramics were fired in an oxidizing atmosphere (fig. 4, *10-11*).

Ceramics from the Neolithic settlement of Göytepe.

The raw materials used in the manufacture of pottery were ferruginous, medium and highly sanded. Following the tradition of dividing ceramics into products with organic and mineral admixtures [23, p. 23–25; 26, p. 261–286], it can be noted that one part of the studied Göytepe pottery is characterized by the presence of livestock dung impurities in the paste in a concentration of up to 15-30%. The latter is detected by the presence of very small plant impurities with characteristic endings and the shape of the remains (fig. 6, *1–2*) [39, p. 5–109; 40, p. 279–307]. Furthermore, as already mentioned, crushed straw was also present in the pottery paste of the vessels (fig. 6, *3*), as well as, the husks of large grains [23, p. 23–25], on basis of which large plant impurities can be associated with threshing waste (fig. 6, *4*). The vessels were made using both a two-layer slab and a coil construction, which is especially noticeable when studying the joints between the elements when examining the cross-section of the vessels bases: horizontal – in the case of a two-layer slab construction (fig. 6, *8*), and vertical – in the case of a coil (fig. 6, *9*). Vessels can be covered with either red slip (fig. 6) or lightly painted with a simple clay coating, which is noticeable by the cracks appearing through the loose layer of paint, which is the result of uneven drying of the raw material and the additional layer of clay (fig. 6, *5-6*). The bases have imprints of the weaving surface on which the vessel was formed (fig. 6, *7*).

Ceramics with mineral impurities can be divided into two types (fig. 7). The pottery paste of the first type contains an admixture of basalt (fig. 7, *1–2*). The vessels were made using

the slab construction, which can be seen in the joints in the base cross-section (fig. 7, *2*). On the ceramic surface, along the cracks in the surface layer, an additional clay coating and colouring with red pigment were observed (fig. 7, *2*). The second type of ceramics has an artificial admixture of obsidian and a grey mineral admixture. The latter had different sources than the basalt from the first group, judging by the colour (fig. 7, *4–5*). This ceramic also contains grog in a low concentration (no more than 1–10) (fig. 7, *3*). The vessels are made from single-layered elongated slabs and covered with a significant layer of coating (fig. 7, *6*). In addition, this group of ceramics is characterized by reducing firing, which distinguishes it from other groups.

Judging from the colour of the surface and the change in the colour of the central part of the fragments, it can be assumed that the firing took quite a long time when the temperature was reached 750–800°C. According to another study, the firing temperature of ceramics from the Göytepe settlement was determined to be within 600-750°C [24, p. 1–11]. The presented data suggest the use of some more advanced closed firing device.

Petrographic and XRD analyzes

Ceramics fragments of from the Chokh settlement (8 samples from the Neolithic period and 2 samples from the Bronze Age, as well as samples of ceramics from the Göytepe settlement (5 samples)) were studied using mineralogical-petrographic and XRD analyzes (only 1 sample for the Göytepe settlement). Mineralogical and petrographic analysis was carried out in the sections (thin sections of a ceramic sample 0.03 mm thick) using an Axio Scope 40 Carl Zeiss polarizing microscope. The study of sections of ceramics allows for accurate determination of the mineral composition and quantitative ratios of raw materials, mineral and organic artificial impurities, morphology, size and number of voids [41, etc.].

The XRD phase analysis method is based on the phenomenon of X-ray diffraction from the planes of crystal lattices of minerals. Since the crystal lattice of different minerals is different, it is possible to determine its structure, and therefore the mineral itself, by the nature of the diffractogram. The method acquires the greatest importance in the diagnosis of clay minerals in raw materials of ceramic samples. The analysis was carried out in prepared specimen from ceramic samples on a MiniFlex 600 X-ray diffractometer (bulk analysis) (Table 1).

Table 1. Results of XRD analysis (bulk samples).

Sample no.	illite	serpentine	quartz	KPSh	plagio-clase	hematite	sum
CHOKH B 1	7	1	52	31	9	0	100
CHOKH B 3	7	0	48	19	23	3	100
CHOKH N 2	32	0	51	6	11	0	100
CHOKH N 4	27	1	43	15	14	0	100
CHOKH N 5	22	0	50	11	17	0	100
CHOKH N 6	53	0	22	18	7	0	100

CHOKH N 8	33	0	47	12	8	0	100
CHOKH N 9	2	1	52	11	34	0	100
CHOKH N 10	33	0	39	15	13	0	100
GT-7	0	0	70	0	28	2	100

Ceramics of the Chokh settlement

The studied samples of Neolithic ceramics from the Chokh settlement (Chokh-N-2, 4, 5, 6, 8, 9, 10, 11, 12) have differences both in the composition of raw materials and in the composition of artificial admixtures. One of the distinctive features of Neolithic ceramics from the Chokh settlement is the mass fracturing of the fragments. There are small elongated, unidirectionally oriented microcracks 0.02-0.4 mm long, 0.005-0.01-0.02 mm wide; as well as single isometric large voids measuring 0.6mm x 0.3 mm to 0.8 mm x 0.4 mm, individual ones up to 1-2 mm, often encrusted along the edges with microcrystal calcite.

The first type of structure of Neolithic raw materials is defined as pelitic. This includes samples Chokh-N-2, 4, 5, 6, 11, 12. It is characterized by a predominance of clay substance with a dimension of less than 0.005 mm and a small natural admixture of silty and fine sandy material in an amount of less than 5%. The composition of the clayey part is essentially illite (fig. 8, *1*); the composition of the silt-fine sand admixture is predominantly quartz. This type of raw material is characterized by impurities from a single source, in amounts ranging from 10% to 25% from sample to sample. These are fragments of quartz crystals, less commonly microcline, orthoclase, plagioclase; single fragments of altered acidic effusive rocks, quartzites, bacterial and algal limestones, sandstones with calcite cement. Single clots ranging in size from 0.15 to 1 mm, round and elongated, opaque, structureless, homogeneous, presumably of organic matter are being traced. There are two types of grog: 1. intraclastic, predominant, in the form of fragments up to 0.75 mm, of varying degrees of burntness; and 2. alien, more rarely found, in single quantities. The latter is represented by fragments of a pelitic structure, homogeneous, clayey, essentially illite fragments of ceramics, without impurities, and was also found in Bronze Age samples from the Chokh location; as well as fragments of silty-pelitic structure, slightly transparent due to the saturation with natural finely dispersed organic substance and iron oxides developing on them (such grog, in turn, sometimes contains grog) (fig. 9, *1–9*, *7*).

The second type of raw material structure, characteristic of Neolithic ceramics from the Chokh settlement, is silty-pelitic, characterized by the fact that the natural silty admixture to the essentially illite clay mass is at least 15–20% (samples Chokh-N-8,9,10) (fig. 8, *2*). At the same time, the amount of artificial admixture of sand size is relatively small: from 5 to 15%. The admixture consists of fragments of quartz crystals, feldspar, rarely mica (with a single completely chloritized biotite) and isolated fragments of altered acid effusives and quartzites. Grog of its own intraclast (prevails) and alien in the form of large (0.75–1–1.75 mm) homogeneous, clayey, essentially illite fragments of ceramics, without impurities, identical to those found in Neolithic samples with the structure of type 1 raw materials, also recorded in the bronze age samples. There are single clots ranging in size from 0.15 to 0.75 mm, round and elongated, opaque, structureless, homogeneous, presumably of organic nature (fig. 9, *8* – 9, *12*).

The studied samples of Bronze Age ceramics from the Chokh settlement (Chokh-B-1 and Chokh-B-2) have differences both in the composition of raw materials and in the quantity and composition of artificial admixtures. Compared to Neolithic ceramics from the Chokh settlement, Bronze Age samples use common sources of raw materials and artificial admixtures (for example, fragments of bacterial-algal limestone).

The Chokh-B-1 sample is characterized by a silty-pelitic structure of the raw material, consisting of a main clay mass with a particle size of less than 0.005 mm and silty particles (0.005–0.05 mm), rarely fine sandy (0.05–0.1 mm) size, in amount up to 10-15%. According to XRD data, the composition of the clay component corresponds to illite (fig. 8, *3*). The natural admixture of silty-fine sandy material in the raw material consists of a predominant quartz, feldspars are less common – orthoclases, microclines, acid plagioclases, as well as micas. There is a single calcite shell detritus measuring 0.15-0.2 mm. The artificial additive consists of single fragments of sedimentary rocks with dimensions from 0.2 mm to 2 mm, represented by fragments of micritic limestone (with crystal dimensions less than 0.005 mm), as well as fragments of siltstone of quartz composition with film clay cement. One fragment of metamorphic rock was discovered – shale with characteristic foliation textures. In single quantities, opaque yellow-brown clots, presumably organic matter, 0.05–0.4 mm in size, homogeneous, are detected. Grog is distinguished, which has two varieties: 1) corresponding to the composition of the bulk of the ceramics (raw materials) ("local", intraclast); 2) foreign to the composition of the bulk of the ceramics (alien). Intraclast grog predominates, has a dimension of 0.4-1.2 mm and is represented by darker (more fired) and lighter (less fired) varieties. Alien grog is rarely found in the form of fairly homogeneous, clayey fragments of essentially illite composition. There are no natural crystalloclastic impurities here (fig. 10, *1* – 10, *3*). Such fragments are completely identical to fragments from Neolithic ceramics from the Chokh location. The ceramic sample Chokh-B-1 has voids of an elongated and isometric shape, measuring 0.1 mm x 0.3 mm, 0.03mmx0.4mm, 0.3mm x 0.2mm.

For sample Chokh-B-3, the structure of the raw material is colloform-pelite. The pelitic component is clayey, abundantly impregnated with finely dispersed hematite. According to XRF data, the composition of the pelitic component is illite (fig. 8, *4*). The natural admixture of silt grains (less than 10–15%) is represented by mica-quartz material and contains fragments of quartz, microcline, orthoclase and plagioclase crystals with a size of 0.15–0.2 mm in an amount of less than 5%. There are no faunal remains. The added limestone fragments are generally identical to the fragments in the Chokh-B-1 sample and structurally represent bacterial-algal varieties. In single quantities, opaque yellow-brown clots, presumably organic matter, 0.4–0.6 mm in size, homogeneous, are detected. As in the Chokh-B-1 sample, there are 2 types of grog: the predominant intraclast, of varying degrees of firing, with dimensions of 0.25–4.5 mm; and alien, rare, which in composition and structure is completely identical to alien grog in the Chokh-B-1 sample (clayey, homogeneous, without impurities, essentially illite composition) (fig. 10, *4*–10, *7*). There are voids of isometric and elongated shape with dimensions of 0.2 mm x 0.15 mm, 0.9 mm x 0.3 mm and others.

Ceramics of the Göytepe settlement.

The studied ceramic samples from the Neolithic settlement of Göytepe (GT-7, 13.1, 13.2, 14, 15) are very different from the ceramics of the Chokh settlement. The differences lie in

the composition and structure of raw materials, the composition of artificial admixtures, as well as in the morphology and number of void spaces. The voids in all samples are multiple, presented in two varieties (fig. 11). The first type of voids has an anomalous shape: with pronounced hooks, teardrop-shaped or simple isometric. The dimensions of such voids range from 0.25 mm x0.1mm to 2.25 mm x 0.3mm. The second type is elongated, flattened, 1-2 mm long, 0.1 mm wide.

The raw materials of ceramics from the Göytepe settlement are of two types. Type 1 raw materials have a collomorphic-pelite structure, primarily composed of illite, and are actively impregnated with hematite. The natural admixture of silt-sized particles, amounting to no more than 10–15%, is predominantly quartz, with feldspars and pyroxenes also present, and micas appearing rarely. Type 2 raw materials have a silty-pelite structure, essentially of clayey (illite) composition. The silty natural admixture (20%) is predominantly quartz, with feldspars and micas present. In sample 14, the silty-clayey raw material is carbonated, with a thin scattering of calcite microcrystals developing along it.

The sources of artificial admixture for Göytepe ceramics were volcanic rock massifs: basic composition (basalts) and acidic composition (rhyolites, dacites). Both types of volcanics can be found in the same sample. In sample 14, along with fragments of volcanic rocks, there are fragments of acidic volcanic glass—obsidian. The obsidian fragments are notably strong and difficult to remove from the bedrock and crush, resulting in sharp, cutting edges (fig. 11, *3*, *4*). The size of the artificial additive ranges from 3 to 4.5 mm. In addition to fragments of basic and acidic volcanics and obsidian in the artificial additive, there are fragments of crystals—single grains of pyroxene and feldspar. There are also clots of presumably organic matter, up to 0.2 mm in size, as well as elongated varieties. Sample GT-7 contained one fragment of intraclast grog.

Spherulite analysis

Spherulite analysis can be used to determine the presence of dung in ceramics [42, p. 211-225; 43, p. 740–748]. Four samples from the Chokh settlement (Chokh-N-8, 9 and Chokh-B-1,3) and seven samples from the Göytepe settlement (GT-2, 7, 13, 15, 19, 21 and 25) were chosen for the study. The analysis focused solely on the presence of dung spherulites, without quantitative assessment. Eleven fragments of ceramics were crushed into a powder and investigated under cross-polarized light using the ADF U 300 microscope.

The best preservation of spherulites and the largest number of them (on one slide) were observed in samples of Neolithic ceramics from the Chokh settlement (fig. 12, *1*–*3*). In other fragments of ceramics, spherulites are extremely rare, which, on the one hand, may indicate a small proportion of dung admixture, and on the other, its destruction under the influence of high temperatures. The experimental data [44, p. 32–45] shows deformation, darkening and destruction of spherulites under the influence of temperatures above 500 C°. Both considered options are possible, since the studied fragments of ceramics (except for two samples from the Neolithic layers of the Chokh settlement) contain dung spherulites, indicating high-temperature firing. (fig. 12, *4*).

Discussion and conclusion

A comprehensive analysis of the Neolithic ceramics from the Chokh settlement revealed, on the one hand, that the pottery was entirely of local production. Despite the general homogeneity of the pottery, three types of raw materials were identified: two types of primary clay composition from which the vessels were made, and which are also found in "local" grog (indicating continuity at this site), as well as the raw materials of "alien" grog. The latter is also found in the Bronze Age pottery from the overlying layer of the settlement, suggesting that this local source of raw materials was utilized by the inhabitants of the settlement for thousands of years.

On the other hand, there is a connection with one of the types of Transcaucasian ceramics – vessels fired in a reducing atmosphere, in which grog was found along with other mineral impurities in the pottery paste. Moreover, this type of ceramic also contains appliqué knobs, another feature noted by Hizri A. Amirkhanov on the Neolithic ceramics of the Chokh settlement [30, fig. 3, *2*]. It should be noted that the fragments available for comparison from the Göytepe settlement are younger than those from the Chokh settlement, which explains some of their differences. However, the existence of such a group of ceramics is very significant and likely existed in Transcaucasia from the beginning of the 6th millennium BCE. In the settlement of Hacı Elamxanlı Tepe, a group of ceramics with mineral and organic admixtures and a grey-yellow-brown surface color is mentioned in the early layers [21]. Additionally, the description of the ceramics from the early 6th millennium BCE at the Gadachrili Gora settlement, with the exception of the use of basalt instead of grog, is very similar to the ceramics studied from the Chokh settlement. These similarities include the presence of rare plant admixtures, rare appliqué knobs, simple smoothing, and firing in a reducing atmosphere [27; 9, fig. 7].

The presence of dung in the Neolithic ceramics of Chokh, although in very limited quantity, was primarily indicated by the presence of spherulites. Additionally, petrographic thin sections showed rounded and elongated clots of organic matter (possibly dung in the form of squeezes or liquid fraction), which aligns with the main traditions of Neolithic ceramics in Transcaucasia. This is clearly documented in this study based on materials from the Göytepe settlement, and extends further south to the eastern part of the Fertile Crescent [39; 40].

Analysis of vessel production from the Neolithic and Bronze Age periods at the Chokh settlement revealed differences in both the selection of primary raw materials and the artificially added impurities. These differences include the admixture of crushed stone (limestone and possibly other minerals) and variations in grog size, with larger grog observed in Bronze Age pottery. However, it is crucial to note the persistence of a common concept in the use of artificial admixtures over millennia: the consistent use of dung and grog. During the Chalcolithic period, while grog continued to be used as an admixture (as evidenced in pottery from the Malinkarat settlement), crushed stone also emerged as a new admixture in Central Dagestan (observed in the Ginchi settlement), a feature not present in Neolithic pottery. Both these impurities are subsequently found in Bronze Age pottery throughout the region.

The evolution of construction methods is challenging to assess due to the limited size and poor preservation of Neolithic pottery fragments. Only a general observation about the use of clay slabs can be confidently made. However, clear technological advancements are evident in

surface treatment techniques. While vessel polishing is absent in Neolithic pottery, it emerges during the Chalcolithic period and becomes a significant technological feature in the Bronze Age.

Spherulite analysis of dung in pottery from various periods has yielded additional insights into firing temperatures. Well-preserved spherulites found in Chokh Neolithic pottery suggest brief exposure to high temperatures. In contrast, the presence of nearly destroyed, darkened spherulites in Bronze Age pottery and Transcaucasian Neolithic pottery (which shows clear external evidence of dung inclusion) indicates prolonged exposure to temperatures exceeding 500–700 °C, which is also confirmed by other observations.

In conclusion, this study reveals a dual narrative in the pottery production of this remote mountainous region. On the one hand, there is clear evidence of continuity in traditions, particularly in the persistent use of grog and dung as artificial admixtures. On the other hand, we observe gradual technological development: the evolution in the use of mineral admixtures, the introduction of polishing techniques, and the refinement of firing conditions.

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Fig. 1 Map of Neolithic settlements of Transcaucasia, as well as Eneolithic and Bronze Age sites of Central Dagestan, mentioned in the article.

Рис. 1. Карта памятников неолита Закавказья, а также энеолита и бронзового века Центрального Дагестана, упомянутые в статье.

Fig. 2 1-2 – 1-2 – Chokh settlement, Gunibsky district, Central Dagestan; 3-4 – Göytepe settlement, Tavuz region (Azerbaijan) (photo 2019)

Рис. 2. *1-2* – поселение Чох, Гунибский район, Центральный Дагестан; *3-4* – поселение Геой-тепе, Тавузский район (Азербайджан) (фото 2019 г.)

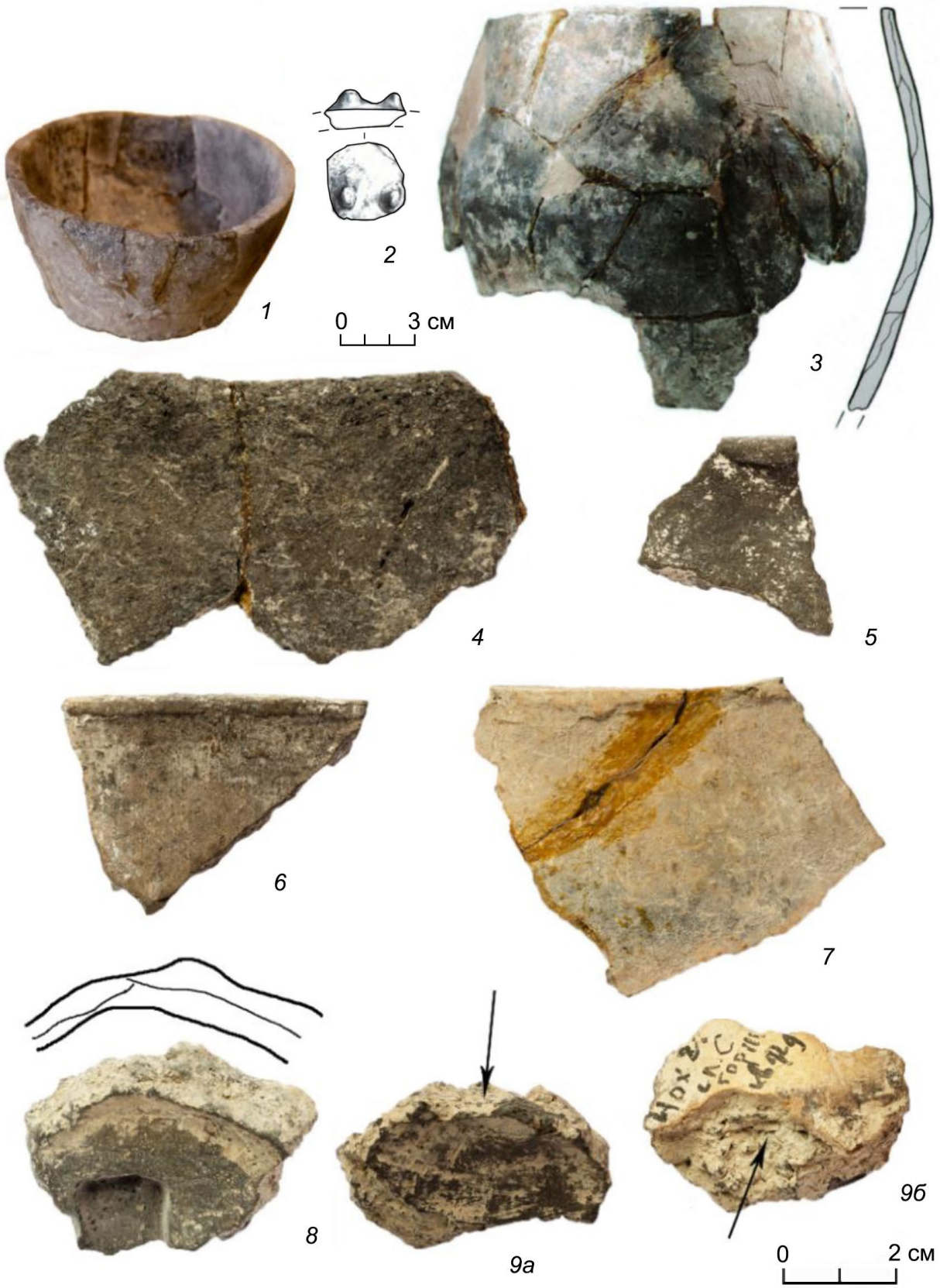


Fig.3 Ceramics from the Neolithic layer of the Chokh settlement. 1-3 – after Amirkhanov, 2023.

Рис. 3. Керамика из неолитического слоя поселения Чох. *1-3* – по: Амирханов, 2023.

Fig. 4 Ceramics of the Chalcolithic and Bronze Age periods of Central Dagestan. 1, 2 – Malinkarat site; 3-6 – Ginchi settlement; 7-9 – Nokhola-ad burial ground; 10, 11 – Bronze Age layer of the Chokh settlement.

Рис. 4. Керамика периода энеолита и бронзового века Центрального Дагестана. *1, 2* – стоянка Малинкарат; *3-6* – поселение Гинчи; *7-9* – могильник Нохола-ад; *10, 11* – слой бронзового века поселения Чох.

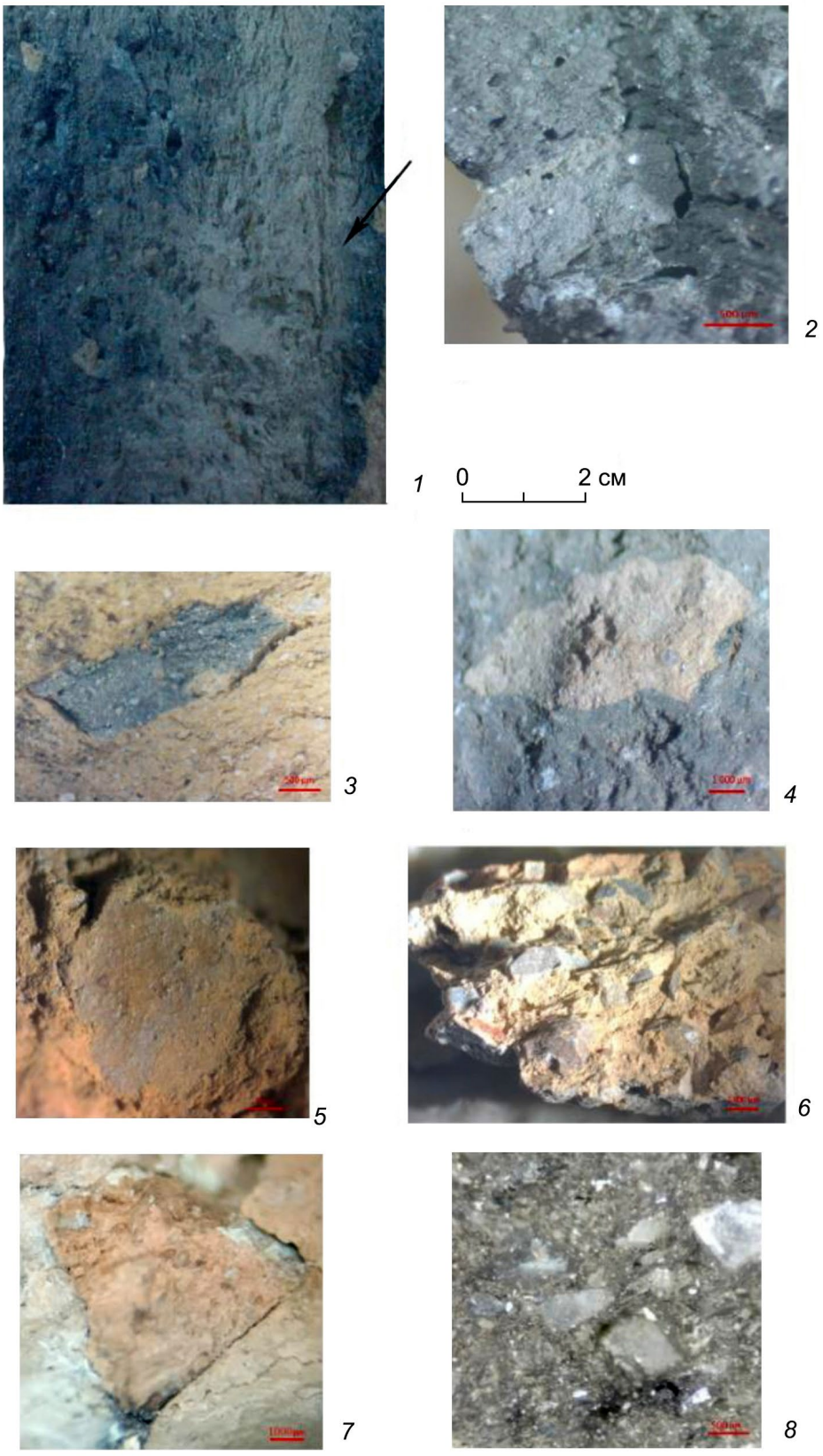


Fig. 5 Microphotographs of ceramics from Central Dagestan: 1-4 – grog – Neolithic layer of the Chokh settlement (1 – arrow indicates the presence of organic plant impurities); 5 – grog with polishing – Malinkarat site; 6 – crushed stone - Ginchi settlement; 7-8 – grog, crushed stone – Nokhola-ad burial ground.

Рис. 5. Микрофотографии керамики Центрального Дагестана: *1-4* – шамот – неолитический слой поселения Чох (1 – стрелкой указано присутствие органической растительной примеси); *5* – шамот с лощение – стоянка Малинкарат; *6* – дресва – поселение Гинчи; *7-8* – шамот, дресва – могильник Нохола-ад.

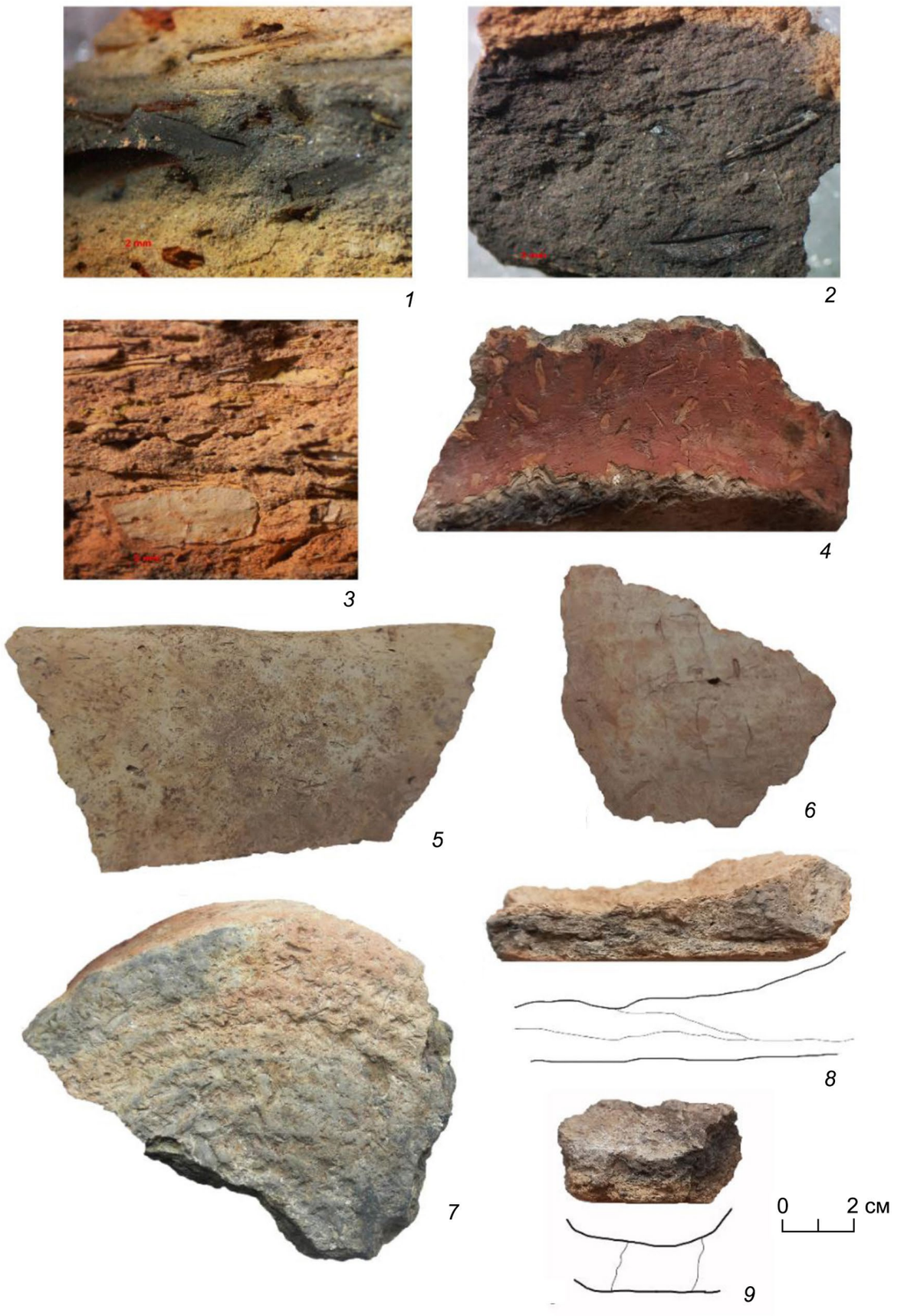


Fig. 6 Ceramics 1-4 horizons of the Göytepe settlement with organic impurities: 1-2 – microphotos of remains associated with dung; 3 – microphotos of remains associated with straw; 4 – fragment of the vessel base with imprints of the husk of large grains and a coating of red slip (publication: Alakbarov, 2018); 5-6 – light coloring of the surface over the coating (6 – cracks that appeared on the additional layer of clay coating); 7 – imprints of the wicker surface; 8 – slabs in the base cross-section; 9 – coils in the base cross-section.

Рис. 6. Керамика горизонта 1-4 поселения Геой-тепе с органическими примесями: *1, 2* – микрофото остатков, связанных с навозом; *3* – микрофото остатков, связанных с соломой; *4* – фрагмент днища сосуда с отпечатками шелухи крупных зерен и покрытие красным ангобом (публикация: (Алекперов, 2018. С. 23-25; Alakbarov, 2018). Рис. 3); *5, 6* – светлое окрашивание поверхности поверх обмазки (6 – трещины, возникшие на дополнительном слое обмазки глиной); *7* – отпечатки плетеной поверхности; *8* – лоскутный налеп в изломе днища; *9* – жгутовой налеп в изломе днища.

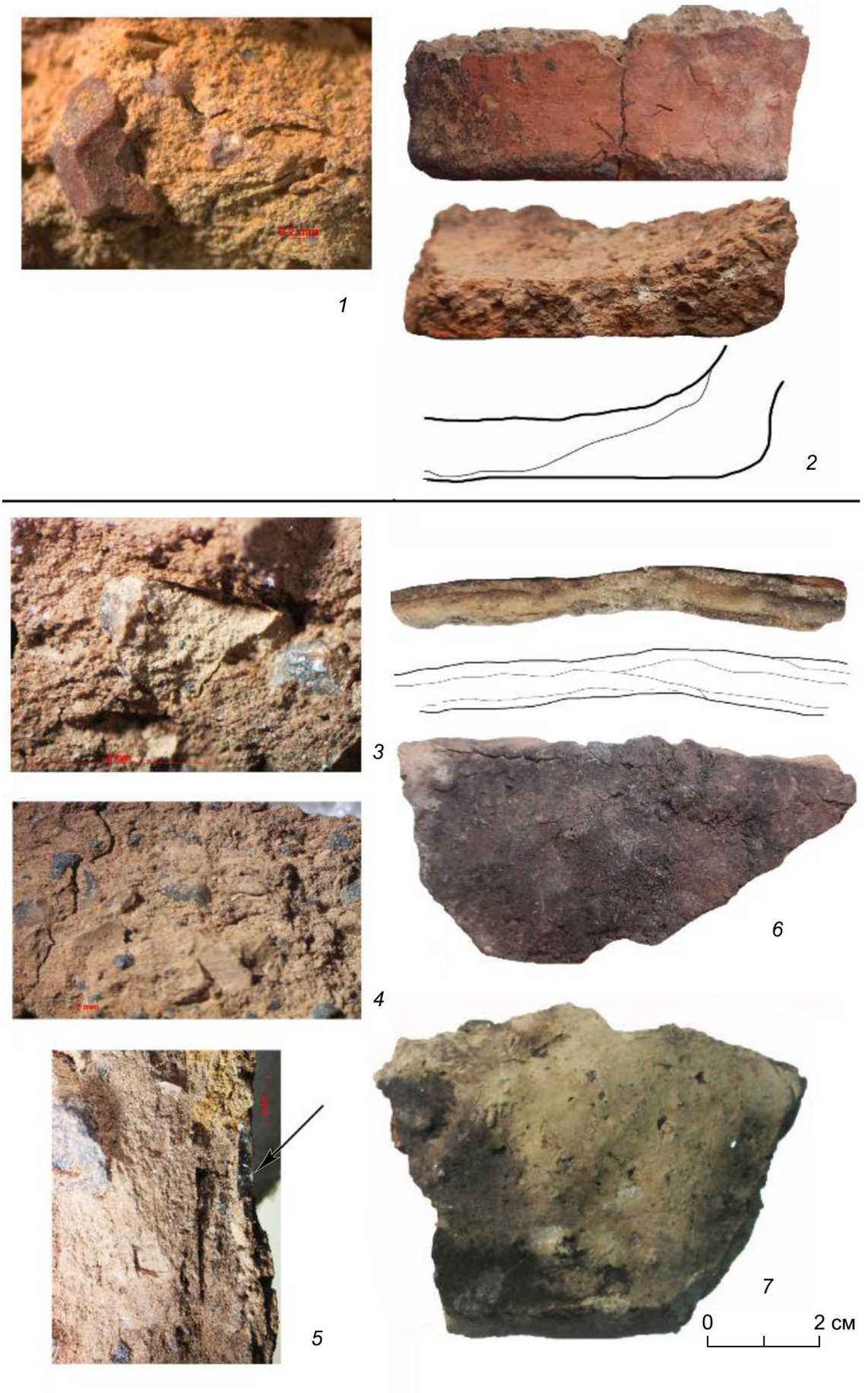
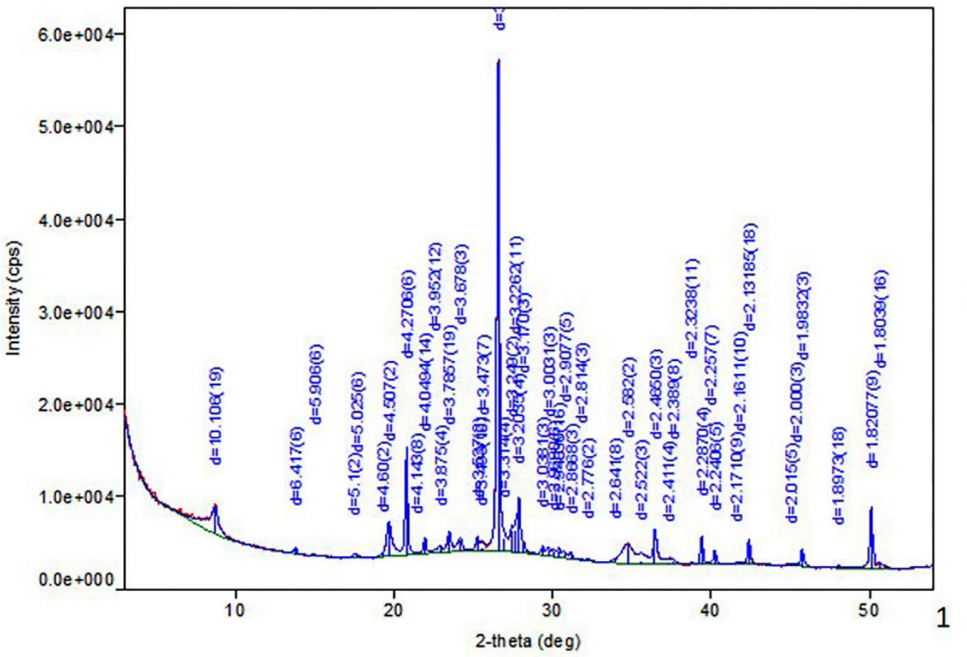
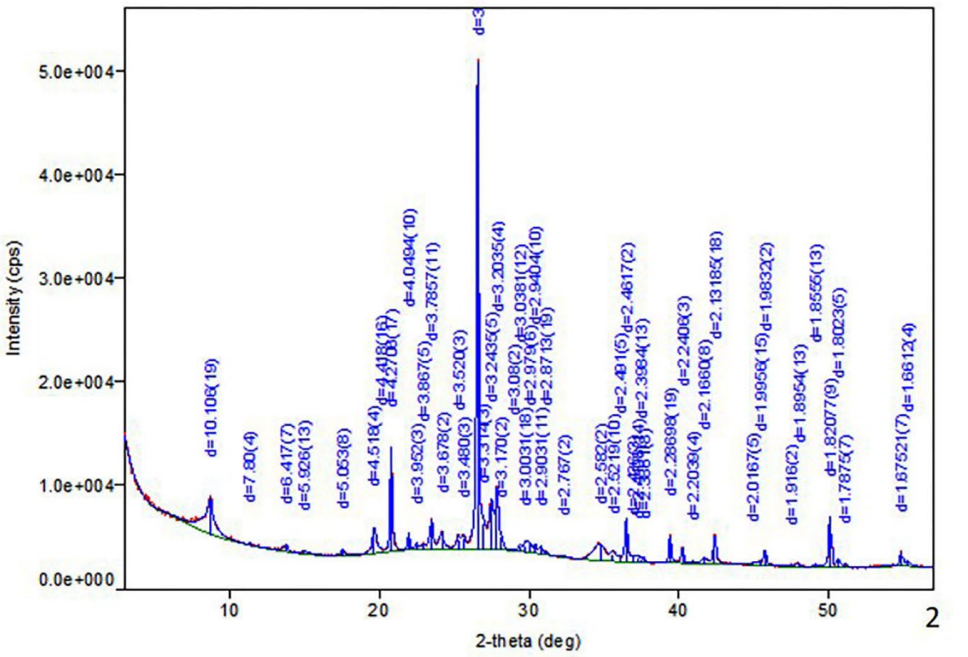
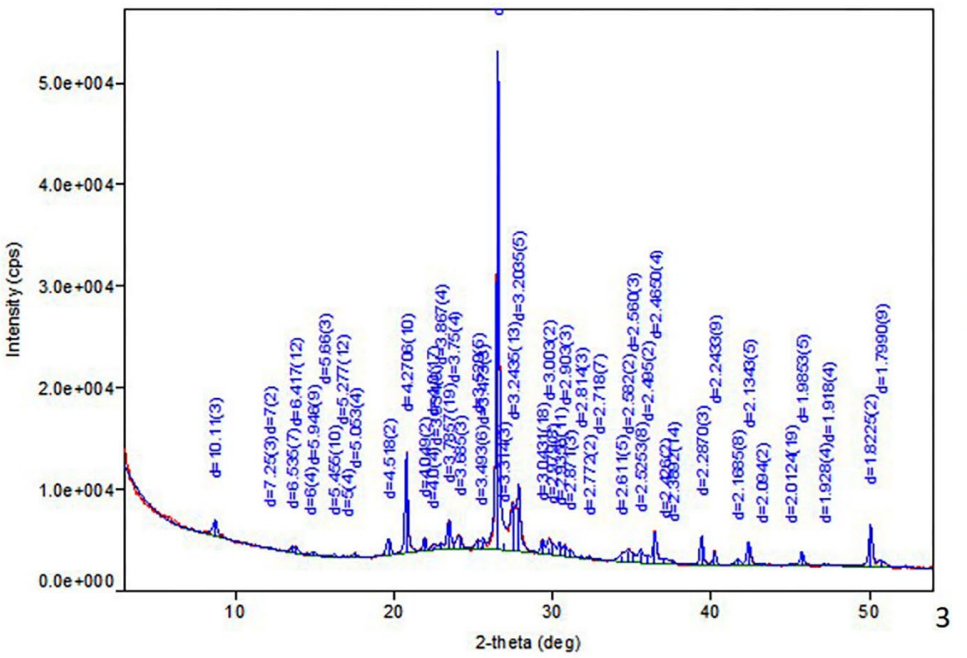


Fig. 7 Ceramics 1-4 horizons of the Göytepe settlement with mineral admixtures: 1, 4-5 – microphotos of basalt and obsidian admixtures (5 – marked with an arrow); 6 – outer surface of the elongated slab in the cross-section of the wall; 6-7 – a layer of additional clay coating on the surface.

Рис. 7. Керамика горизонта 1-4 поселения Геой-тепе с минеральными примесями: *1, 4-5* – микрофото примеси базальта и обсидиана (5 – отмечен стрелочкой); *6* – внешняя поверхность вытянутого лоскута в изломе стенки; *6-7* – слой дополнительной глиняной обмазки поверхности.







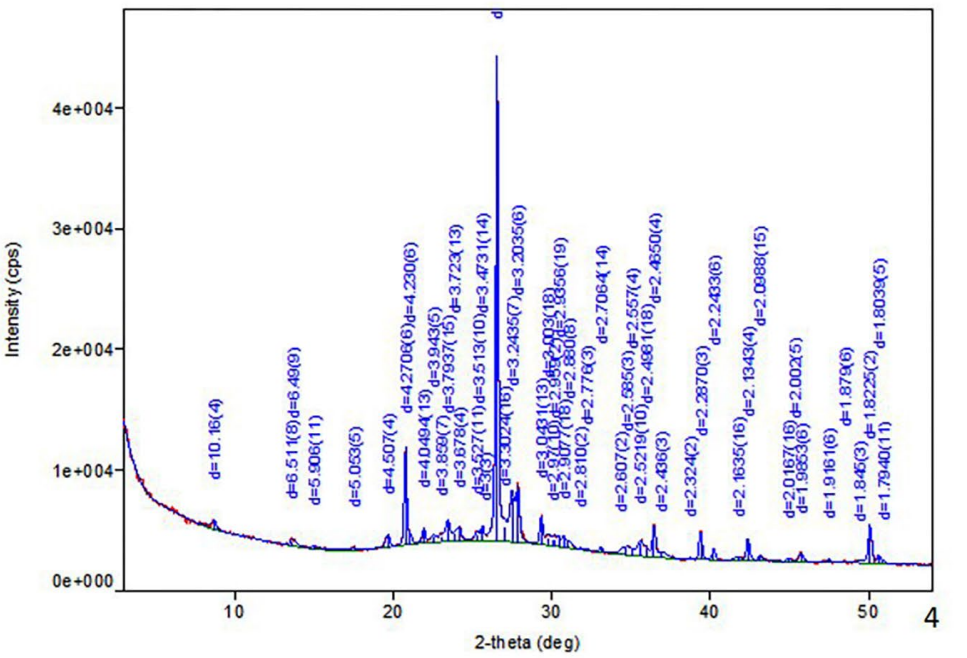


Fig. 8 Diffraction patterns of samples: Neolithic ceramics Chokh-N-2 (1), Chokh-N-10 (2); Bronze Age ceramics Chokh-B-1(3), Chokh-B-3(4).

Рис. 8. Дифрактограммы образцов: неолитической керамики Чох-Н-2 (1), Чох-Н-10 (2); керамики бронзового века Чох-Б-1(3), Чох-Б-3(4).

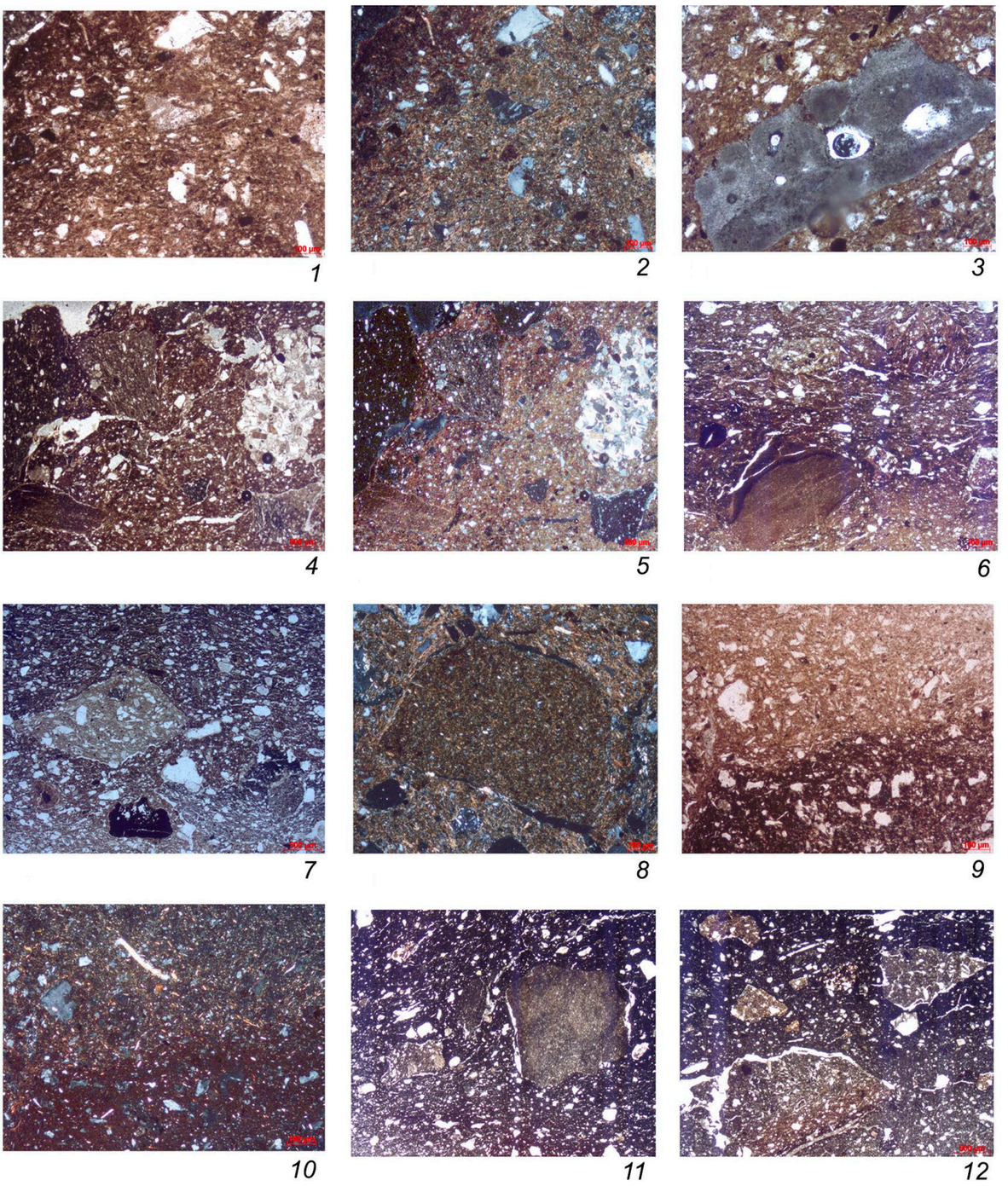


Fig. 9 Photographs of thin sections of Neolithic ceramics from the Chokh settlement.
9.1-9.7 – photographs of thin sections of Neolithic ceramics of type 1: 1, 2 – structure of raw material of type 1, artificial additive (quartz, orthoclase, fragment of acid effusive) thin section Chokh-N-4, magnification 100x, analyzer – (1), + (2). 3 – fragment of bacterial-algal limestone, thin section Chokh-12, magnification 25x, analyzer –. 4,5 – fragment of sandstone with calcite cement; 2 types of grog (intraclastic and alien), thin section Chokh-11, magnification 25x, analyzer – (4), + (5). 6 – 2 types of grog (intraclastic and alien); clot, presumably, OM. Chokh-N-6 thin section, 25x magnification, analyzer – 7 – 2 types of grog (intraclast and alien); clot, presumably, OV. Chokh-N-2 thin section, 25x magnification, analyzer –. 9.8-9.12 – photographs of thin sections of Neolithic ceramics of type 2: 8 – alien grog, Chokh-N-10 thin section, 100x magnification, analyzer +. 9,10 – structure of raw material of type 2, dark and light stripes – different degrees of firing, Chokh-N-8 thin section, 100x magnification, analyzer – (9), + (10). 11,12 – different types of chamotte, Chokh-N-8 (11), Chokh-N-9 (12) thin sections, 25x magnification, analyzer -.

Рис. 9. Фотографии шлифов неолитической керамики поселения Чох.
1-7 – фотографии шлифов неолитической керамики 1 типа: *1, 2* – структура сырья 1 типа, искусственная добавка (кварц, ортоклаз, обломок кислого эффузива) шлиф Чох-Н-4, увеличение 100^{x}, анализатор – (1), + (2). *3* – обломок бактериально-водорослевого известняка, шлиф Чох-12, увеличение 25^{x}, анализатор –. *4, 5* – обломок песчаника с кальцитовым цементом; 2 типа шамота (интракластовый и чужеродный), шлиф Чох-11, увеличение 25^{x}, анализатор – (4), + (5). *6* – 2 типа шамота (интракластовый и чужеродный); сгусток, предположительно, ОВ. Шлиф Чох-Н-6, увеличение 25^{x}, анализатор –. *7* – 2 типа шамота (интракластовый и чужеродный); сгусток, предположительно, ОВ. Шлиф Чох-Н-2, увеличение 25^{x}, анализатор –. *8-12* – фотографии шлифов неолитической керамики 2 типа: *8* – чужеродный шамот, шлиф Чох-Н-10, увеличение 100х, анализатор +. *9,10* – структура сырья 2 типа, темные и светлые полосы – разные степени обжига, шлиф Чох-Н-8, увеличение 100^{x}, анализатор – (9), + (10). 11,12 – разные типы шамота, шлифы Чох-Н-8 (11), Чох-Н-9 (12), увеличение 25х, анализатор –.

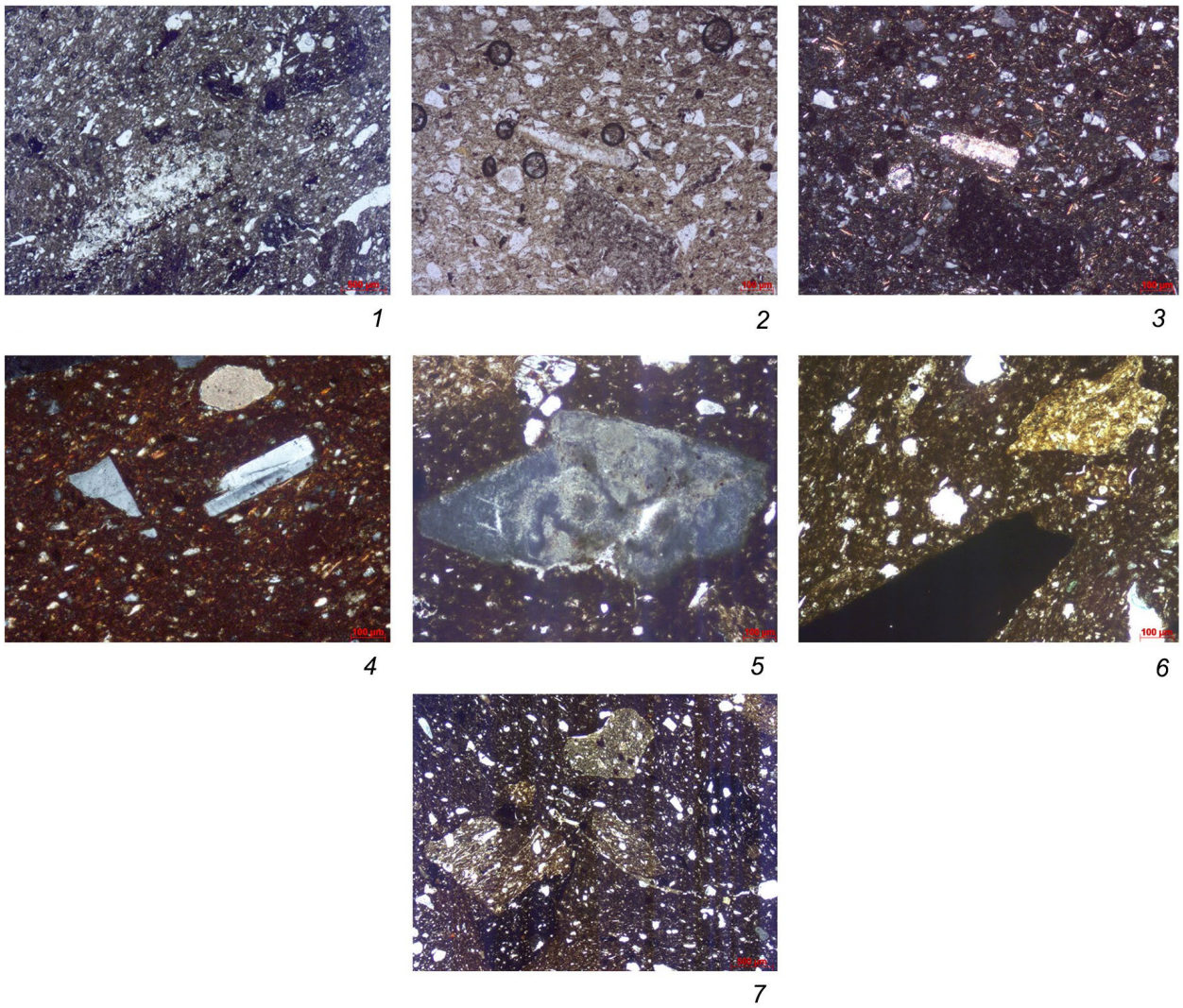


Fig. 10 Photographs of a thin sections of ceramics from the Bronze Age settlement of Chokh.
10.1-10.3: photographs of a thin section of sample Chokh-B-1: 1 - silt-pelitic structure of raw material; artificial additives: fragment of siltstone, fragment of clay shale, intraclastic grog. Magnification 25x, analyzer -. 2,3 - fragment of shell detritus, fragment of clay shale. Magnification 100x, analyzer - (2), + (3).
10.4-10.7: photographs of a thin section of sample Chokh-B-3. 4 - colloform-pelitic structure of raw material; artificial additives: fragment of micritic limestone, fragment of quartz, plagioclase. Magnification 100x, analyzer +. 5 - fragment of bacterial-algal limestone. Magnification 100x, analyzer -. 6 - component of organic matter, intraclastic grog. Magnification 100x, analyzer -. 7 – intraclast and foreign grog. Magnification 100x, analyzer -.

Рис. 10. Фотографии шлифа керамики бронзового века поселения Чох.
1-3: фотографии шлифа образца Чох-Б-1: 1 – алевро-пелитовая структура сырья; искусственные добавки: обломок алевролита, обломок глинистого сланца, интракластовый шамот. Увеличение 25^{x}, анализатор –. *2, 3* – обломок раковинного детрита, обломок глинистого сланца. Увеличение 100^{x}, анализатор – (2), + (3).
4-7: фотографии шлифа образца Чох-Б-3. *4* – колломорфно-пелитовая структура сырья; искусственные добавки: обломок микритового известняка, обломок кварца, плагиоклаза. Увеличение 100^{x}, анализатор +. *5* – обломок бактериально-водорослевого известняка. Увеличение 100^{x}, анализатор –. *6* – компонент органического вещества, интракластовый шамот. Увеличение 100^{x}, анализатор –. *7* – интракластовый и чужеродный шамот. Увеличение 100^{x}, анализатор –.

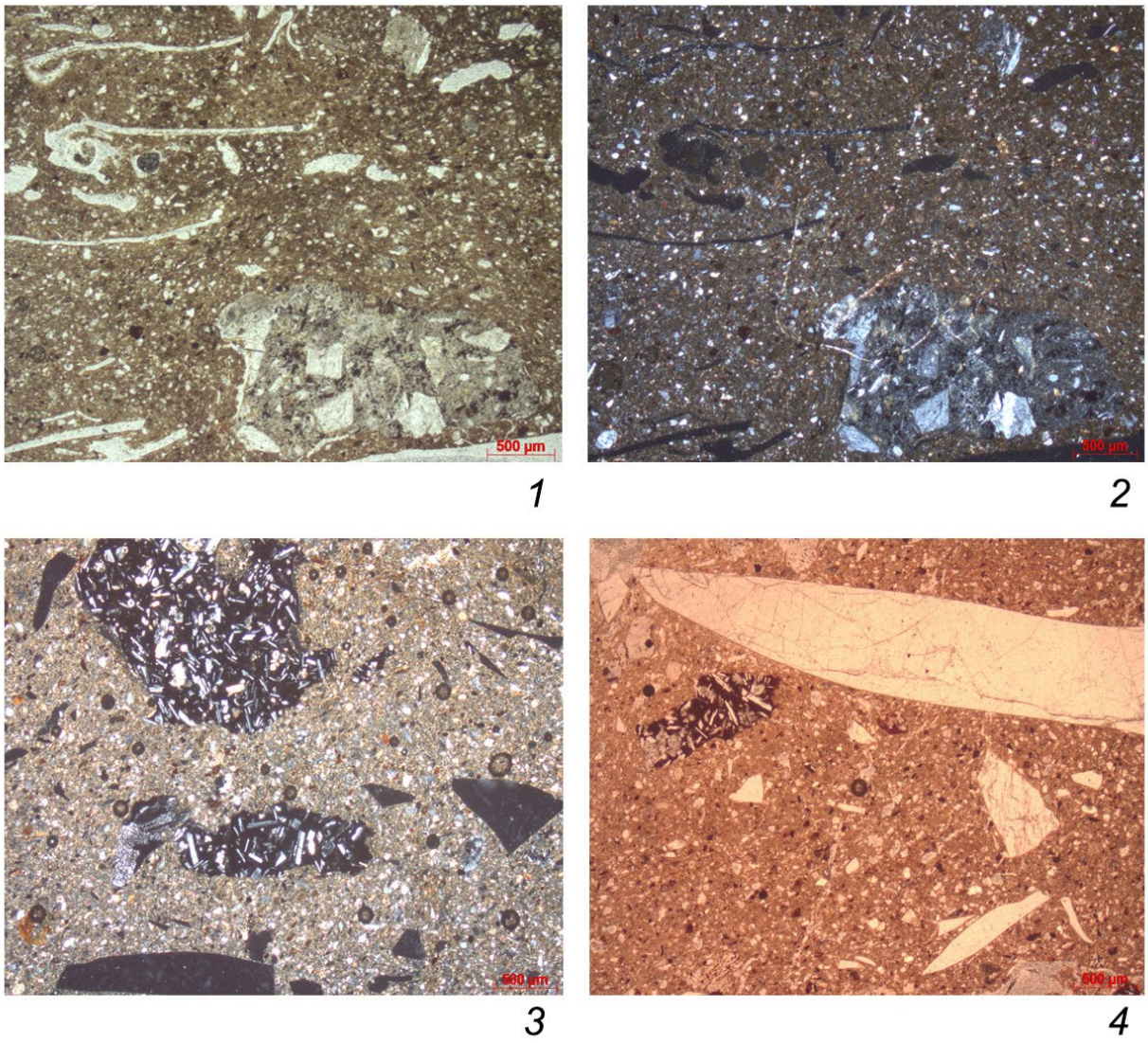


Fig. 11. Photographs of thin sections of Göytepe ceramics: 1-2 – hooked types of voids; fragment of rhyolite, thin section 13, magnification 25x, analyzer – (1), + (2); 3 – calcitized silty-pelite raw material; basalt fragments; fragments of obsidian (black), thin section 14, magnification 25x, analyzer +; 4 – basalt fragment, multiple obsidian fragments, thin section 14, magnification 25x, analyzer –.

Рис. 11. Фотографии шлифов керамики Геой-Тепе.
1, 2 – крючковатые типы пустот; обломок риолита, шлиф 13, увеличение 25х, анализатор – (1), + (2).
3 – кальцитизированное алевро-пелитовое сырье; обломки базальта; обломки обсидиана (черное), шлиф 14, увеличение 25х, анализатор +. *4* – обломок базальта, множественные обломки обсидиана (белое), шлиф 14, увеличение 25х, анализатор –.

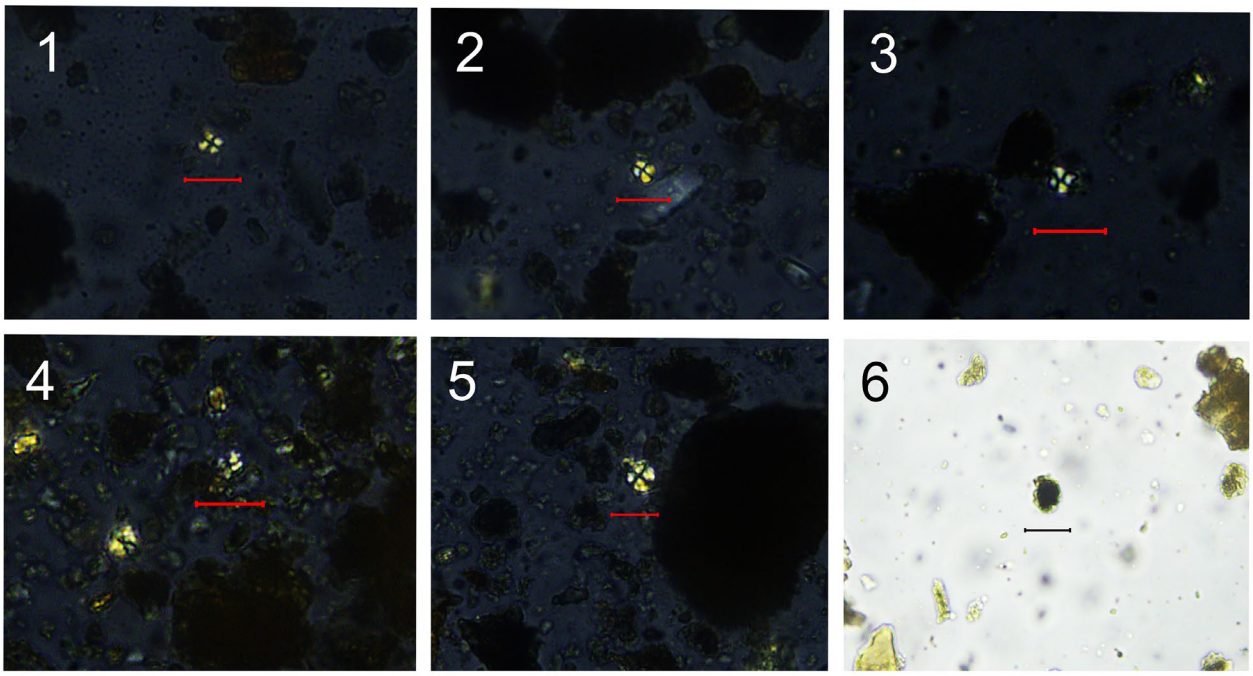


Fig. 12. Spherulites from Neolithic (1, 2, 3) and Bronze Age (4) ceramics from the Chokh settlement and Neolithic ceramics from the Göytepe settlement (5, 6); 5 - enlarged due to thermal exposure, 6 - darkened spherulite. 1-5 - view in cross-polarized light, 6 - view in polarized light. Scale bar 15 μm.

Рис. 12. Сферулиты из керамики неолитического периода (1-3) и бронзового времени (4) поселения Чох и неолитической керамики поселения Геой тепе (5, 6); 5 – увеличенный в размере из-за термического воздействия, 6 – потемневший сферулит. *1-5* – вид в кросс-поляризованном свете, *6* – вид в поляризованном свете. Масштабный отрезок 15 мкм.

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