USE-WEAR AND RESIDUE ANALYSIS OF STONE TOOLS USED BY EARLIEST FARMERS AT THE KLERK-5 SITE IN PRIMORYE (RUSSIA) (PRELIMINARY RESULTS)

Análisis de huellas de uso y de residuos de los instrumentos de piedra usados por los primeros agricultores en el yacimiento Klerk-5 de Primorye (Rusia). Resultados preliminares

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ABSTRACT The research of the tools for processing plants is of great importance for finding out when gathering and farming begins in many regions of Eurasia. In the territory of East Asia the migration of farmers' communities of Zaisanovski cultural tradition is traced from North-East China at first to Central Primorye of the Russia's Far East, and after that to the coastal parts of this region, where the traditional occupation of the population was primarily fishing and hunting marine mammals (about 5300-4600 BP). The traceological analysis involving the experimental data allowed to figure out that some stone tiles, their fragments and pebbles from the Klerk 5 settlement, based on the coast of the Sea of Japan, had been used as grinding stones for processing plants. The results of the traceological analysis were confirmed by the detection of starch residues on the working surfaces of these tools. These facts indicate that the migration of farmers from the continental regions to the coastal part of Russian Far East contributed to the development of farming, previously unknown in this territory.

Key words: East Asia, Early Agriculture, Stone Tools, Use-wear Analysis, Experiments, Starch Residue Analysis.

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RESUMEN La investigación de los instrumentos para el procesado de plantas es de gran importancia para descubrir cuándo comenzó la recolección y la agricultura en muchas regiones de Eurasia. En el territorio de Asia Oriental, la migración de las comunidades campesinas de la tradición cultural Zaisanovski procede del noreste de China hacia Primorye Central del Lejano Oriente de Rusia primeramente, y después alcanza las partes costeras de esta región, donde la ocupación tradicional de la población era principalmente la pesca y la caza de mamíferos marinos (en torno a 5300-4600 BP). El análisis traceológico, que incorporó datos experimentales, permitió descubrir que algunas losas de piedra, sus fragmentos y guijarros del asentamiento Klerk 5, ubicado en la costa del Mar de Japón, se habían utilizado como molinos para el procesado de plantas. Los resultados del análisis traceológico se confirmaron mediante la detección de residuos de almidón en las superficies de trabajo de estos útiles. Estos hechos indican que la migración de los agricultores de las regiones continentales a la parte costera del Lejano Oriente ruso contribuyó al desarrollo de la agricultura, anteriormente desconocida en este territorio.

Palabras clave: Este de Asia, Agricultura antigua, Útiles de piedra, Análisis de huellas de uso, Experimentos, Análisis de residuos de almidón.

INTRODUCTION

The Holocene witnessed significant environmental changes in all parts of Eurasia during the transition from Atlantic to Subboreal period. At the time East Asia saw the migration of farmers' groups from inland continental areas to maritime coastal strips. That was an adaptive reaction of humans to deterioration of agro-climatic conditions resulting from general cooling. Coastal strips suffered less: droughts had less severe aftermaths, floods occurred rarely, overall agro-climatic conditions tended to be more stable; in addition there was an abundance of relatively permanent marine resources. The earliest farmers of Zaisanovsky culture tradition with cord-decorated ceramics moved from the Northeastern China (valley of Mudanjiang River) to continental areas of the Primorye region of Russian Far East about 5300 BP. One of their settlements is Krounovka-1 (fig. 1). The inhabitants of this site cultivated three species of cereals: *Setaria italica, Panicum miliaceum* and *Echinochloa crusgalli*, and grasses – *Perilla sp*. (Komoto and Obata, 2004). After cooling of climate near 4900 BP, there occurred a natural shrinkage of agricultural resources in continental Primorye. As a result, the early farmers began to populate coastal margin of the Sea of Japan. Evidences of the migration were found on the Klerk peninsula (Bay of Peter the Great) at a permanent all-year-round Klerk 5 settlement and are connected with the Neolithic layer (Obata, 2007). Archaeological data indicated that the inhabitants had practiced hunting terrestrial and marine mammals, fishing in open sea and lagoon, and gathering marine mollusks, as well as nuts, apples, and beans. Besides, there is a hypothesis that the migrants could preserve the tradition of cultivation of cereals.

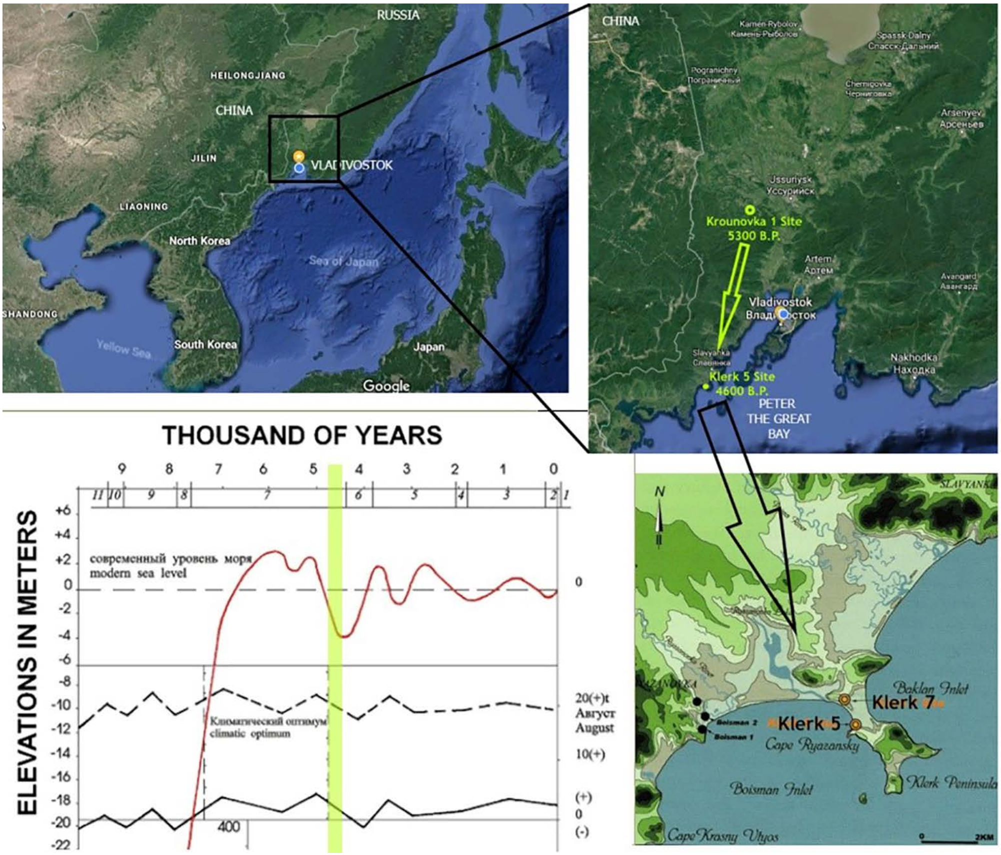

Fig. 1.—Maps of Klerk 5 site location and climatic and sea level dynamics in the Sea of Japan region in Holocene (Upper maps based on Google Maps; the paleoclimate diagram based on Korotky and Vostretsov, 1998:14).

MATERIALS AND METHODS

Among the artifacts of Klerk 5 several stone tiles, their fragments and pebbles of natural unmodified forms were found, 7 artifacts were selected for research (fig. 2). Their functions have been studied by means of experimental-traceological method and the analysis of starch residues left on their surfaces.

Use-wear analysis was carried out at magnifications to × 100 with a stereomicroscope MBS-10. Photos were made using a metallurgical microscope Olympus, equipped with camera Canon EOS 400D.

The results were compared to experimental models that had been made in the course of studying of the same tools from other sites.

Organic residues from the surface of the artifacts and soil samples from the cultural layers of the settlement were extracted with the methods that had been

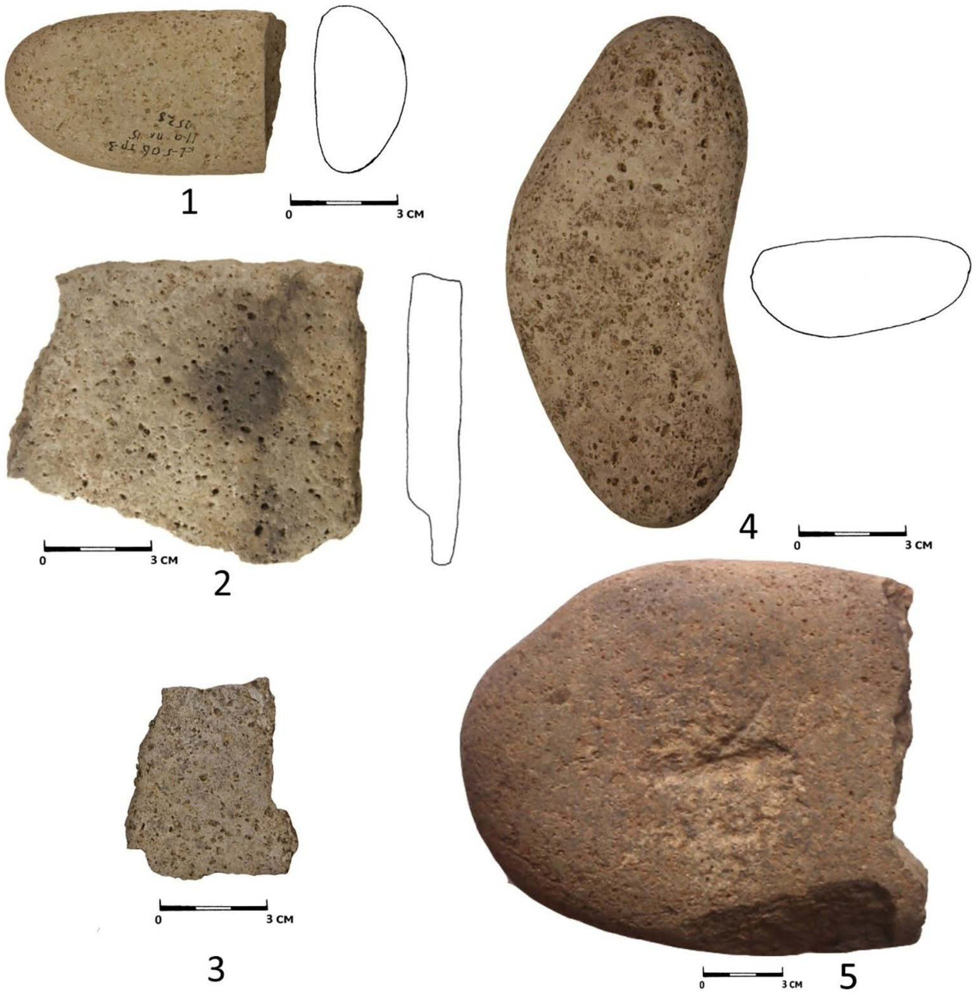

Fig. 2.—Stone tools from the Neolithic layer of the Klerk 5. 1, Fragment of upper grinding stone n.º 44; 2, fragment of grinding stone n.º 46; 3, fragment of upper grinding stone n.º 45; 4, upper grinding stone n.º 51; 5, fragment of stone used as a grinding stone and an anvil n.º 58.

described in the works by Therin and Lentfer (2006) and Yang *et al*. (2012), etc. Starch residues were searched and photographed with the Carl Zeiss AxioScope. A1 Polarized Light Microscope at magnifications from × 200 to × 1000 using three working modes: white field, polarization and DIC-contrast. For identification of the residues the reference collection of 67 species was used, including *Poaceae, Fabaceae, Fagaceae* families, plants with starchy USO (*Thypha sp., Lillium sp., Nelumbo sp*., ferns) and wild nuts.

RESULTS OF THE EXPERIMENTAL-TRACEOLOGICAL RESEARCH

In the course of traceological research the tools of various degree of utilization were identified, one of them had been used in two functions. During the microscopic analysis of the stone tools' surfaces clear-cut use-wear traces were revealed, typically found on tools for grinding plants. On their surfaces were detected parts with spotted polishing and shallow linear traces with soft, blurred edges (figs. 2 y 3). Such traces were found on 5 of 7 researched items. Among them are a part of an elongated pebble with a bright sheen on its slightly convex working surface (n.º 44, fig. 2:1) and plano-convex pebble with well distinguishable traces of utilization on its convex working surface (n.º 51, fig. 2:4), used as upper grinding stones; small pebble flake (n.º 45) —a fragment of upper grinding stone, bearing pronounced macro— and microtraces of utilization on the dorsal surface (fig. 2:3, fig. 3); large quadrangular fragment of a tile with ground-in central part of the surface used as a grinding stone (n.º 46, fig. 2:2); and a fragment of a large oval flat pebble used in two functions: initially as a grinding stone, and after that as an anvil, which is testified by the deep cells left by the pounding (n.º 58, fig. 2:5).

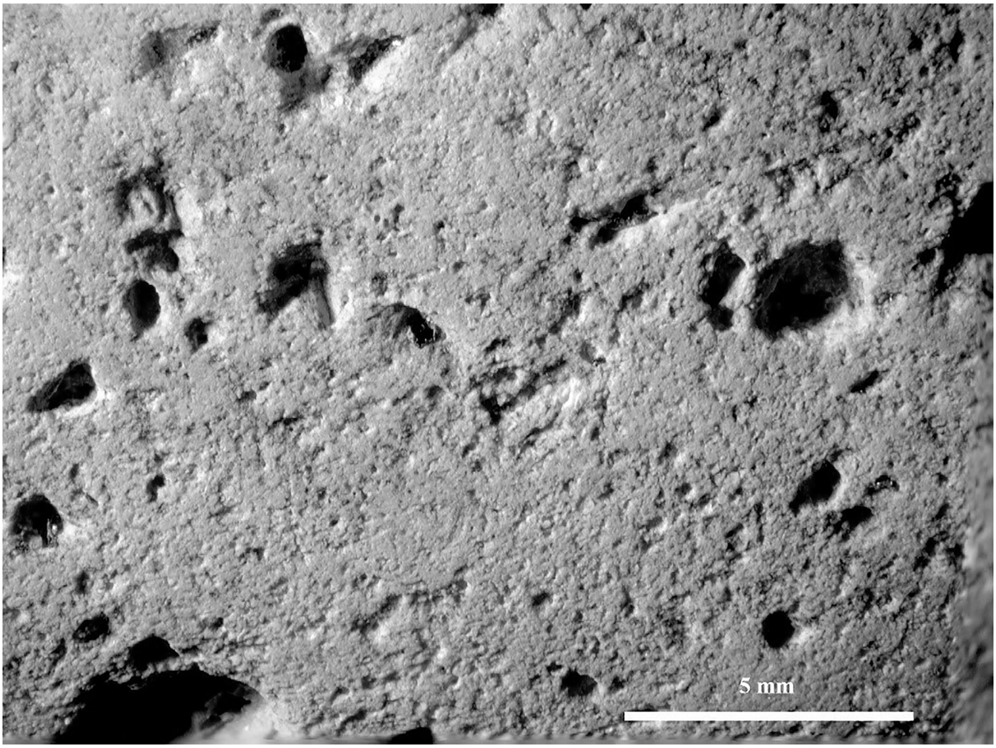

Fig. 3.—Photo of use-wear traces on the working surface of the fragmented upper grinding stone n.º 45 (×80).

Using of unmodified stone tools in the economic activity of Klerk 5 settlement testifies to purposeful choice of tiles and pebbles with a suitable form and surface for processing plants. Flat pebbles (n.º 46, 58) were used as grinding stones, and elongated pebble, a fragment with slightly convex working surfaces and a flake (n.º 51, 44, 45) were used as upper stones.

The comparison of use-wear traces on the tools from Klerk 5 with those on the experimental tools (Reverdin *et al*., 2010) for grinding plants showed their identity.

STARCH RESIDUE ANALYSIS

For the verification of obtained traceological data that allowed to identify the researched tools as grinding stones for proceeding plants the analysis of the organic residues from their surface was carried out. On these parts of tools starch grains of different degree of preservation were detected. They were compared against the reference collection of various plant species by such criteria as grain shape, surface features, position and form of the hilum and fissure, layer visibility, position and shape of the polarization cross.

On the item n.º 44 6 starch granules and fragments of plant material were found. One grain by its features corresponds to starch of Triticeae tribe. The largest number of starch grains is detected on the tools n.º 45 and n.º 46: 1040 and 231 respectively. The granules are of different species. At the moment, two types of cereals have been identified: millets (fig. 4:1-5) and wheats (fig. 4:6-8). On the tool n.º 45 an aggregate of Triticeae tribe starch is detected, presumably of barley (*Hordeum sp.*) (fig. 4:7). On the tool n.º 46 an aggregate of starch grains is found identified as *Sorghum sp.* (fig. 4:1). The tool n.º 51 yielded 38 starch granules. All of them correspond to Triticeae tribe, part is identified as *Hordeum sp.* (fig. 4:8). 39 starch granules and 2 aggregate of starch grain were gathered from the surface of a grinding stone n.º 58. The latter were identified as barley (*Hordeum sp.*) (fig. 4:6).

Fissures on granules from the aggregate resulted from physical damage of grains. For the same reason polarized cross is absent except for some small intact granules. Other starch residues are identified as millets and Triticeae tribe.

Besides the analysis of residues from the surfaces of the artifacts soil deposits from the cultural layer were specifically examined to determine starch concentration. The amount of starch in the soil was utterly insignificant in comparison with that on tools (Barton *et al*., 1998). This provides an argument against the possibility of "contaminating" the tools due to their contact with soil.

Thus, the analysis of residues from the surfaces of the tools, which have been identified during the traceological investigation as grinding stones, permitted to detect residues of grains and their aggregates corresponding to millet, sorghum and barley.

Archaeobotanical finds at the sites of Russian Primorye, Korea, North and Nort-Eastern China show that traditional Neolithic agricultural cereals were *Setaria italica* and *Panicum miliaceum*. Besides there is a great number of a wild grass in these regions, related to millet's and Triticeae tribe's cereals. These grasses could be an object of intentional gathering in different periods (Liu *et al*., 2011; Yang *et al*., 2012; Wang *et al*., 2016).

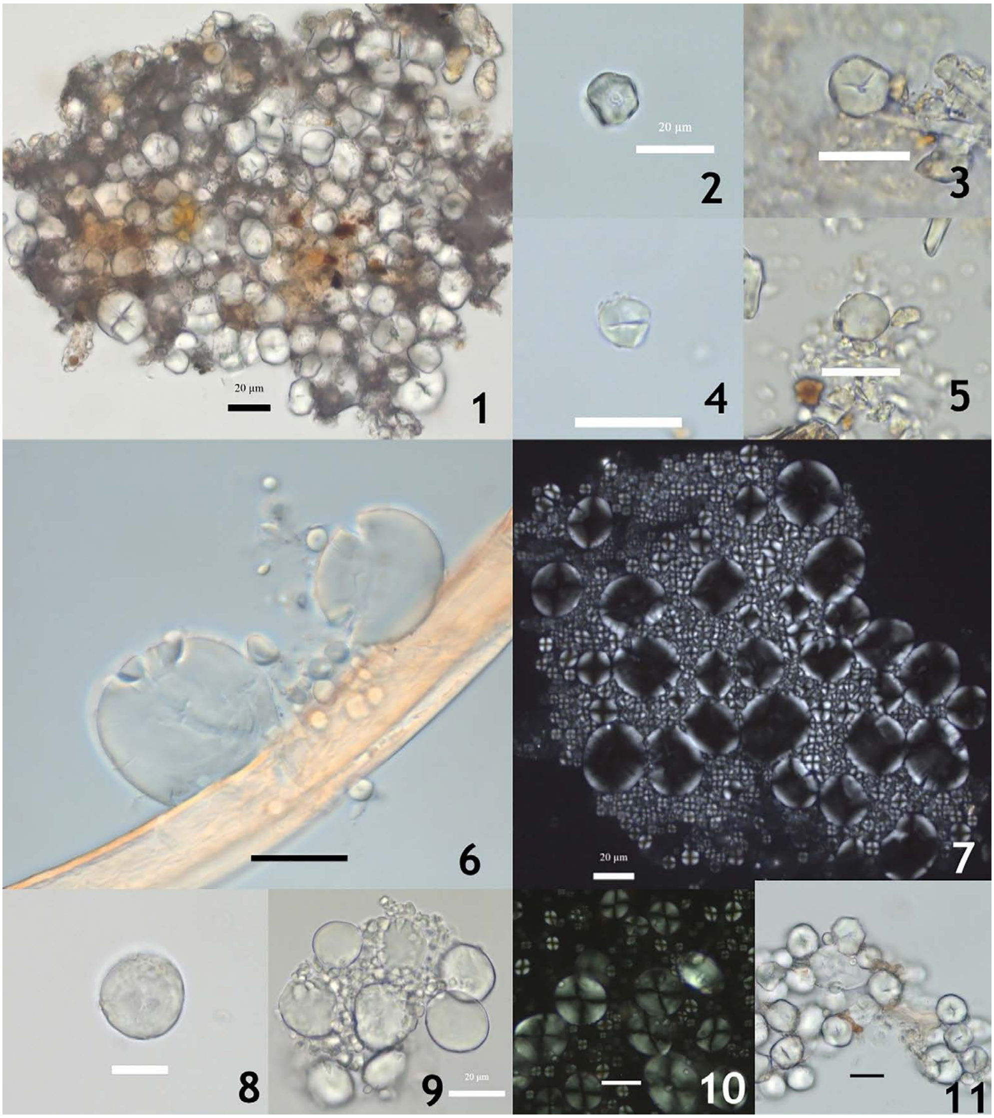

Fig. 4.—Starch grains recovered from the Klerk-5 site (1-8) and reference species (9-11): 1, Starch aggregate from tool n.º 46 (presumably gaoling); 2-5, starch grains from the millets (2, 4 from tool n.º 45; 3 from tool n.º 58; 5 from tool n.º 46); 6-8, starch grains from the *Hordeum sp.* (6 from tool n.º 58; 7 from tool n.º 45; 8 from tool n.º 51); 9-10, modern starch from *Hordeum vulgare*; 11, modern starch from *Sorghum bicolor*. (1-5, 8-9, 11 – white field; 6 – DIC contrast; 7, 10 – polarization. Scale bars: 1-5, 7-11 – 20 µm, 6 – 10 µm).

It was not possible to accurately identify such species as *Setaria italica* and *Panicum miliaceum* at the Klerk 5 site, but among the detected starch some granules were presented, which had morphometric features of millet cereals. The identification of starch of gaoling is preliminary, for carbonized residues of sorghum are not known in adjacent territories, and finding of this plant's starch in North-Eastern China (Chahai site, 8000-7500 cal. BP) is known only by references (Wang *et al*., 2016). The cultivation of *Sorghum* at Klerk 5 instead of traditional for Neolithic sites of Manchuria, Korea, North and Nort-Eastern China *Setaria italica* and *Panicum miliaceum* can probably be explained by the fact that gaoling is less susceptible to disease, well tolerates both drought and waterlogging (Tolmachev, 1928:23). The question about the time and place of domestication of barley isn't solved yet. N. I. Vavilov with the help of his differential-geographical method determined that Eastern and South-Eastern Asia, China and surrounding countries had been a center of origin of hulled barley (Vavilov, 1926). He also recognized the significant role of the Middle East areas in the evolution of wild and cultured barley. Modern studies of the hulled barley's genetics consider Himalayas, southwestern Iran and Tibet as possible centers of its cultivating. According to the same genetic studies it is assumed that hulles and hulled barleys originate from different ancestors (Zheleznov *et al*., 2013: 287; Dai *et al*., 2012; Dickin *et al*., 2012; Badr *et al*., 2000; Zeng *et al*., 2015). It is now believed that hulled barley had already existed as early as 11700 years ago while naked barley was there about 10000 years ago (Zheleznov *et al*., 2013:287; Helback, 1959).

The discovery of the starch of cultivated barley in a layer connected with migrating Neolithic farmers indicates that the inhabitants of Klerk 5 had not left the agricultural practice at that time, but also cultivated various types of cereals in the changing conditions of the cooling climate. A distinctive feature of barley is its extreme unpretentiousness to the conditions of cultivation.

CONCLUSIONS

The experimental-traceological analysis shows that 5 of 7 stone tools found during the excavations of the Neolithic cultural layer of Klerk 5 settlement had been used as grinding stones for processing plants (tools n.º 46 y 58), tool n.º 58 was used as an anvil after the breaking, elongated pebbles with slightly convex surface were used as upper grinding stones (tools n.º 44, 45 y 51). The residue analysis allowed to identify the ancient starch grains related to such cereals as sorghum, barley and millets. Thus, the combination of two approaches to the study of stone farming tools (Reverdin *et al*., 2010; Barton *et al*., 1998) allowed to supplement the characterization of the agricultural development in the Primorye region of Russian Far East. These facts make it possible to consider that the bearers of the tradition of "cord-marked ceramics" during their migration to the reach in seafood maritime areas nevertheless preserved their skills in cultivation of crops and consumed several types of cereals, which indicates the development of agriculture in this area.

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