INTERDISCIPLINARY STUDY OF NEOLITHIC-EARLY BRONZE AGE MACRO TOOLS (BASED ON GRINDING STONES FROM GEORGIAN NATIONAL MUSEUM)[1]

ნეოლით-ადრე ბრინჯაოს ხანის მაკრო იარაღების ინტერდისციპლინური კვლევა (საქართველოს ეროვნულ მუზეუმში დაცული ხელსაფქვავის ქვების მიხედვით)[2]

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Abstract. The grinding stone is a significant tool for agricultural purposes, as supported by numerous archaeological sites from Transcaucasia. It's worth noting that grinding stones have received less attention compared to other artifacts like flaked industry, pottery, and metal artifacts. This theoretical and methodological gap has resulted in a lack of crucial information concerning the definition of prehistoric socio-economic activities. The objective here is to illuminate the type, raw material, and function of grinding stones, as well as the plants processed by the inhabitants of Kvemo and Shida Kartli regions in Eastern Georgia during the Neolithic (second half of the 6th millennium BC) to the Early Bronze Age (second half of the 4th millennium BC). This research aims to contribute both qualitative and quantitative data to address questions pertaining to the techno-typological and functional aspects of stone macro tools.

The research involves the study of Grinding Stone Tools (GSTs) from several archaeological sites: Gadachrili Gora, Shulaveri Gora, Imiri Gora, and Kvatskhelebi, Eastern Georgia. The chosen artifacts for this study are preserved in the archaeological collections of the National Museum of Georgia. The typological study of stones has revealed various shapes of grinders and querns, including oval, saddle-shaped, and quadrangular ones (concave and flat working surfaces). Petrographic analysis encompassed the study of eight different rock types utilized in the production of GSTs, including Rhyolite (porphyry), rhyolitic hyaloclastite, rhyodacite, tuff (rhyolitic), vesicular basalt, basalt, sandstone (carbonatic), and diorite.

The use-wear analysis, conducted using Omax (40X magnification) and Dino-lite digital microscopes (50X magnification), identified smooth, glossy surfaces, occasionally displaying linear traces. This suggests that GSTs were primarily used for plant processing. Additionally, palynological analysis was employed to specify the types of plants that were processed, revealing a variety of plant usage for both dietary (sowing cereals, walnuts, hazelnuts, grapevine, and chenopodium) and medicinal (Tilia, oak, Artemisia, plantago, and urtica) purposes.

Key words: grinding stone; typology; petrography; use-wear analysis; palynology;

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აბსტრაქტი. ხელსაფქვავის ქვა სამეურნეო დანიშნულების ერთ-ერთ წამყვან იარაღს წარმოადგენს, რომელთა გამოყენების აქტუალობა ამიერკავკასიის არაერთ სხვადასხვა არქეოლოგიურ ძეგლზე დასტურდება. აღსანიშნავია, რომ ხელსაფქვავის ქვებს ნაკლები ყურადღება ექცეოდა სხვა არტეფაქტებთან შედარებით, როგორიცაა ნატკეცი ქვის მასალა, თიხის ჭურჭელი და ლითონის არტეფაქტები. ამ თეორიულმა და მეთოდოლოგიურმა ხარვეზმა გამოიწვია გადამწყვეტი ინფორმაციის ნაკლებობა პრეისტორიული სოციალური-ეკონომიკური საქმიანობის განსაზღვრასთან დაკავშირებით. სწორედ, წინამდებარე სტატიის მიზანია ხელსაფქვავების ტიპის, საიარაღე მასალისა და ფუნქციის, აგრეთვე დამუშავებული მცენარის სახეობის დადგენა აღმოსავლეთ საქართველოს ქვემო და შიდა ქართლის რეგიონების ნეოლით (ძვ.წ. მე-6 ათასწლეულის მეორე ნახევარი)-ადრებრინჯაოს ხანის (ძვ.წ. მე-4 ათასწლეულის მეორე ნახევარი) არქეოლოგიური ძეგლებზე დადასტურებული მასალების მიხედვით. გარდა ამისა, სტატიის მიზანია ხარისხობრივ, ასევე რაოდენობრივ მონაცემებთან ერთად ქვის მაკრო იარაღების ტექნიკა-ტიპოლოგიური და ფუნქციონალურ ასპექტებთან დაკავშირებული საკითხების კვლევა.

კვლევისათვის შეირჩა ხელსაფქვავის ქვები, რომლებიც აღმოჩენილია აღმოსავლეთ საქართველოში ნეოლით-ადრე ბრინჯაოს ხანის არქოლოგიურ ძეგლებზე - გადაჭრილი გორა, შულავერის გორა, იმირის გორა, ქვაცხელები. ხელსაფქვავების ტიპოლოგიურმა შესწავლამ გამოავლინა ოვალური, უნაგირისებური და ოთხკუთხა ფორმის იარაღები, რომელთა სამუშაო ზედაპირი ძირითადად ბრტყელი და ჩაღრმავებულია. პეტროგრაფიული ანალიზის მიხედვით განისაზღვრა რვა განსხვავებული საიარაღე მასალის გამოყენება იარაღის დასამზადებლად, როგორებიცაა რიოლითი (პორფირი), რიოლითური ჰიალოკლასტიტი, რიოდაციტი, ტუფი (რიოლითური), ფორებიანი ბაზალტი, ბაზალტი, ქვიშაქვა (კარბონატული) და დიორიტი.

არტეფაქტების ფუნქციონალურმა ანალიზმა, რომელიც ჩატარდა ომაქს ბინოკულარული (OMAX, 40X გადიდება) და დინო-ლაით დიგიტალური (Dino-Lite Digital, 50X გადიდება) მიკროსკოპების გამოყენებით, გამოავლინა მოგლუვების, სიპრიალისა და იშვიათ შემთხვევაში ხაზოვანი კვალი, რაც მიუთითებს იარაღის გამოყენებას მცენარის დასამუშავებლად. გარდა ამისა, პალინოლოგიური ანალიზის გამოყენებით განისაზღვრა თუ რა სახის ორგანული ნარჩენები იყო არტეფაქტის სამუშაო ზედაპირზე; დადასტურდა მცენარეთა მრავალფეროვნება, რომელიც გამოიყენებოდა როგორც საკვები (სათესი მარცვლოვნები, კაკალი, თხილი, ვაზი, ნაცარქათამა) ასევე სამკურნალო (ცაცხვი, მუხა, ავშანი, მრავალძაღვა, ჭინჭარი) მიზნებისთვის.

საკვანძო სიტყვები: ხელსაფქვავი; ტიპოლოგია; პეტროგრაფია; ფუნქციონალური ანალიზი; პალინოლოგია.

Introduction

Caucasia stands as an independent hub of agriculture, where favorable living conditions have played a significant role in the formation and development of prehistoric communities (Japaridze, Javakhishvili 1971). In Transcaucasia, conditions for the development of agriculture differed from those in the preceding Asian regions. Unlike Asia, the adoption of agriculture occurred later in this region. Due to the arid climate, it was necessary to artificially irrigate the land. As a result, the development and use of irrigation systems have been prevalent in the Transcaucasian heartland since its inception. Determining the initial stages of the emergence of agriculture is a challenging task, first Neolithic Culture in Caucasia were dated second half of the 6 th millennia BC. Therefore, a comprehensive approach involving the utilization of archaeological, historical, ethnographic, geological, botanical, geographical, and other data is necessary for studying this issue (Japaridze, Javakhishvili 1971; Hamon et al. 2016; Возникновение и развитие земледелия 1967).

Paleoethnobotanical catalog based on archaeological materials from Neolithic and Eneolithic sites in the Caucasus and in the Middle East is composed of 27 types of cultivated wheat, including single-grain wheat (Triticum monococcum L.), two-grain wheat (Triticum dicoccum Schuebl), emmer wheat (Triticum macha Dek. Et Men.), spelt (Triticum spelta L.), durum wheat (Triticum durum Desf), soft wheat (Triticum aestivum L.), dika (Triticum carthlicum Nrvsy-T/persium VaV). In Eastern Georgia the paleobotanical record from this period is primarily known from the sites referred to Shulaveri-Shomu Tefe culture, which yielded various types of wheat, including soft wheat (Triticum vulgare), durum wheat (Triticum durum), savory wheat (Triticum compactum), double-grain wheat (Triticum dicoccum), single-grain wheat (Triticum monococcum), spelt (Triticum spelta), and dika (Triticum carthlicum) (Горгидзе, Русишвили 1984; Dzidziguri 2000).

My research objective is the study of grinding stones found at Neolithic (second half of the 6th millennium BC) to Early Bronze Age (second half of the 4th millennium BC) archaeological sites in Shida Kartli and Kvemo Kartli regions of Georgia. These sites include Gadachrili Gora, Shulaveri Gora, Imiri Gora, and Kvatskhelebi, and the artifacts are preserved in the archaeological collections of the National Museum of Georgia.

Dozens of grinding stones recorded at the indicated archaeological sites belong typologically to the group of agricultural tools. They vary in terms of working technique, raw material type, function, and morphological aspects. Through a comprehensive approach involving typological, petrographic, functional, and palynological analyses, we gathered crucial information about the tool's function and typology, the correlation between the tool's raw material and its function, and the presence of organic residues on the working surface.

The scientific literature on the above-mentioned archaeological sites, offers us mostly typological data about stone artifacts (Menabde, Kighuradze 2001; Kighuradze 1976; Dzidziguri 2000; Javakhishvili, Japaridze 1975; Javakhishvili, Ghlonti 1962; Jalabadze 2010; Hamon et.al. 2016). Until present, the macro lithic stone tools related to the processing of crops were poorly investigated, with the valuable exception of the typological and functional analysis of ground tools – discovered at the Shulaveri-Shomu sites carried out by C. Hamon that play a key role to the understanding of similar tools in the region (Hamon 2009). A part this prized exception, the study of specific household tools in Transcaucasia, and especially in Georgia, has not received attention until recently.

I examined a total of 58 grinding stones from Shulaveri-Shomu tepe culture acraheological sites of Kvemo Kartli region (6th Millenium BC, Shulaveri, Imiri, and Gadachrili Gora) and Early Bronze age archaeological site of Shida Kartli region (second half of 4th Millenium BC, Kvatskhelebi).

15 units from the Shulaveri archaeological site, which is situated near the Khrami River, approximately 2.5 km southwest of the village of Imir. The excavations at different levels of this site unveiled 9 different horizos, and up to 40 residential and economic structures made of mudbricks (Javakhishvili, Japaridze 1975: 11; Kighuradze 1976: 52). The grinding stones we studied come from different construction horizons (1st, 2nd, 4th, and 9th) in the areas of construction N11 and N19, as well as from the land excavated by bulldozers around the hill.

11 units of grinding stones come from Imiri Gora, which is located near to village Imiri, on the left bank of the Shulaveri gorge. 7 construction horizons were revealed on Imir Gora, on which 80 mudbrick buildings were excavated (Javakhishvili, Japaridze 1975: 60; Kighuradze 1976: 61). The studied grinding stones come from the 9th, 10th, and 17th buildings.

Gadachrili Gora is located southeast of the village of Imiri. During several archaeological fieldworks, two cultural layers were identified, in which mudbrick buildings characteristic of the Shulaveri-Shomu tepe culture were discovered. Seventeen units of grinding stones were obtained from locus 3, 10, 11, 15, and 16 during the 2017-2019 archaeological fieldwork seasons.

Kvatskhelebi is located 2.5 km east of the village Urbnisi, on the left bank of the Kura River. Two main cultural layers (B and C), 7 settlement areas, and up to 40 buildings were discovered. Fifteen units of grinding stones preserved in the GNM archaeological collections come from the areas excavated in 1956-57, specifically from locus 1, 10, 22, and layer B (Javakhishvili, Glonti 1962: 1;27-28;34;37).

The grinders primarily exhibit oval and saddle shapes, with flat and concave working surfaces (Fig. 1). In the case of the querns, in addition to the oval shape, there are quadrangular-shaped tools with mainly concave and trough-shaped working surfaces (Table 1, Fig. 2).

Archaeological Site	**Grinder**		**Quern**		**Broken**
	Flat	**Concave**	**Concave**	**Through-shaped**	
Shulaveri Gora	10		3	1	1
Imiri Gora	6		1	2	2
Gadachrili Gora	8	2	6	1	
Kvatskhelebi	4	5	5	1	
Total	28	7	15	5	3

Table 1. Typological classification of grinding stones.

Within the petrographic study of grinding stones, the artifacts were grouped based on the physical characteristics of the rocks, including color, specific gravity, grain size, texture, and acidity. Damaged artifacts were carefully selected to determine the raw materials. Samples were extracted from these artifacts to create transparent slices for analysis. The examination of these samples revealed various tool materials - Rhyolite (porphyry), rhyolitic hyaloclastite, rhyodacite, tuff (rhyolitic), vesicular basalt, basalt, sandstone (carbonatic) and diorite are used for making grinding stones (Tab. 2).

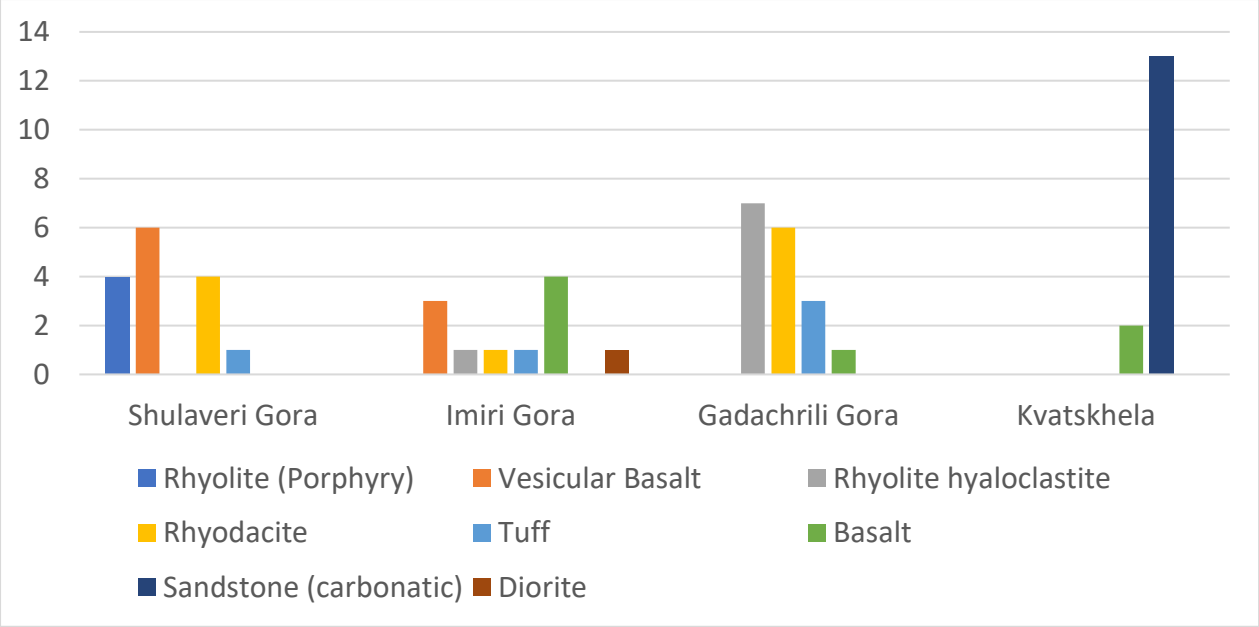

Table 2. Raw material used for Grinding stones

In terms of functional analysis, the working surface of the tool was initially examined under a binocular microscope (OMAX, magnification 40X) and, based on the size of the tool, further investigated using a digital microscope (Dino-Lite, magnification 50X). The majority of the studied grinding stones exhibited smooth, glossy surfaces, with occasional linear traces. Some units had patinated surfaces, making observation challenging. Based on the usage traces found on the working surfaces of the tools, it can be inferred that they were used for processing plants.

The palynological analysis conducted on the grinding stones, where 20 samples were selected, revealed the presence of plant pollen grains and non-palynological remains. Based on the palynological data, the organic remains can be categorized into various forms including plants, shrubs, herbs, seeds, and weeds.

The comprehensive analysis of grinding stones available at the archaeological collections of GNM will create an unprecedented reference model for the similar structures of the Transcaucasia. Hence will also provide valuable insights into the material culture, ecological changes and daily life of the local inhabitants throughout Neolithic- Early Bronze Age-period, also providing a comprehensive understanding of the importance and functions of grinding stones in prehistoric farming.

Methods

A typological study of stone artifacts involves grouping materials based on their shape and processing techniques, with the aim of characterizing the types and subtypes of both upper and lower grinding stones across different chronological periods. The upper grinding stones vary in size, with lengths ranging from 10 to 40 cm, widths from 7.2 to 27 cm, thicknesses from 2.5 to 10 cm, and weights from 0.450 to 7.8 kg. On the other hand, the dimensions of the lower stones are as follows: length 14-53 cm, width 12-31.5 cm, thickness 3.5-12 cm, and weight 3.25-8 kg.

Geologist Rusudan Chagelishvili identified the types of rocks suitable for grinding stones through petrographic analysis. Within the research, the artifacts were grouped based on the physical characteristics of the rocks, including color, specific gravity, grain size, texture, and acidity. The study involved the use of binocular microscope, and hand magnifications of different sizes (x10; x20), specialized strength measuring sticks, and 3% hydrochloric acid for thorough examination.The research revealed that the grinding stones were made from eight different species or types of rock - Rhyolite (porphyry), rhyolitic hyaloclastite, rhyodacite, tuff (rhyolitic), vesicular basalt, basalt, sandstone (carbonatic) and diorite are used for making grinding stones. The rocks of rhyodacite volcanic-sedimentary formation and vesicular basalts found in the nearby river valleys, terraces and natural outcrops were used for the manufacture of agricultural tools found on Shulaveri, Imiri and Gadachrili Gora. The source of the tool material for grinding stones found in Kvatskhelebi, dwelling is the natural outcrops of local sedimentary rocks common on the belt of Georgia, the alluvium and terraces of the Mtkvari and Ptsi rivers. As for the basalt grinding stones, their source is Adjara-Trialeti, which is brought by the Dzama River and its tributaries and deposited on the alluvion and terrace of the Mtkvari River.

To determine the function of the grinding stones, macro and micro-observations were conducted. The functional study involved an initial examination of the tool's working surface using a binocular microscope (OMAX) with 40X magnification. Based on the tool's size, a digital microscope, the AM7013MZT Digital microscope Dino-Lite, with 50X magnification, was used for further study. During microscopic observation,

samples with and without use traces were distinguished. In cases where traces were present, tools were grouped based on similarities and differences in wear patterns. The working surface was examined for polish, smoothness, scratches, and diagnostic traces to determine their function (see Table 3, Figure 3).

To identify the presence of organic residues on the grinding stones, we conducted palynological studies analyzed by palynologist Inga Martkoplishvili. The material was processed in several stages at the palynological laboratory of the National Museum of Georgia. Initially, the artifacts were boiled in potassium alkali, followed by separation of organic remains using a heavy liquid. Finally, acetolysis, specifically palynomorph staining, was performed. The palynological analysis conducted at the research site revealed pollen grains of trees, plants, and shrubs, along with seed grains from various herbs. In addition to pollen, the non-palynological remains included burned wood cells, granular starches, phytoliths, flax, and hemp fibers.

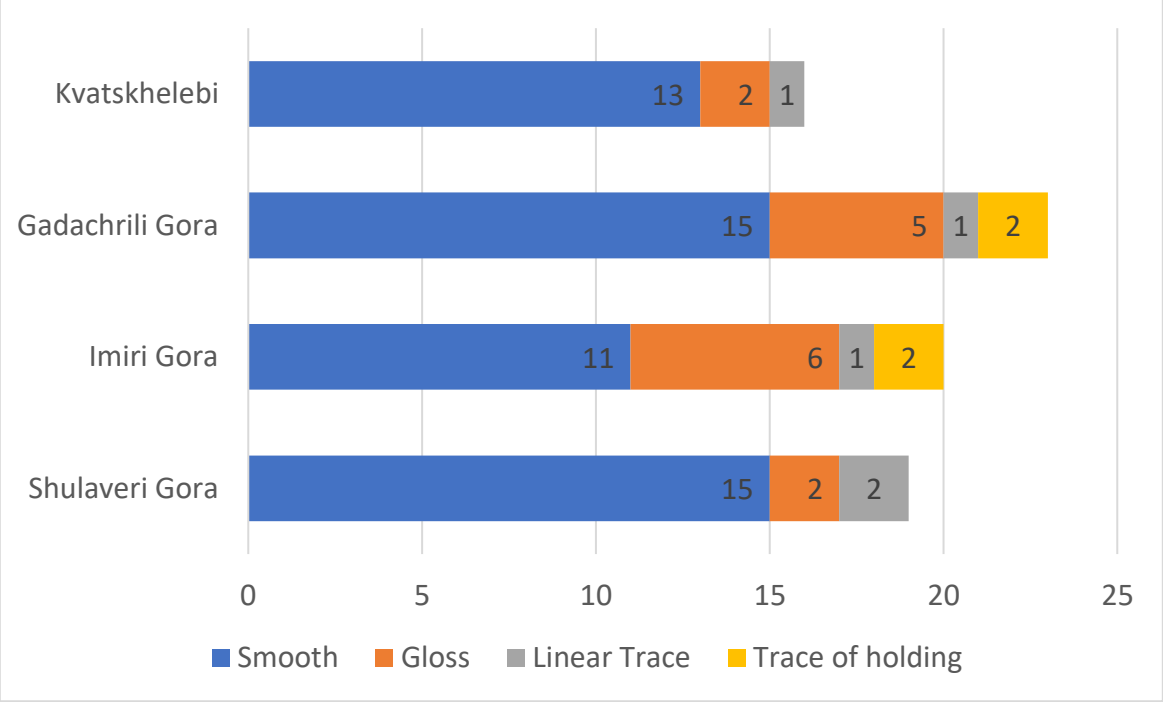

Table 3. Use-wear traces on the grinding stones.

Results and discussion

The application of interdisciplinary methods in the study of grinding stones preserved in the archaeological collections of the National Museum of Georgia provided us with the following insights:

Shulaveri Gora. Out of 15 grinding stones from Shulaveri Gora, 11 units are grinders, 3 units are querns, and there is 1 fragment. The predominant tool raw material identified are rhyolite (porphyry), rhyodacite, tuff (rhyolitic), vesicular basalt is used.

Functional analysis revealed smooth, gloss and linear traces on the grinding stones. It's worth noting that for the grinders, the smoothing traces on the back side suggest marks resulting from hand pressure during use.

The palynological analysis of the material of Shulaveri Gora showed pollen grains of trees and shrubs: pine (*Pinus*), Fir (*Abies*), spruce (*Piceae*), hornbeam (*Carpinus betulus*), oak (*Quercus*), elm (*Ulmus*) and Viburnum (*Viburnum*). Cereals (*Cerealia*) and its weeds such as Chenopodiaceae are sown in small quantities from grasses. Pollen grains of Poaceae, Xanthium, Artemisa, Plantago, Urtica are also found. Among the non-palynological remains are burnt cells of wood pulp, cereal starch, phytoliths and flax fibers.

Imiri Gora. Out of 11 grinding stones of Imiri Gora, 8 units are grinders, and 3 units are querns. The grinding stones are made of vesicular basalt, basalt, diorite, tuff (rhyolitic), rhyolitic hyaloclastite and rhyodacite.

Diagnostics of the traces on the working surface of the tool showed that traces of smoothening traces were observed on all samples. Additionally, some tools exhibited gloss and linear traces along with smoothness.

For palynological analysis, 4 samples were selected, according to which it was confirmed that they belong to the group of trees and shrubs – Fir (*Abies*), Spruce (*Piceae*) and Pine (*Pinus*), as well as walnut (*Juglans regia*), hornbeam (*Carpinus betulus*) and hazel (*Corylus*)) pollen as well. There are Cerealia, Poaceae, Xanthium, Artemisia, Plantago, Serratula and Chenopodiaceae. In addition, herbaceous phytoliths, flax and hemp shoots, wood pulp cells, and starch grains were observed.

Gadachrili Gora. Out of the 17 grinding stones from Gadachrili Gora, 11 units are grinders, and 6 units are querns. They are made from raw materials such as rhyolitic hyaloclastite, basalt, rhyolitic, tuff (rhyolitic).

Traces of use in the form of smoothening, gloss and linear traces, were observed on the working surface of the studied material.

Four samples were selected for palynological analysis, the research of which revealed the presence of Fir (*Abies*), spruce (*Piceae*), pine (*Pinus*), walnut (*Juglans regia*), hornbeam (*Carpinus betulus*), oak (*Quercus*), alder (*Alnus*), and lime tree (*Tilia*), hazel (*Corylus*) and viburnum (*Viburnum*) pollen grains. From grasses: pollen grains of Cerealia, Artemisia, Aster, Plantago, Chenopodiaceae, Rosaceae and Sedum. A large number of wheat keel phytoliths were observed on one of the samples; burned wood cells, starch, flax fibers are also present.

Kvatskhelebi. Out of 15 grinding stones from Kvatskhelebi, 9 units are grinders and 6 units are querns. Basalt and sandstone (carbonatic) are used as the raw materials for the tools. Regarding the working traces, smoothness, gloss and linear traces were observed.

Four samples were selected for palynological analysis from the grinding stones of Kvatskhelebi. From trees and plants, pollen grains of hornbeam (*Carpinus betulus*), pine (*Pinus*), fir (*Abies*), spruce (*Piceae*), walnut (*Juglans regia*), oak (*Quercus*) and hazel (*Corylus*) were confirmed; Among the herbaceous plants, single pollen grains of Cerialia, Artemisia, Plantago, Xanthium, Poaceae, Cannabis sativa, Chenopodiaceae and Rosaceae are presented. In addition, flax and hemp fibers were observed.

As for the non-palynological spectrum, burned wood cells and herbaceous phytoliths, starch grains were recorded.

Conclusion. The comparison of the grinding stones from Shulaveri Gora, Gadachrili Gora and Imiri Gora revealed that similar types of upper stones were used in these settlements, with flat sides ion both the dorsal and the ventral surfaces (Fig. 4.2, 4.4); Tools with a flat working surface and a convex backside were also identified (Fig. 4.1, 4.3). Both single and double-handed grinders were in use. On the other hand, the upper stones found in Kvatskhelebi share a convex backside, the middle part of which is flat, with flat and concave working surfaces (Fig. 4.5, 4,6).

The research archaeological sites are situated in two distinct locations. Specifically, Shulaveri Gora, Gadachili Gora, and Imir Gora are situated in Kvemo Kartli, within the basin of the Khrami River gorge. On the other hand, Kvatskhelebi are located in Shida Kartli, on the left bank of the Mtkvari River. The sites in Kvemo Kartli are situated very close to each other, within a radius of 3-4 km, on the right bank of the Khrami River, in the lower belt of the northern slope of the Loki ridge, on the Kvemo Kartli plain. The terrain within this specified territory is characterized by river valleys (wide, low-banked beds), gullies, and ditches. Floodplains, along with the first and second terraces, as well as low hills and seres, are typical features of this region (Геоморфология Грузии, 1971). In the case of Shida Kartli, the sandstones used for the agricultural tools found here are sourced from natural outcrops of Paleogene sedimentary rocks that span across Georgia, as well as from the alluvium and terraces along the Mtkvari and Ptsi rivers. The source of the basalt grinding stones can be traced to the middle Eocene basalts of Adjara-Trialeti. These basalts were carried by the Dzama River and its tributaries, eventually depositing on the alluvium and terraces of the Mtkvari River. The most accessible collection of basalt can be found in the Mtkvari valley.

The functional analysis reveals that traces of gloss and smooth are most prominent on the grinding stones made of vesicular basalt. In contrast, the smoothness on the working edge of the tools made from rhyo-dacite and rhyolite (porphyry) were observed on fine-grained impurities. Regarding the secondary use of the tool, it was recorded in one sample of Gadachrili Gora: the grinder was repurposed as a pestle. Traces of use on the working surface of the tools, such as smoothness and gloss, indicate that grinding stones were used to process plants (Fig.5).

Based on the palynological analysis, it can be concluded that during the Neolithic period, people consumed plants such as sowing cereals (სათესი მარცვლოვნები), walnuts (კაკალი), hazelnuts (თხილი), grapevine (ვაზი), and chenopodium (ნაცარქათამა). They also used various plants like Tilia (ცაცხვი), oak (მუხა), Artemisia (ავშანი), plantago (მრავალძარღვა), and urtica (ჭინჭარი) for medicinal purposes to treat various diseases (e.g., gastrointestinal diseases, sedatives, hemostatics, bronchial asthma, vasodilators, etc.). The abundance of phytolith starch from non-palynological palynomorphs also suggests that almost all the grinding stones were used to process plants.

The extensive grinding of wood pulp cells on grinding stones implies a significant presence of forests in the landscape during the Neolithic and Bronze Age. The pollen grains of plants constituting broad-leaved forests, such as walnut, alder, hornbeam, brush, elm, oak, etc., primarily indicate heat-loving plants. This leads us to infer that the climate was likely quite warm during the mentioned periods

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Fig. 1. Grinders from Shulaveri Gora, Imiri Gora and Kvatskhelebi.

Fig. 2. Concave and trough-shaped querns.

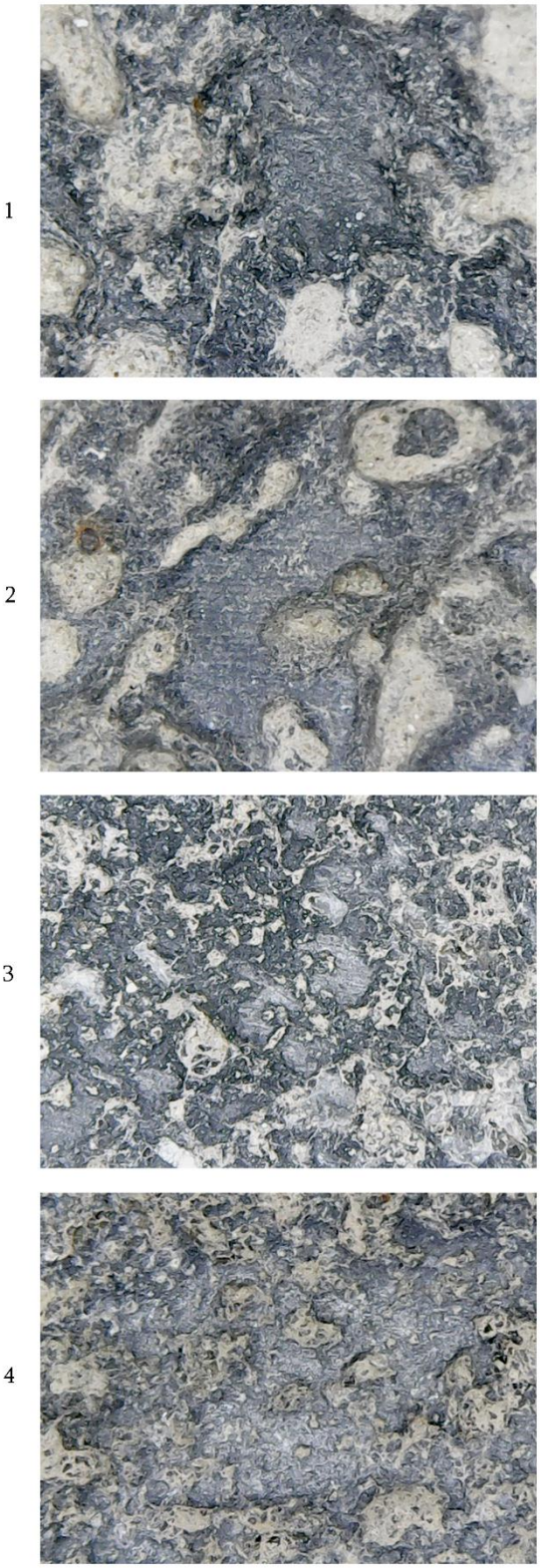

Fig. 3. 1, 3 - Smooth, 2 – linear trace and 4- polish trace on the grinding stones.

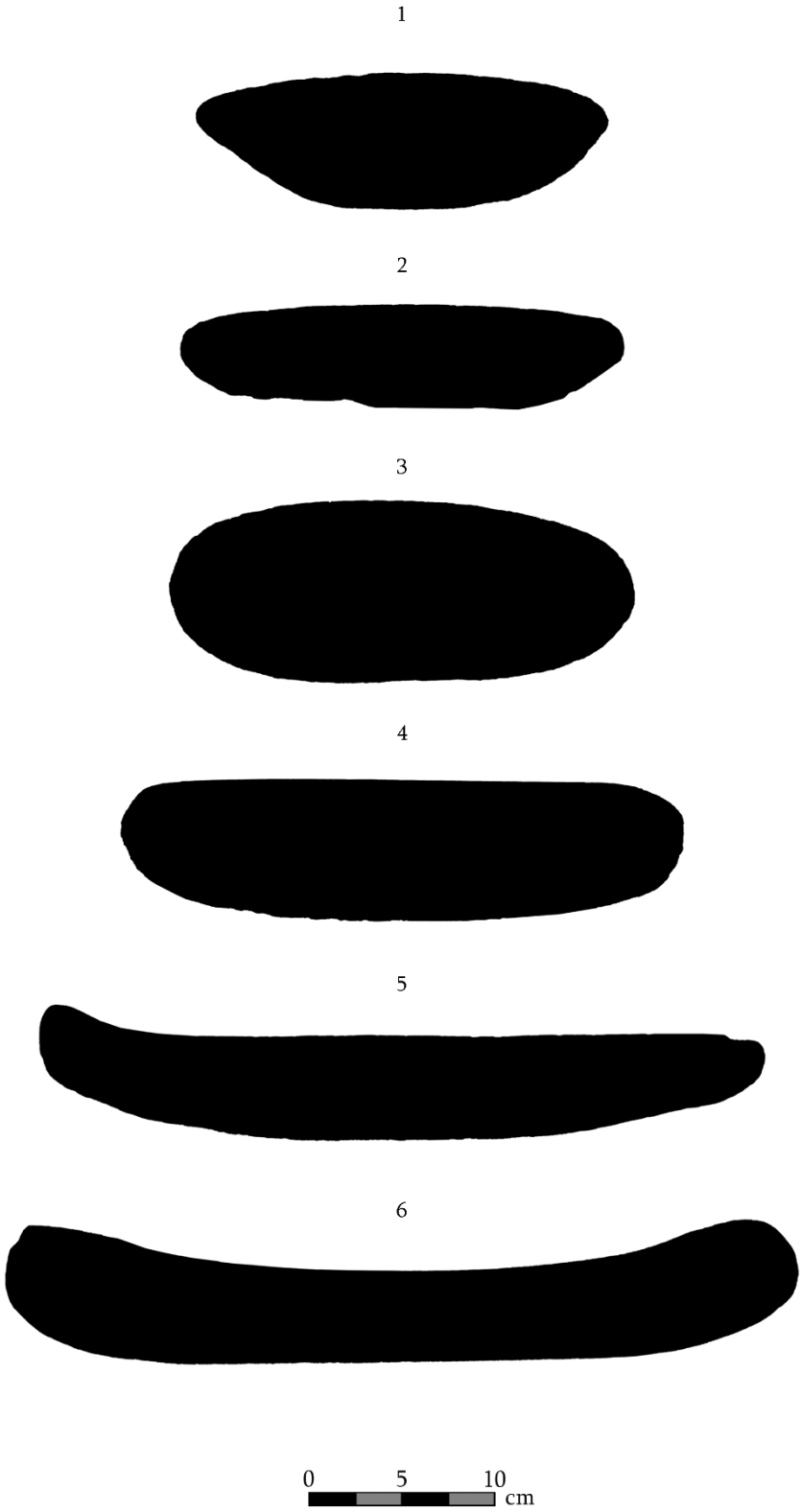

Fig. 4. Typological classification of grinders.

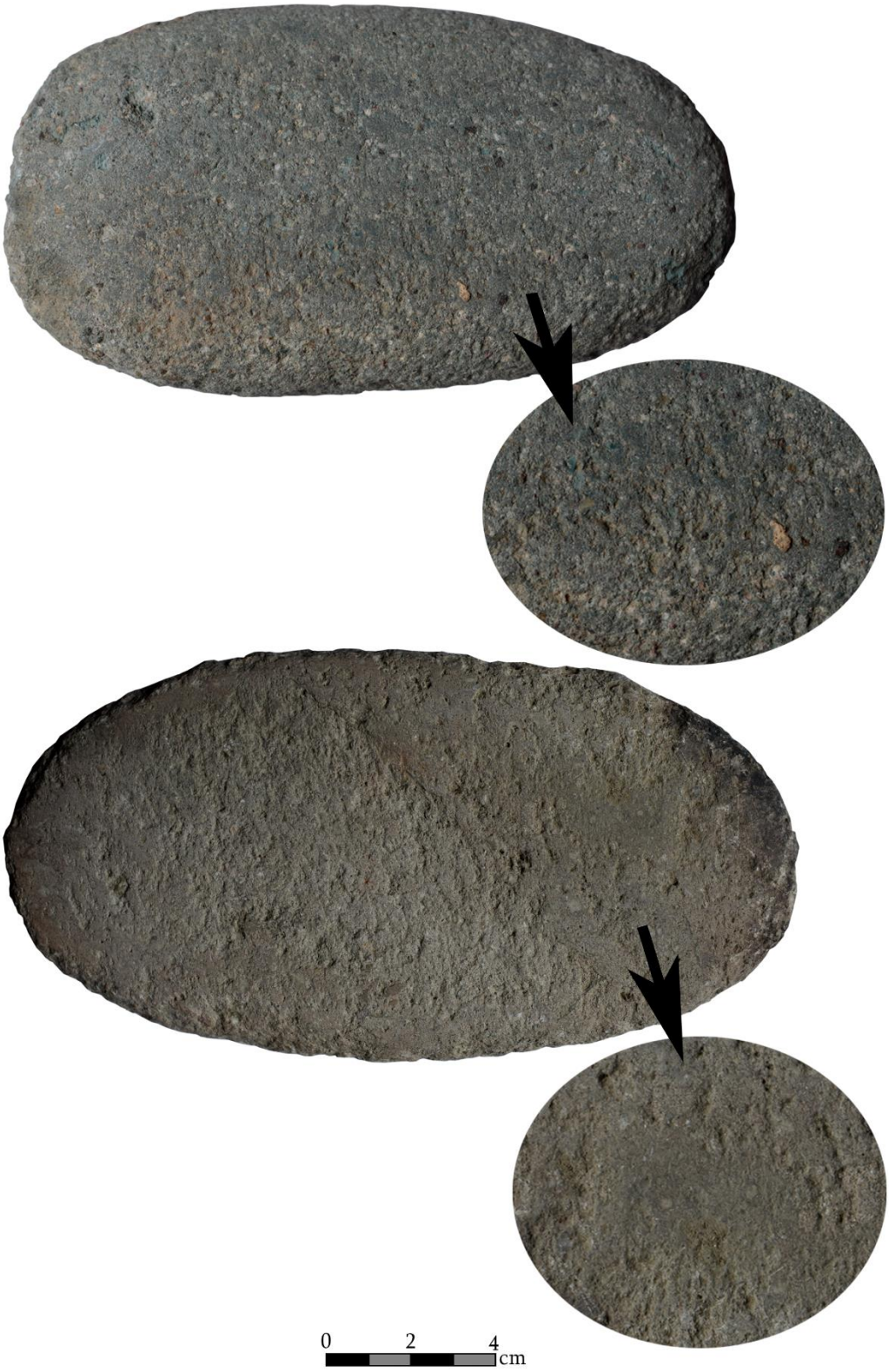

Fig. 5. Traces of use-wear on grinders.