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A petrographic Study of Late Chalcolithic and Early Bronze Age Pottery Found at Gourab Tepe

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Abstract

Gourab Tepe is one of Iran's most important prehistoric sites, located in the city of Malayar in the province of Hamedan. Unlike Godin Tepe, Gourab's transition from the Late Chalcolithic period to the Early Bronze Age was without any ruptures, and the Bronze Age artifacts found there belong to the Kura-Araxes culture, a culture covering a vast geographical area whose wide spread through the region and the reasons for their expansion have been subjects of great fascination to archeologists. Petrography is a scientific method used in the geological sciences to identify minerals based on their optical properties. The pottery found on Gourab Tepe provides an incredible opportunity to study the transition from the Late Chalcolithic period to the Early Bronze Age, which in itself is an important topic of discussion for archaeology. This article aims to understand the makeup of the minerals present in the pottery found on Gourab Tepe and analyze the transition from the Late Chalcolithic period to the Early Bronze Age to understand the influence of cultural changes on the structure, texture, and makeup of the pottery in the region. Research questions include: Which minerals are present in the Late Chalcolithic and Early Bronze Age potteries, and what does their presence signify about the geological structure of the region? What effect did the Cultural transition and change have on the structures of potteries, and in the case of these changes, how can we interpret and analyze this phenomenon from an archeological standpoint? The petrographic study analyzing 20 samples—10 of which were from the Late Chalcolithic period and 10 of Kura-Araxes origin—showed that the Gourab Tepe potteries underwent significant structural changes from the Late Chalcolithic period to the Early Bronze Age, and whilst these potteries were produced in the same region, the clay and the pottery-making techniques used had fundamental differences.

Keywords: Gourab Tepe, Late Chalcolithic Period, Early Bronze Age, Petrography.

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Introduction

The presence of both native and non-native cultures was observed in Central Zagros during the Late Chalcolithic period. Official findings from Godin Tepe (levels V–VI) report that traces of Uruk cultures were found alongside traces of the region's natives. The Uruk lived in enclosed spaces and separately from the other residents of the region (Weiss and Young, 1975).

The characteristics of Godin VI potteries are fair-painted wares or potteries coated in a thick layer of white slip (Young, 1969: 514; Levine and Young, 1987: 17). The wares found in the Kermanshah and Mahidasht regions resemble those of Godin V–VI (Henrickson, 1985). Godin V-VI potteries have also been found on the surface layers of the encore in Malayar. (Howel, 1979: 157)

The end of the Late Chalcolithic period brought on a decline in the number of settlements and, subsequently, a decline in the region's population. Holeylan reportedly entered a period of interregnum at the beginning of the Bronze Age (Mortensen, 1976: 45–46), and Mahidasht exhibited a different early Bronze Age culture from the dominating cultures in the east, meaning Hamedan and Kangavar (eastern parts of Central Zagros). In these regions, the painted potteries have a red clay coating and are decorated with the snake and swirling designs corresponding to the earlier II and III periods, which can also be seen in the effects of the seals (Henrickson, 1984: 709). The Godin III potteries were discovered after (Levine, 1976).

As was the case with the Late Chalcolithic period, the presence of non-native cultures in the region that had roots in the northwest of Iran and the Caucasus region was also observed. These cultures are known as Transcaucasian, Yanik, Kura-Araxes, etc. This culture's artifacts have been reported along the eastern banks of northern Zagros, around Hamedan (Young, 1966, transition; 2008), Malayar (Howel, 1979), Kangavar, Bijar, Miandoab (Swiney, 1975), and along the riverbanks of Qareh Chay in western parts of the Markazi province (Shirzad and et al., 2019).

One of the most important topics of prehistoric archeology, especially in the case of Iran and other regions where traces of Kura-Araxes groups have been found, is understanding the reasons why this group expanded so widely and how. Kura-Araxes is so expansive that the traces of Kura-Araxes potteries and assemblages have been spotted all over the region, stretching from northern parts of the Iranian plateau to the Levant region, the northern Caucasus region, Dagestan, Chechnya, and all the way back to

Harsin in Kermanshah (Alizadeh, 2010). Kura-Araxes groups and cultures seemingly formed between the rivers Aras and Kura (Burney, 1962; 1964; Kohl, 2009), and later, during their second period (Transcaucasian II), spread out to the neighboring area (Burney & Lang, 2007; Ajorloo, 2003). The first Iranian archeologist who studied these potteries was Seifollah Kambakhshfard, but other Iranian archeologists did not really take note of his work (Alizadeh, 2010). The Kura-Araxes group was widely known as Yanik in Iran, even though this archaeological site was not the first site with traces of Kura-Araxes artifacts to be excavated. In fact, multiple studies and literature were published about these excavations; the first comprehensive research on these potteries was conducted by Burton Brown in Geoy Tepe (Talaii B, 2006: 7; Burton Brown, 1951), but due to Burney's extensive research and work on the Yanik Tepe and the proper presence of a sequence indicating the Early and Middle Bronze Age there, which led to the publication of his cohesive findings on the aforementioned subjects, it fed into the use of the word Yanik by Iranians. This is true despite the fact that these same wares were discovered in the Caucasus region by the Russian archeologist Kuftin.

The discovery of the vast reach of the Kura-Araxes peoples made the cause and manner of their expansion a significant topic of consideration for archeologists, whose answers were most commonly purely theoretical. The use of Natural Sciences in archeology has a hundred-year history, with different methods being used all over the world to understand archeological data and artifacts. Petrography, which has its roots in geology, is one such method and has been used to understand the possible changes from the Late Chalcolithic period to the Early Bronze Age. The petrographic method was used to study three archeological sites (Godin, Baba Qasem, and Sangalan) established in the Zagros Mountain, which is one of the areas where Kura-Araxes traces have been found (Mason and Cooper, 1999). Mason and Cooper reported the changes in the structure and textures of the potteries from Godin V-VI to the Early Bronze Age (Godin IV) and to the Middle Bronze Age (Godin III) and attributed these changes to migration and displacement, though they could have been a result of both migration (including the migration of artisans) or trading (Mason and Cooper, 1999; Batiuk, 2000). Another one of their arguments was the appearance of grog or crushed baked pottery as a temper in Kura-Araxes potteries. Mason and Cooper's theories about the continuity between Godin Periods V–VI and Godin Period IV were later disputed. These disputes created more doubt about whether or not changes had occurred in pottery-making techniques between these periods, whether they were simply the result of migration, or even if the potteries had appeared before the first Kura-Araxes settlement in the region or after.

In order to conduct proper research to evaluate these hypotheses, an archeological site with multiple layers to dig would be necessary so that the different periods and the changes occurring from one phase to another could be properly studied. Gourab is an excellent excavated site for this very reason. This article aims to understand the makeup of the minerals present in the potteries found on the Gourab and analyze the transition from the Late Chalcolithic period to the Early Bronze Age to understand the influence of cultural changes on the structure and makeup of the potteries in the region.

Methodology: Petrography is derived from the two words 'petro' and 'graph, which respectively mean rock and to graph or to draw. In geology, the study of rocks in thin sections using microscopes is called petrography. This is a method wherein the use of a polarizing A microscope aids in the study of the structure, texture, and composition of materials. Petrographic methods were previously used in geological studies (Batiuk, 2005: 171). This study includes examining the structure, texture, composition, and components of the rocks and the relationship between each of them. This method was used to study the petrofabrics and identify the components of the pottery samples. Each piece of pottery was glued to a glass plate, and then the thickness of the sample was increased to 0.03 mm. This thickness allowed the light to pass through the clay and made the reading and identification of the minerals present in the clay sample possible. The light also made it possible to see if the minerals present in the sample were the size of grains, round, or angular (Shepard, 1957: 139–140). Two simple lights, Plain Polarized Lights (PPL) and Crossed Polarized lights (XPL), were used to identify the minerals. The history of studying ancient pottery in thin sections dates back to the mid-to-late 19th century, when the British Henry Clifton Sorby, who was an influential role in the development of the study of rocks in thin sections via the use of a microscope, used this method to study eastern England tiles and Roman and medieval bricks. Although the first publications in the field date back to 1879 and Foucault and Auguste Michel-Lévy's geological study of the prehistoric pottery on the island of Santorini (Sean Quinn, 2013: 10).

Research questions and hypotheses: Which minerals are present in the Late Chalcolithic period and Early Bronze Age pottery, and what does their presence signify about the geological structure of the region?

What effect did the Cultural transition and change have on the structures of pottery, and in the case of these changes, how can we interpret and analyze this phenomenon from an archeological standpoint?

Research Methodology

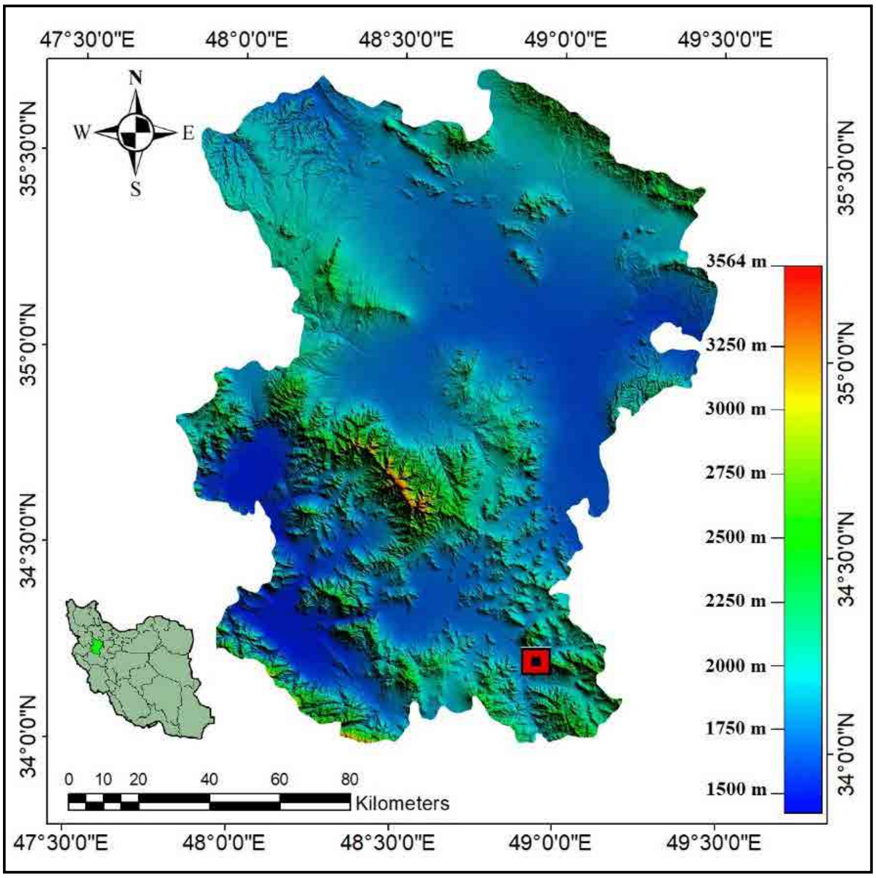
Part of this research was field work (excavation on the Gourab site by Mr. Khaksar), and another part included the study of the pottery findings from site excavation, which was done with the help of preparing thin sections and observing them under an optical microscope, which is considered an interdisciplinary method. Overall, 10 Late Chalcolithic and 10 Early Bronze Age pottery samples were collected and studied.

Research Background

The first petrographic study of Kura-Araxes pottery was conducted by Mason and Cooper (1999), who focused on the Bronze Age Pottery found on the Godin, Baba Qasem, and Sangalan sites and determined that each period had a distinct structure and texture. Batiuk studied the pottery found in Bayburt, northwestern Turkey (Batiuk, 2000). He studied 20 areas and spoke about the presence of non-native samples. Batiuk concluded that each region produced its own pottery based on the available textiles. This could strengthen the theory that pottery was very much a homemade and domestic product. Kibaroglu and company (Kibaroglu et al., 2011) conducted petrographic studies on Kura-Araxes pottery discovered in the Sos Höyük site located in Northeastern Turkey. They compared their findings with other studies in neighboring regions and concluded that pottery was made locally and possibly for home use. Though some differences between the samples are also noted. Iserlis studied the Kura-Araxes pottery found in Beth Yerah and proved that technologically (pottery making techniques) there were significant differences between the Khirbet Kerak pottery and the local pottery that followed the traditions and techniques of southern Levant. These differences from the selection of raw materials continued on throughout the pottery-making process in all stages, such as the technique, the shaping, the tempering, and the decorating (Iserlis, 2009). Iserlis and company published the result of their research on Kura-Araxes and Khirbet Kerak pottery and two Kura-Araxes archaeological sites in Armenia (Aparan III and Karnut I) on TUBA-AR in 2010. They announced that all three areas of study had completely local pottery industries and had a few characteristics that set them apart from non-Kura-Araxes pottery. Schwarts and his colleagues studied the Ceramics of Malatya and Elâzığ. Their research also showed that the Malatya and Elâzığ pottery were produced locally (Schwartz, Erdman, & Morison, 2009).

Geography of the study area

The Gourab is actually a multi-period archeological site that has been included in the list of national monuments with the code 1042 (Khaksar, 2006). Gourab Tepe is located twelve kilometers south of Malayar in the direction of the main road to Arak (from Malayar). It is located in the village of Gourab (Fig. 1). Gourab Tepe is at an altitude of 1832 meters above sea level and is 28 meters above surrounding lands. Its latitude is 34˚, 13′, 32″. Longitude: 48˚, 51′, 54″. The remaining breadth of the site is about 3.8 hectares (Khaksar, 2006).



◄ **Fig. 1: The location of the province of Hamadan in western Iran and the Gourab site in the region (Map by authors based on the maphil site).**

The Gourab Tepe was first discovered in 1973 and Mehdi Rahbar attributed the site to the Sasanian dynasty based on the pottery found on the surface level (Rahbar, and Young, 1974). Following this initial investigation, Ahmad Kabiri studied the Gourab site once again (Kabiri, 1973). During this investigation the surface level pottery were analyzed, and the historical periods the site had covered were officially determined to be prehistoric (fourth millennium BC) until the middle Islamic period. As indicated above, before the actual scientific and archeological exploration of the site the reports determining the culture and periods the site covered were insufficient and contradictory until stratigraphic explorations solved these issues. In 2006, systematic excavations and archeological studies were carried out under the supervision of Ali Khaksar to determine the area of excavation, propose the parameters of research (boundaries for protection) and stratification (Khaksar, 2006). Stratigraphic studies in Gourab Tepe began with the formation of three stratigraphy trenches. These trenches led to significant results. All in all, eight periods were discovered (table 1). The most significant result here was the evidences of the continuity between the periods specifically the proof of the transitional period between the Late Chalcolithic period and the Early Bronze Age (Kura-Araxes), along with solid evidences which officially dated the archeological site at the Late Chalcolithic and Early Bronze Age and finally provided absolute dating for the site. This is one of the very few archeological sites in western Iran that has absolute proof placing it as a site that encompasses the transitional period from the Late Chalcolithic period all the way to the Early Bronze Age.

Table 1: Classifications and periodization of Gourab Tepe's different layers based on (Khaksar et al., 2014). ▶

Cultural level	Period	Archeological evidence
I	Ilkhanids	Pottery and architecture
II	Seljuk dynasty	Pottery
III	Early Islamic Period	Pottery and architecture
IV	Sasanian dynasty	Pottery, architecture, Carbon sample 14
V	Parthian dynasty	Pottery, architecture, Carbon sample 14
VI	Iron? Achaemenid?	Pottery and architecture
VII	The Bronze Age (Early)	Pottery, architecture, Carbon sample 14
VIII	The Late Chalcolithic period	Pottery, architecture, Carbon sample 14

Absolute Dating

The following chronology is suggested for the site based on the results of the cultural study and data obtained through excavations in addition to the presentation of Carbon 14 sample (Khaksar, 2006). Three Carbon 14 samples (OxA-X-2242-41, OxA-18039, and OxA-18093) have been collected from different layers of the site for absolute dating. The samples were dated at the Oxford University's Archeology, History, and Art laboratory. The samples included bone fragments. The uncorrected results were determined based on Before present time (B.P) and the half-life of 5568 years were used for the Carbon sample. The other samples were corrected based on Before Christ (BC) with a probability of 95.4% (the highest probability) and are presented in table 2. From the total of 13 samples dated through the Carbon 14 method, three are related to the Late Chalcolithic period of Gourab Tepe (Gourab VIII) the details for which can be found on Table 2.

Sample name	Sample	Catalog	Uncorrected date	Corrected date	Probability coefficient
OxA-18039	Bone fragments	C49	5405 ± 40	4346-4226BC 4204-4164BC 4130-4114BC 4100-4073BC	82.2% 8.3% 1.6% 3.2%
OxA-X-2242-41	Bone fragments	C49	5396 ± 34	4340-4226BC 4204-4166BC 4128-4116BC 4098-4075BC	82.6% 8.7% 1.3% 2.8%
OxA-18093	Bone fragments	C14	5769 ± 32	4708-4542BC	95.4%

◀ **Table 2: Dating the Carbon 14 samples for the Late Chalcolithic period in Gourab VIII (Hemati Azandariani, et al., 2020).**

Geomorphology

The majority of the rocks in the region are Phyllite and Slate which are relatively short to medium height. The eastern and southeastern heights of Malayar are made of thick limestone layers and masses that belong to the Lower Cretaceous. The granite and granodiorite intrusive masses south of Malayar remain relatively low. The quaternary alluvial and muddy plains around the Kusaj Khalil area, however, are the lowest in the region - about up to a thousand acres lower.

Geology

Malayar is located in the Sanandaj-Sirjan region where it comes to the structural geology of Iran. This zone is actually a part of the structural zone of Central Iran.

Phyllite units (Jph): These are lower and middle Jurassic rocks, and famously known as the Phyllites and Slates of Malayar and Hamadan. Most of their outcrops are in Malayar and its adjacent regions. The general color of the rocks is dark gray to black. The microscopic study shows that these

Sample name	Sample	Catalog	Uncorrected date	Corrected date	Probability coefficient
QxA-17792	Coal	C25	4138±30	2874-2620	95.4%
QxA-18091	Bone Fragments	C25	4109±31	2762-2573 2866-2804 2776-2770	71.2% 23.6% 0.6%
QxA-18092	Bone Fragments	C33	4359±30	3028-2904 3084-3064	90% 5.4%
QxA-18090	Bone Fragments	F7	5041±31	3952-3764 3722-3716	94.5% 0.9%
QxA-18088	Bone Fragments	C38A	5055±30	3953-3784	95.4%
QxA-18087	Bone Fragments	C41	5081±31	3961-3796	95.4%

◀ **Table 3: Dating the Carbon 14 Samples for the Yanik period (Khaksar et al., 2014).**

rocks are made of quartz, phyllosilicate minerals, and feldspar. Siltstones, sandstones, and microcrystalline quartz are also widely available in the area.

Jms and Kx units: These two units are Jurassic rocks that are available in the region. Their colors are dark gray and dark green with interlayers of phyllites and slates.

KI, Ksd, Kml,s: These units range from Limestone-marl alternations with thin creamy layers to sandstones and thick bigmass limestones with interlayers of thin sandstone and dolomite outcrops within the area under investigation.

Gabbro (gb): This coarse grained unit has outcrops in the southern part of the zone. The outcrops are black and crystalline. Gabbro's minerals include amphibole, plagioclase, bionite, and alkali feldspar.

Granite (gd) and (g): This is the most outspread and widely available unit in the region and it's made up of granite, granodiorite, monzodiorite, and diorite. The main minerals in the granite are alkali feldspar, amphibole, and quartz. Garnet-Mica Schist rocks and present-day alluvial sediments are also available in addition to the aforementioned outcrops (Fig. 2).

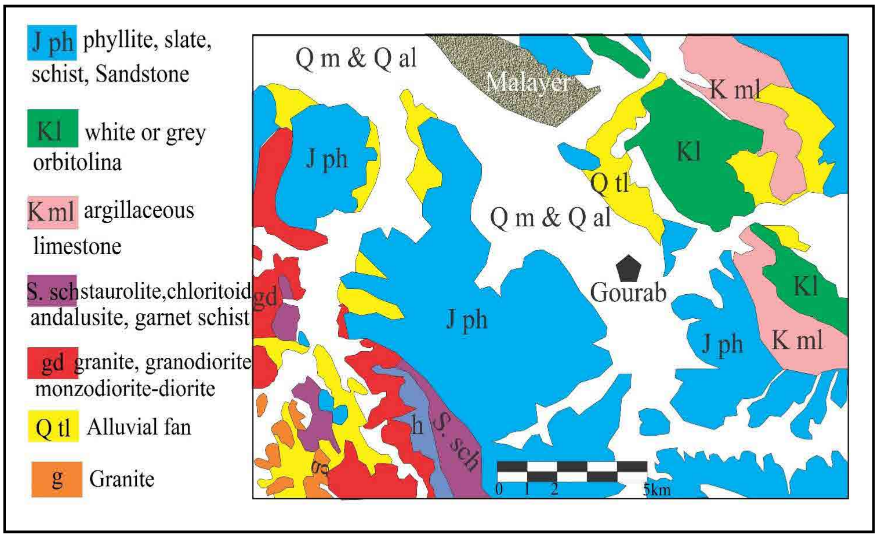


Fig. 2: Geological map of the area under study (Gourab Tepe) taken from the Geological map of 100 000: 1 Malayar, Geological Survey and Mineral Exploration of Iran). ▶

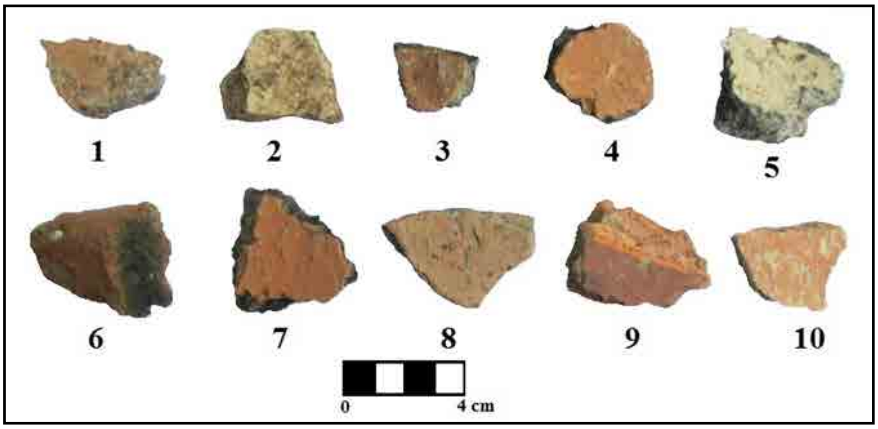
The Petrographic analysis of the Gourab pottery

Preparing the pottery for a petrographic analysis includes a few steps that outlined below:

At first, a sample cutting is taken. Then a subsample cutting is taken to remove the blade's effect and flatten the sample's surface, the glass slide is then matted to create more adhesion followed by sticking the sample to the glass slide using epoxy glue. The cuts must be ground until they are only 30 microns thick. The samples are then stuck to the slide and ready to study. Once the sample has been correctly prepared, they will be analyzed under Polarizing microscopes. This study used the binocular polarizing microscope by JAMES SWIFT & SON which was kindly provided by the Conservation and Restoration Research Institute of the Cultural Heritage Organization.

The Late Chalcolithic samples

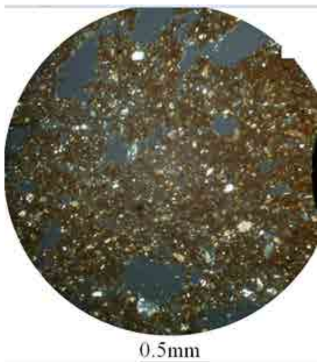
Two fine grained textures (porphyritic and silt textures) were observed in these samples. Samples 1 and 5 had a carbonated silt texture. Samples 2 and 3 had a heterogeneous silt texture. Sample 4 and 7 had a porphyritic texture. Sample 6 had a fine grained porphyritic texture. Sample 8 had a carbonated porphyritic texture. Sample 9 had a silt texture, and sample 10 had a carbonated heterogeneous silt. Out of the 10 samples 6 ended up having a silt texture with 4 samples having a porphyritic texture. Samples 1 and 2, and 6 and 7 were similar in texture. Most of the textures were carbonated due to bad baking and glazing techniques. Slate rocks were observed more or less in every sample. Samples 1 through 7 had discolorations (two different colors) due to being half-baked whilst samples 8 through 10 had a unified color (nearing bright brown) due to the being baked and glazed correctly.



◄ Fig. 3: Gourab Tepe Late Chalcolithic pottery (Khazaie Kouhpar, 2017).

Gourab Tepe's Early Bronze Age Potteries

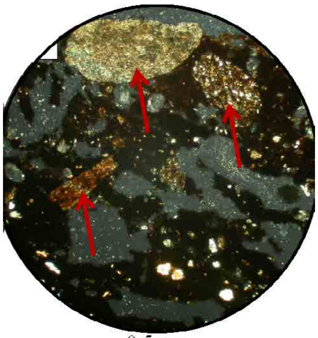
Samples 1, 5, 6, 7, 9, 10 are anisotropic and samples 2, 3, 4, 8 are isotropic. The samples can be categorized into three textures: mega-porphyritic, porphyritic, and microcrystalline or silt texture. This is reflected in table 4. Quartz, plagioclase, amphibole, iron oxide, mica and calcite minerals were present in all the samples though it must be noted that the trace amounts were different for each sample. Quartz was the most abundant mineral in these samples and its trace amounts varied in each sample anywhere between 10% to 15%. Quartz is generally a microcrystalline rock and its



▲ Fig. 4: Microscopic image of sample 10, enlarged X4, Light XPL, Silt textured, abundant presence of fine mineral calcite and quartz (Khazaie Kouhpar, 2017: 95).

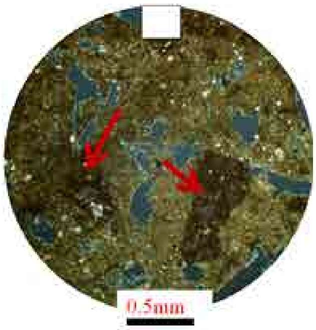
Table 3: The result of the petrographic analysis of Gourab Tepe's Late Chalcolithic pottery (Khazaie Kouhpar, 2017). ▼

Number of Sample	Qz (Clean)	Qz (Cloudy)	Plg	Am & Py	Fe-oxid	Mic	Cc(Mic)	Cc(Sp)	M-Rock	Chert	Sand & Silt Ston	grog	Texture
GOURAB-1	*	-	-	-	*	-	*	-	-	-	-	-	Silt
GOURAB-2	*	-	-	-	*	-	*	-	-	*	-	*	Silt
GOURAB-3	*	*	-	-	*	-	*	-	-	-	-	*	Silt
GOURAB-4	*	*	-	-	*	-	*	-	*	-	*	-	Porphyritic
GOURAB-5	*	-	-	-	*	-	*	-	-	-	-	-	Silt
GOURAB-6	*	*	-	-	*	-	-	-	*	-	*	-	Porphyritic
GOURAB-7	*	*	-	-	*	-	-	-	*	*	*	-	Porphyritic
GOURAB-8	*	*	-	-	*	-	*	-	*	*	-	-	Porphyritic
GOURAB-9	*	-	-	-	*	-	*	-	*	-	*	-	Silt
GOURAB-10	*	-	-	-	*	-	*	-	*	-	*	-	Silt



0.5mm

▲ Fig. 5: Microscopic image of sample 7, enlarged X4, Light XPL, porphyritic texture, presence of chert and slate rocks (Khazaie Kouhpar, 2017: 95).

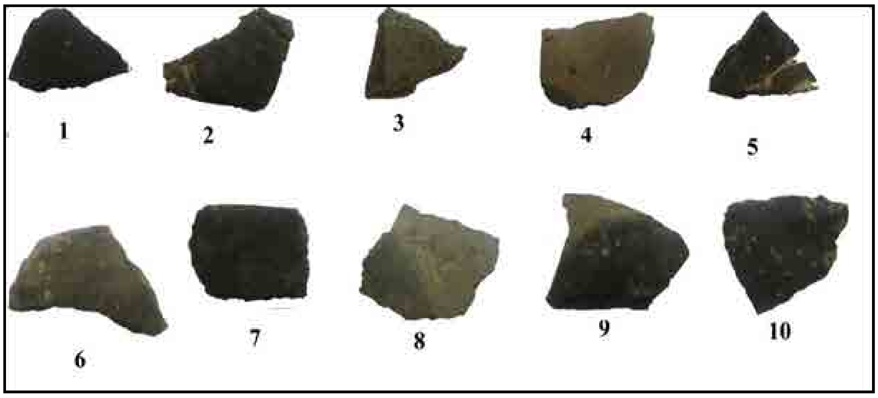


▲ Fig. 6: Microscopic image of sample 2, enlarged X4, Light XPL, Porphyritic texture, presence of grog (Khazaie Kouhpar, 2017: 95).

size doesn't normally exceed 0.5mm. Quartz grains are also angular to semi-rounded and the grains of quartz phenocryst are usually richer in material than the grains of polycrystalline quartz. (Images 10 & 11)

The rock pieces in the pottery samples include metamorphic rocks (Slate rocks and Phyllites) (Figs 8 & 15) sandstones, (Fig. 9) siltstones, igneous rocks, and baked clary fragments (grog) as seen in images 13&17. Sample 3 is the only sample in which the remains of internal igneous rocks (amphibole and granite) were found alongside phenocryst of eluted feldspar which were mostly intact (Figs 11 & 12). This sample's texture was mega-porphyritic with the size of its components reaching 4mm.

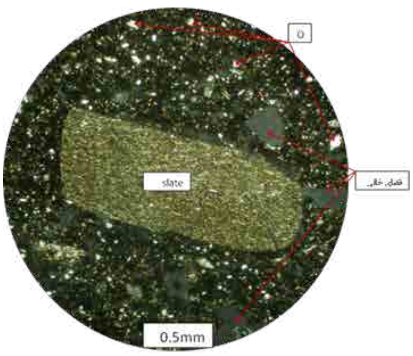
Sample 7 had more grog present than all the other samples. The grog pieces were usually two dark colors or matched the color of the background. The darker color had iron oxide which could possibly be an external result rather than a result of the raw material of the clay (Fig. 13). The clay and silt materials that had the same colors were also present in the original material of the pottery (Fig. 16). All samples had calcite present (Fig. 11). This calcite was the primary constituent and in two samples (1&6) coarse calcite (sprite) was also observed (Fig. 18). In the study of pottery, calcite is often used as a thermal Indi sprite actor since it is the primary constituent. Calcite dissolved around 850-850 centigrade and considering that all samples had calcite found in them, the baking temperature for the pottery would have had to be below 800 centigrade.



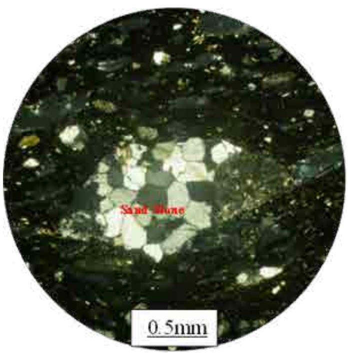
◄ **Fig. 7: Gourab Tepe's Early Bronze Age pottery (Khazaie Kouhpar, 2017: 96).**

Table 4: The result of the petrographic analysis of Gourab Tepe's Early Bronze Age pottery (Khazaie Kouhpar, 2017). ▼

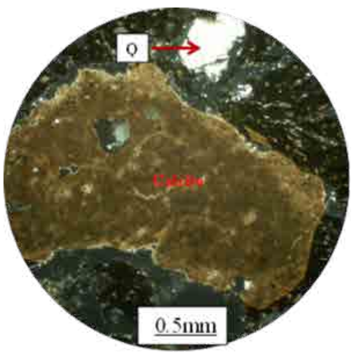
Number of Sample	Qz (Clean)	Qz (Cloudy)	Plg	Am & Py	Fe-oxid	Mic	Cc(Mic)	Cc(Sp)	M-Rock	P.Rock V.Rock	Sand & Silt Ston	grog	Texture
GOURAB-1	*	*	tr	*	*	*	*	tr	*	-	*	*	porphyritic
GOURAB-2	*	*	*	*	*	*	*	–	*	-	*	*	Porphyritic
GOURAB-3	*	*	*	*	*	*	*	–	*	*	*	-	Mega-porphyritic
GOURAB-4	*	*	tr	*	*	*	*	–	*	-	*	*	porphyritic
GOURAB-5	*	*	*	*	*	*	*	-	*	-	*	*	porphyritic
GOURAB-6	*	*	*	-	*	*	*	*	-	-	*	*	Silt
GOURAB-7	*	*	*	*	*	*	*	-	*	-	*	*	porphyritic
GOURAB-8	*	*	*	*	*	*	*	-	*	-	-	tr	Silt
GOURAB-9	*	*	*	*	*	*	*	-	*	--	*	*	Silt
GOURAB-10	*	*	*	*	*	*	*	-	*	-	*	*	porphyritic



▲ **Fig. 8: Photomicrograph, sample 2, XPL light, FOV 2.7 mm, Porphyritic texture, siltstone present in the middle of the image. Anisotropic terracotta, bright-colored microcrystal quartz scattered throughout (Khazaie Kouhpar, 2017: 98)**



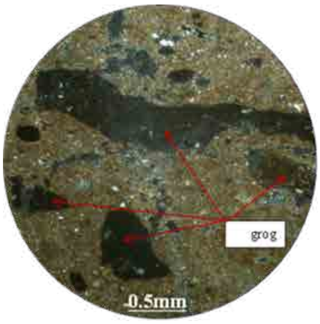
▲ **Fig. 9: Photomicrograph, sample 3, XPL light, FOV 2.7 mm, sandstones present in the middle of the image, Anisotropic terracotta, bright-colored microcrystal quartz along with amphibole (Khazaie Kouhpar, 2017: 98)**



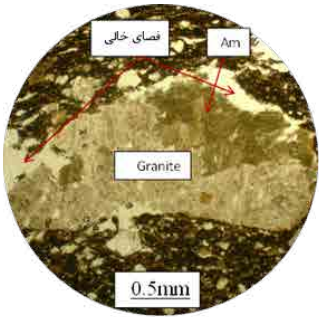
▲ **Fig. 10: Photomicrograph, sample 3, XPL light, FOV 2.7 mm, Coarse calcite crystal in the middle of the image. Quartz crystals can be seen at the top of the image (Khazaie Kouhpar, 2017: 98).**

It's important to mention that the amount of filler materials (tempers) was noticeably low in sample 8 and the secondary process of formation and alteration that is zeolite (the yellow discoloration) had occurred widely (Fig. 17). This was also the only sample in which garnet was present (Fig. 18).

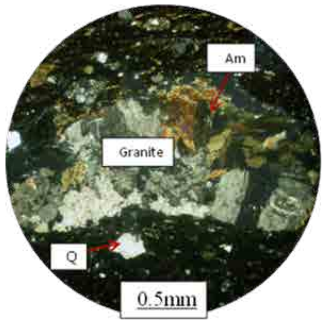
In samples 2, 4, and 6 the edges of the samples were lighter in color in comparison to the rest of the sample making the samples somewhat two colored. Due to the composition of the parts being similar, the main reason for this was considered oxidation. That is the use of higher temperatures mostly in the middle of the sample rather than the edges and consequently the presence of more oxygen around the edges of the sample during the baking process (Fig. 14).



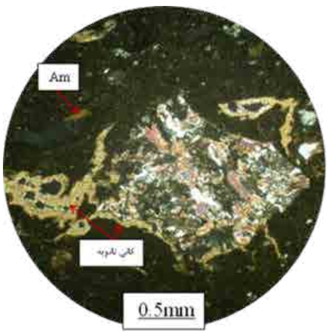
▲ Fig. 13: Photomicrograph, sample 9, XPL light, FOV 2.7 mm, grogs are now visible as dark colors. Uniform isotropic microcrystalline (Khazaie Kouhpar, 2017: 98).



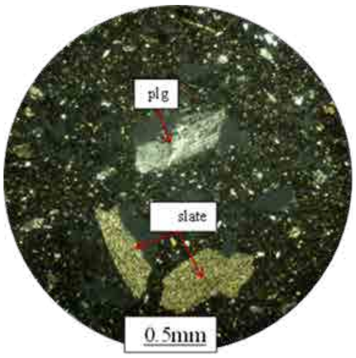
▲ Fig. 12: Photomicrograph, sample 3, PPL light, FOV 2.7 mm, similar to image 4 but polarized. Amphibole is visible as green. Under this light, the empty space and the quartz are bright colored (Khazaie Kouhpar, 2017: 98).



▲ Fig. 11: Photomicrograph, sample 3, XPL light, FOV 2.7 mm, granite in the middle of the image, feldspar along with amphibole and quartz (Khazaie Kouhpar, 2017: 98).



▲ Fig. 16: Photomicrograph, sample 8, XPL light, FOV 2.7 mm, yellow secondary mineral as a result of alternation. This mineral was formed in the clay due to secondary processes such as humidity, heat, and other environmental factors at the time of forming under the surface (Khazaie Kouhpar, 2017: 99).



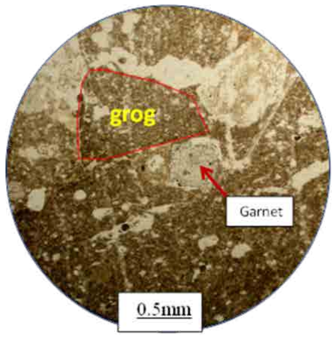
▲ Fig. 15: Photomicrograph, sample 2, XPL light, FOV 2.7 mm, plagioclase with macules shown as light grey in the middle of the image. In the lower part of the image slate and phyllite rocks are visible (Khazaie Kouhpar, 2017: 99).

▲ Fig. 14: Photomicrograph, sample 2, PPL light, FOV 2.7 mm, completely heterogeneous texture, the oxidized part is shown with light colors and the reduction of oxide is shown with dark colors. The main reason for these changes were the heat used to bake the clay (Khazaie Kouhpar, 2017: 99).

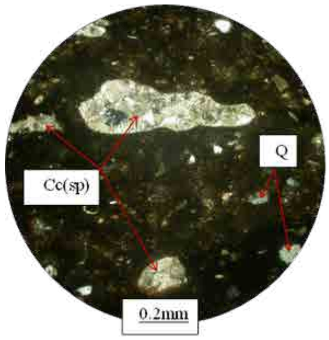
Discussion

The majority of the Malayar heights are made of black phyllites and intrusive granite masses. These rocks do not withstand tough weather conditions and wear out easily due to their physical nature and structure. The limestone heights are located in the southwest of Malayar and stand at the tallest points of the area. They follow a northwest-northeast path. The only river in this area is the Khorram Abad River, which flows from east to west and passes just near Gourab Tepe.

As mentioned above, Malayar is located in the Sanandaj-Sirjan region when it comes to the structural geology of Iran. This zone includes nine different types of rocks. These rocks are quartz, siltstones, sandstone, plagioclase, amphibole, feldspar, granite, and several other types of minerals. (Geological Survey and Mineral Exploration of Iran, Malayar Map 1/100 000) The Malayar plutonic zone can be divided into three sections: the granite, granodiorite, and gabbro-diorite zones, based on the works of Divsalar and company (Divsalar et al., 2012). The granodiorite section is a big part of the zone; however, due to weathering and its low plains, most of it has been turned into farmland (Ramor et al., 2013). It contains quartz, plagioclase, amphibole, pyroxene, and mica minerals (Ahadnejat et al., 2008; Divsalar et al., 2012). The western parts of Malayar contain a row of Triassic (volcanic and carbonated rocks) and Jurassic (mostly shale and sandstone) rocks (Karami et al., 2012).



▲ **Fig. 17: Photomicrograph, sample 8, PPL light, FOV 2.7 mm, garnet along with visible grog (Khazaie Kouhpar, 2017: 99).**



▲ **Fig. 18: Photomicrograph, sample 6, XPL light, FOV 1.3 mm coarse crystalline calcite (sparite) in light yellow along with quartz (Khazaie Kouhpar, 2017: 99).**

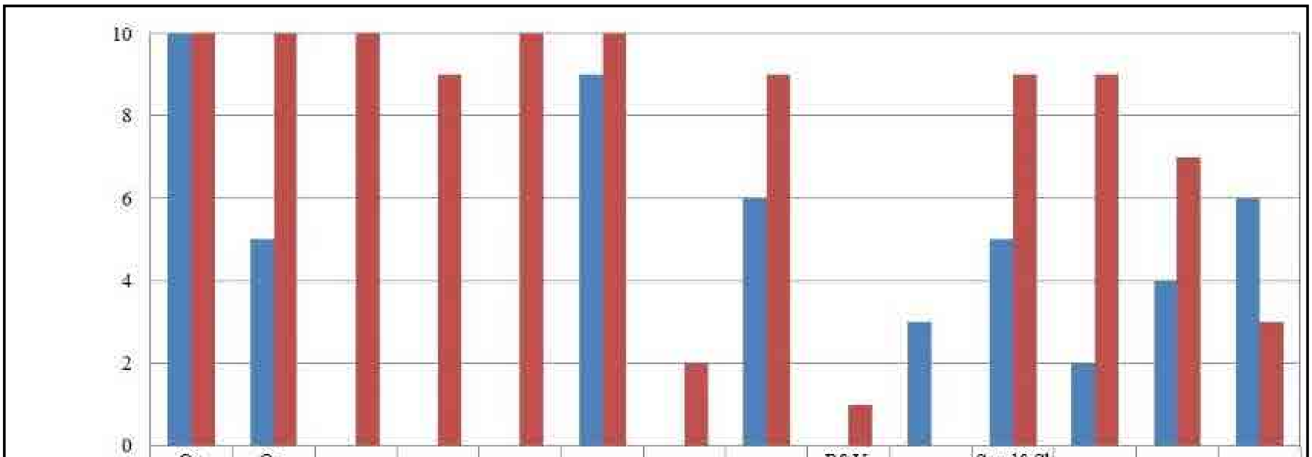
The geological study of the region showed that slate, phyllite, granite, garnet, schists, sandstones, and limestones were all available in the region, while the petrographic study of the pottery proved that these same materials were also present in the pottery. This definitively proved that the available materials in the region were used to create the pottery, which means that these pieces were locally sourced and made. The Late Chalothlic samples did not have traces of amphibole or plagioclase; instead, they had traces of various metamorphic rocks. Metamorphic rocks were observed in at least six of the samples. Other assemblages and structures built with these rocks could be found west and south-west of Gourab Tepe, but the same assemblages or wares cannot be found east or southeast of Gourab. The soils carried out by the river towards Ghale Khalifi village, Marvil, and Davijan were the closest sources of the material to the region's pottery makers.

The Early Bronze Age samples proved not to have been baked at a higher degree than 800 centigrade due to the presence of Calcite in the samples. Sample 3 is different from the other Early Bronze Age samples when it comes to the raw materials used; the presence of intrusive igneous fragments proves that this sample was locally sourced and made. Samples 9 and 8 have fewer minerals, but the amount of silt, clay, and grog is significantly higher than the rest of the samples in these two. Amphibole is present in most of the Early Bronze Age samples. Amphibole rocks are available in the north and northwest of the zone of study in Jokar, Cheshmeh Pahne-Nanj, Shahsoon, and Kheir Abad. The nearest area where this material could be spruced up is located 30 kilometers from Gourab Tepe.

Conclusion

The geological study of the region showed that slate, phyllite, granite, garnet, schists, sandstones, and limestones were all available in the region. These same materials and minerals were found in the pottery samples. This definitively proved that the available materials in the region were used to create the pottery, which means that these pieces were locally sourced and made. The presence of Calcite in the samples also proved that the samples had not been baked at a higher temperature than 800 degrees Celsius. The presence of grog in sample 2 of the Late Chalcolithic pottery showed that, despite what Mason, Cooper, and Batiuk argued, these pottery-making skills were not specific to the Kura-Araxes groups, nor did they enter the plateau with their migration; rather, these traditions and techniques existed in the Zagros area long before. There is no evidence of granitic masses in any of the Late Chalcolithic samples. The presence of Chart in samples 2–8 and the fact that none of the findings saw traces of Chart in the Kura-Araxes samples is a fascinating distinction between the two and proves the differences in the available soil, clay, and source material. None of the Late Chalcolithic samples had plagioclase, amphibole, or pyroxene in them, whereas every Kura-Araxes sample did.

The Kura-Araxes (Early Bronze Age) sample number 3 is different from the other samples when it comes to the raw materials used, and the presence of intrusive igneous fragments proves that this sample was locally sourced and made. Samples 9 and 8 have fewer minerals, but the amount of silt, clay, and grog is significantly higher than the rest of the samples in these two. But in terms of texture, there are differences, which suggest a difference in the location of the sourced material or the preparation process. 10 of the studied samples were Late Chalcolithic pottery, 6 of which have a silt texture, with 4 of them having a porphyritic texture, but in the Early Bronze Age samples, out of the 10 studied samples, 3 had a silt texture and 7 had a porphyritic texture.



	Qz. Clean	Qz. Cloudy	Plg	Am/Pyr	Mic	CC(Mic)	CC (Sp)	M-Rock	P&V. Rock	Chert	Sand&Sl it	Grog	Porphyry	Silty
Chalcolithic	10	5	0	0	0	9	0	6	0	3	5	2	4	6
Kura-Araxes	10	10	10	9	10	10	2	9	1	0	9	9	7	3

▲ Fig. 19: Number of identified minerals in each group of pottery (Khazaie Kouhpar, 2017).

The results show that, similarly to Mason and Cooper's earlier suggestions, the transition from the late Chalcolithic period to the Early Bronze Age in Zagros was not simply limited to the changing of color and some minor decorations; rather, there were significant changes to the raw materials and techniques used in Pottery Making. While the changes in material could suggest sourcing the material from other regions, it is still possible that these changes occurred due to a change in the location of the material gathered, which is still in the Gourab area, and could suggest that these wares were locally sourced and made. Both the late Chalcolithic and Early Bronze Age pottery discovered in Gourab are likely still locally sourced and crafted since their minerals and materials coincide with those available in the region. However, one sample has a different material, which could suggest trading with neighboring regions. Besides minerals, grog was also observed in the samples and used as a temper, which correlates with the Early Bronze Age findings at Godin IV.

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مطالعهٔ پتروگرافی سفال‌های مس‌وسنگ جدید و مفرغ قدیم تپه گوراب ملایر

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چکیده

تپـه گـوراب ملایـر از محوطه‌هـای مهـم ایـران در دوران پیش‌ازتاریـخ اسـت کـه در شهرسـتان ملایـر اسـتان همـدان قـرار دارد. برخـلاف تپـه گودیـن، در تپـه گـوراب، گـذار از دورهٔ مس‌وسـنگ بـه دورهٔ مفـرغ بـدون گسسـت بـوده و داده‌هـای عصـر مفـرغ آن از نـوع فرهنـگ کـورا-ارس اسـت. فرهنگـی بـا پهنـهٔ جغرافیایی گسـترده کـه تبییـن علـت و نحـوهٔ گسـترش آن از مسـائل جـذاب باستان‌شناسـی اسـت. پتروگرافـی کـه از روش‌هـای علمـی مورداسـتفاده در علـوم زمین‌شـناختی اسـت؛ براسـاس خصیصه‌هـای نـوری هـر کانـی اقـدام بـه شناسـایی کانی‌هـا می‌کنـد. یافته‌هـای سـفالی تپـه گـوراب فرصتـی مناسـب فراهـم کـرد تـا گـذار از مس‌وسـنگ جدیـد بـه مفـرغ قدیـم کـه موضـوع مـورد بحـث مهمـی در باستان‌شناسـی ارزیابـی کـرد. هـدف از پژوهـش حاضـر درک سـاختار کانی‌هـای سـفال‌های تپـه گـوراب بـا تأکیـد بـر گـذار از مس‌وسـنگ جدیـد بـه مفـرغ قدیـم و درک تأثیرگـذار و تغییـرات فرهنگـی بـر سـاختار سـفال‌های محوطـه اسـت. پرسـش‌های پژوهـش حاضـر عبارتنـداز: سـاختار کانی‌هـا در دوره‌هـای مس‌وسـنگ و مفـرغ شـامل کـدام کانـی هسـتند و نشـانگر چـه نـوع سـاختار زمین‌شناسـی هسـتند؟ گـذار و تغییـر فرهنگـی چـه تأثیـر بـر سـاختار سـفال داشـته‌اند و در صـورت تغییـر، ایـن رخ‌داد را چگونـه می‌تـوان در بافـت و بسـتر نظریـات باستان‌شناسـی تفسـیر کـرد؟ مطالعـه بـه روش پتروگرافـی بـر روی ۲۰ نمونـه سـفال به‌دسـت آمـده از کاوش کـه ۱۰ نمونـهٔ آن از دورهٔ مس‌وسـنگ جدیـد و ۱۰ نمونـهٔ آن از کـورا-ارس اسـت، نشان‌داد سـفال‌های تپـه گـوراب در گـذار از مس‌وسـنگ جدیـد بـه مفـرغ دچـار تغییـرات عمـده در بافـت شـده اسـت و اگرچـه تولیـد ایـن سـفال‌ها در منطقـه صـورت گرفتـه اسـت، امـا منابـع خـاک و تکنیـک سـاخت دچـار تغییـرات اساسـی شـده اسـت.

کلیدواژگان: گوراب، مس‌وسنگ جدید، مفرغ قدیم، پتروگرافی.

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