The Archaeo-Mineralogy of Tapeh Kelar's potsherds dated to the Late Chalcolithic, Early Bronze, and Middle Bronze Ages

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ABSTRACT

Potsherds are very important for the archaeological research because they may date a site, reveal clues about art, technology, and subsistence of people. Potteries show the relationships and exchanges between people from different regions. The Kelar Hill (from now on Tapeh Kelar), Kelardasht region, is one of the most important prehistoric sites in the west of Mazandaran, in north-western Iran. Tapeh Kelar contains cultural materials from the Late Chalcolithic in the fourth millennium BC up to the Islamic Age. The Kura-Araxes context is one of the most significant discoveries of this area. Because Kura-Araxes culture originated far from Tapeh Kelar (in the Southern Caucasus), the primary concern of the present study focused on the structure of the potteries of the site in transitional phase from the Late Chalcolithic to Kura-Araxes and on finding the changes or differences. The study also tries to find the answer to the question whether the Kura-Araxes pots emerged due to exotic agents or not. Twenty five pieces of potsherds from the Late Chalcolithic and Early Bronze Age and Middle Bronze Age periods were studied by petrographic method to compare the mineralogical texture of the Late Chalcolithic and the Middle Bronze Age potsherds with those of Kura-Araxes. Studies show that the pots of Kura-Araxes at this site are local products despite some changes in their texture due to source change; therefore, the idea that Kura-Araxes tradition potteries were first brought by way of exchange or trade and then copied by local potters is negated.

REZUMAT: REZULTATELE ANALIZELOR ARHEO-MINERALOGICE ASUPRA CERAMICII DE LA TAPEH KELAR DIN CHALCOLITICUL TÂRZIU, EPOCA BRONZULUI TIMPURIU SI MIJLOCIU

Ceramica este foarte importantă pentru cercetarea arheologică, deoarece poate data un sit, dezvăluie indicii despre artă, tehnologie și subzistența oamenilor. Ceramica arată relațiile și schimburile dintre oameni din diferite regiuni. Dealul Kelar (de acum înainte Tapeh Kelar), din regiunea Kelardasht, este unul dintre cele mai importante situri preistorice din vestul Mazandaran, în nord-vestul Iranului. Tapeh Kelar conține materiale culturale din Calcoliticul târziu din mileniul IV î.Hr. până în epoca islamică. Contextul Kura-Araxes este una dintre cele mai semnificative descoperiri ale acestei zone. Deoarece cultura Kura-Araxes își are originile departe de Tapeh Kelar (în Caucazul de Sud), preocuparea principală a prezentului studiu s-a concentrat pe structura ceramicii sitului în faza de tranziție de la Calcoliticul târziu la Kura-Araxes și pe găsirea modificărilor acesteia sau a anumitor diferențe. De asemenea, studiul încearcă să găsească răspunsul la întrebarea dacă vasele Kura-Araxes au apărut din cauza agenților exotici sau nu. Douăzeci și cinci de bucăți de fragmente ceramice din Calcoliticul târziu, Epoca Bronzului timpuriu și Epoca Bronzului Mijlociu au fost studiate prin metoda petrografică pentru a compara textura mineralogică a cioburilor Calcoliticului târziu și Epoca Bronzului Mijlociu cu cele din Kura-Araxes. Studiile arată că vasele Kura-Araxes de pe acest site sunt produse locale, în ciuda unor modificări ale texturii lor din cauza schimbării sursei de materie primă; prin urmare, ideea că ceramica de tradiție Kura-Araxes a fost adusă mai întâi prin schimb sau comerț și apoi copiate de olari locali este infirmată.

KEYWORDS: petrography, Late Chalcolithic, Kura-Araxes, geology

CUVINTE CHEIE: petrografie, Chalcoliticul târziu, Kura-Araxes, geologie.

Introduction

The potsherds are the most significant cultural material in archaeological research. Extracting the utmost data from these handcrafts is being done by archaeometry methods. Such data helps us understand the usage of ware and the location of the production of these items. Thanks to such studies, the hidden truths behind them get revealed. Interdisciplinary studies can show the changes in the techniques and the sources and inclusions in pottery making.

In the fourth millennium BC, a new culture spread in the South Caucasus and east of Turkey that is known as Kura-Araxes or Trans Caucasus[1]. This culture is featured by unique burnished black pots, architecture, fixed and portable fireplaces, small figurines, and standard tools.[2] At the beginning of the third millennium BC, this culture spread widely and covered some parts of the Zagros and Alborz mountains in Iran[3] up to the Eastern coast of the Mediterranean Sea[4]. It is known by different names in different regions because this culture spread over wide geographical regions[5].

Archeologists have used different theories to justify the process of this spread such as migration or "movement of individuals or groups from their original places to other places"[6], exchange[7], cultural relationships, imitation and replication and using foreign styles by the local natives or migrant artisans[8]. Although studying pre-history migration has been challenging and complicated, it has been the scholars' center of attention. As mentioned above, with the spread of a new methodology in modern archeology called "Processual Archaeology" the trend to use other specialists and disciplines, especially natural science, and laboratory instruments, for studying archaeological materials and better data analysis have gradually increased.

Generally, archaeometry studies of clay vessels can be divided into two parts: 1. chemical study and 2. mineralogical. As to the former methodology, one can refer to instrumental neutron activation (INAA), X-ray fluorescence (XRF), and Inductive Couple Plasma spectrometry (ICP), for studying elements[9].

Therefore, the writers of the present article turn to study the pots of one of the key sites which contain Bronze Age (Kura-Araxes) and Late Chalcolithic evidence in Mazandaran (Tapeh Kelar) to assess whether any remarkable change has occurred in the pottery making of this area from the Late Chalcolithic up to the Bronze Age (Kura-Araxes). One of the tasks was to find out if these pottery-making traditions were first brought by way of commerce and then copied by local potters or not.

The study site Tape Kelar

Tapeh Kelar located in the west of Mazandaran Province, near to Chalous city (Fig. 1). The Tapeh Kelar has six hectares, an oval shape and it stretches east-west. It is situated on a higher ground, the height difference between the site and the lands around it is between 7 and 12 meters. Its geographical coordinates are the following: latitude 36˚ 31´ 42.69˝, longitude 51 11´ 27.28˝; elevation 1100 meters above sea level[10].

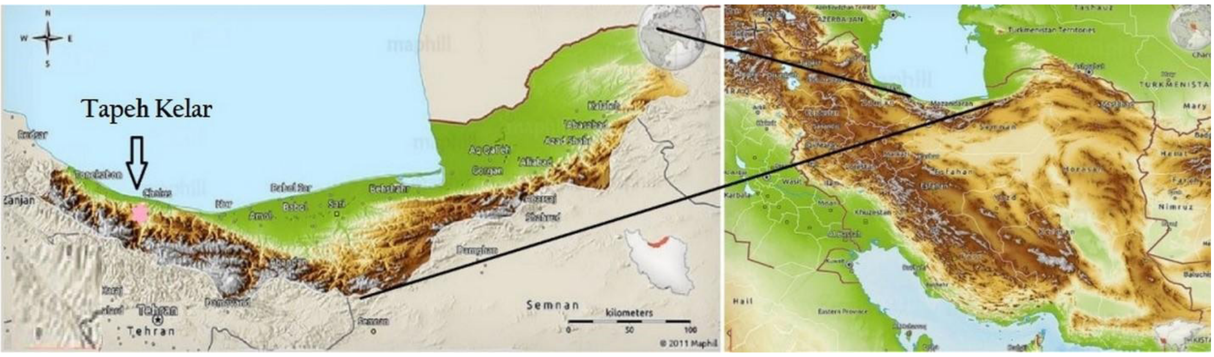

Figure 1: Location of Mazandaran Province and Tapeh Kelar on the map (map by authors based on maphil site).

To determine its area, Tapeh Kelar was excavated in 1997[11]. The first season of archeological excavation was conducted by Seyed Mehdi Mousavi Kouhpar and Rahmat Abbasnejad in 2006[12]. The second excavation was done

1 Rothman 2014.
2 Kiguradze and Sagona 2003.
3 Motarjem 2008; Khazaie Kouhpar 2011; Kohl 2009.
4 Rothman 2014; Batiuk 2005.
5 Alizadeh 2010.
6 Rothman 2003.
7 Abay 2005.
8 Akkermans and Schwartz 2003.
9 Quinn 2013, 1.
10 Mousavi Kouhpar, Abbasnejad, Heydarian 2007.
11 Karimian 1998.
12 Mousavi Kouhpar and Abbasnejad 2006.

***Table 1:** stratigraphy of Tapeh Kelar with Context number and C14 Dating (Heyadrian 2011: Table 5-1, with some modification).*

Context	Period	Absolut Dating C14
132-131 (Trench 1)	Middle Bronze Age	OXA-18240 (3785±30 BP)
140-133 (Trench 1)	Early Bronze Age	OXA-18256 (4116±32 BP) OXA-18241 (4169±30 BP)
145-141 (Trench 1)	Late Chalcolithic	OXA-18213 (4872±33 BP)
150-146 (Trench 1)	Late Chalcolithic	OXA-18242 (4956±31 BP) OXA-23065 (5043±31 BP)

by Mousavi Kouhpar in 2008[13]. In these two seasons, two trenches were dug. The first trench was the central one and was named Trench No. I, while the western trench was called Trench No. II. Evidence shows that residence in the site goes back at least to the Late Chalcolithic period[14], the site being inhabited up to the Islamic period, without interruption. The absolute dating of the site shows that the date of the Late Chalcolithic is 3766 BC, the Early Bronze Age is 2880 BC, and the Middle Bronze Age is 2299 BC (Table 1).

Evidence related to Late Chalcolithic, Early Bronze Age (Kura-Araxes), and Middle Bronze Ages were obtained from contexts 150 to 131. Late Chalcolithic layers were obtained from contexts 150-146. Recovered potsherds from contexts 145-141 combine the Late Chalcolithic and Early Bronze Age (Kura-Araxes). Contexts 133-140 were dated to the Early Bronze Age, and contexts 132-131 has also Middle Bronze Age evidence[15].

Unearthed potsherds from these contexts were divided into five groups. The fourth group belonged to the Early and Middle Bronze Ages and the fifth to the Late Chalcolithic period. According to architectural remains, the fourth group may be divided into two subgroups. The first subgroup includes contexts 133-140, and the second subgroup includes contexts 131-133. The higher percentage of pottery in the second subgroup is gray and more polished. The second subgroup of pottery dates to the Middle Bronze Age. The pottery of the first subgroup has a dark black and light gray fabric, with polished surfaces and with delicate excision. The layer thickness of the Early Bronze Age (Kura-Araxes) at this trench is about one meter. According to Carbon-14 dating, contexts 136 and 137 date back to 2880 BC and 2830 BC, respectively (Table 1).

Contexts No. 141-145 are in the fifth group. Most of the pottery in this group has a brown fabric, and in the first context, there are several pieces of Kura-Araxes pottery. According to the Carbon-14 dating method, the date of context 144 goes back to 3540 BC.

Samples of the Middle Bronze Age were collected from Context No. 131. The thickness of this context is about 50 cm. The unearthed material in this context included besides pottery, bone, a metal object, a stone tool (blade), and a piece of kiln waster.

The most important context regarding the transition from Late Chalcolithic to Kura-Araxes culture is context No. 141, which delivered a combination of Late Chalcolithic and Kura-Araxes pottery. Pieces of pottery (117), bone, and charcoal were obtained from this context. Pottery pieces of this context can be divided into

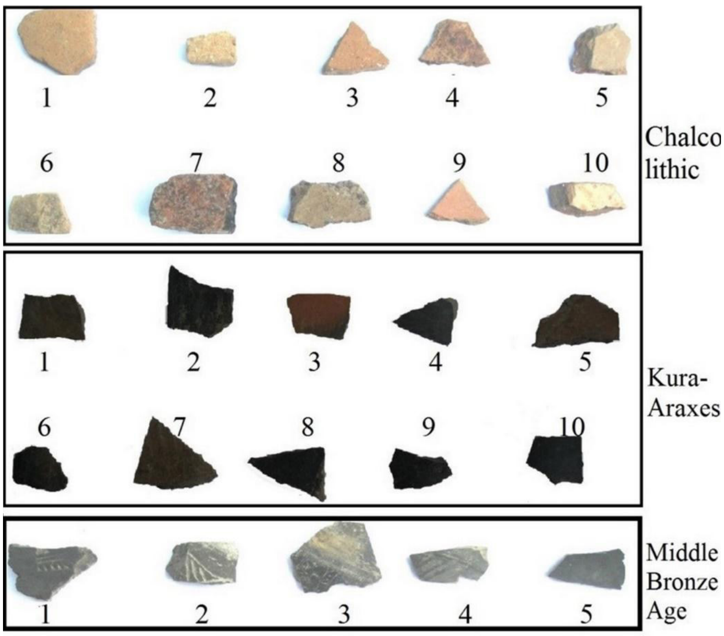

Figure 2: The samples studied in this research (photo by authors).

13 Mousavi Kouhpar 2008.
14 They don't reach virgin soil.
15 Heydarian 2011, 195-205.

two groups: gray and red. The pottery had an engraved decoration and a polished surface. Twenty samples from Kura-Araxes and Late Chalcolithic were collected from this context[16].

Methodology

As mentioned above, 25 potsherd samples were selected from archaeological layers. The main reason for this research was to study the change in pottery techniques during the transition from Late Chalcolithic to Kura-Araxes; ten samples from Kura-Araxes culture and ten samples from Late Chalcolithic were chosen. In addition, five samples from the Middle Bronze Age were as well selected, as local pottery references, besides the Late Chalcolithic (Fig. 2).

Middle Bronze Age samples for this study were selected from contexts 131-132. A total of 155 pottery pieces were obtained from these contexts and divided into two groups: gray and red to brown. Samples of the Early Bronze Age and Late Chalcolithic period were chosen from 141-145 contexts. There were recovered 203 pieces of pottery from both periods; probably these contexts are the Transitional Phase.

Table. 2: characters of Selected Potsherds at research (Table by authors)

Sample No.	Paste color	Interior decoration	Exterior decoration	Major Temper	Period	Date
1	Light Brown	Plain	Plain	mineral	Late_Chalcolithic	Late_Fourth Millennium
2	Light Brown	plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
3	orange	Plain	Painted	Mineral	Late_Chalcolithic	Late_Fourth Millennium
4	Brown	plain	Painted	Mineral	Late_Chalcolithic	Late_Fourth Millennium
5	Brown	Plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
6	grey	plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
7	Brown	plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
8	grey	plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
9	red	plain	Plain	Mineral	Late_Chalcolithic	Late_Fourth Millennium
10	buff	plain	plain	mineral	Late_Chalcolithic	Late_Fourth Millennium
1	brown	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
2	Black	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
3	Brown	plain	plain	mineral	Early Bronze Age	Early Third Millennium
4	grey	burnished	excised	mineral	Early Bronze Age	Early Third Millennium
5	grey	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
6	Black	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
7	brown	plain	plain	mineral	Early Bronze Age	Early Third Millennium
8	grey	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
9	Dark grey	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
10	grey	burnished	burnished	mineral	Early Bronze Age	Early Third Millennium
1	Grey	burnished	excised	mineral	Middle Bronze Age	Middle Third Millennium
2	Grey	burnished	excised	mineral	Middle Bronze Age	Middle Third Millennium
3	grey	burnished	burnished	mineral	Middle Bronze Age	Middle Third Millennium
4	grey	burnished	burnished	mineral	Middle Bronze Age	Middle Third Millennium
5	grey	burnished	burnished	mineral	Middle Bronze Age	Middle Third Millennium

[16] Heydarian 2011, 195-208.

Late Chalcolithic potsherds are handmade pottery with brown, red, and orange paste. The surface of the pottery is shiny, and some specimens have geometric paint patterns.

Early Bronze Age potsherds are still handmade but with brown, black, and gray paste. The surface of the pottery was burnished, and, in some samples, the surface had the geometric incised patterns (Table 2).

For the present study, the polarizing binocular microscope model James Swift & Son was used, which is available in the Iranian Institute for Conservation and Restoration of Cultural Heritage Organization. Samples' dimensions were 2×5 cm and covered with resin after the thin section.

Results

Thin section description of the Late Chalcolithic pots

Sample number 2 is different from others in terms of composition. There is calcite for inclusion. In samples 3 and 5, is feldspar of perthite and antiperthite. Perthite and antiperthite are mainly found in intrusive igneous rock of the alkaline type (Fig. 3). They can be a good guide for finding the origin of the minerals in the pots. In samples number 8 and 9, there are big fragments of *chalcedony* that are not in other samples (Fig. 4).

Table. 3*: Summary of the minerals that exist in every sample potsherds of Late Chalcolithic in Tapeh Kelar (Table by authors).*

N. Sample	Qz (Clean)	Qz (Cloudy)	Plg	Am & Py	Fe-oxides	Mica	Cc (Mic)	Cc (Sp)	P.Rock V.Rock	Silt Shale	chal-ced-ony	Sand-stone	Texture
Kelar-1	*	*	tr	*	*	*	-	-	*	-	-	-	porphyry
Kelar-2	*	*	tr	*	*	-	-	*	-	-	-	-	silty
Kelar-3	*	*	tr	*	*	*	*	-	-	-	-	-	porphyry
Kelar-4	*	-	tr	-	*	-	*	-	*	-	-	-	silty
Kelar-5	*	*	tr	*	*	-	-	*	*	*	-	*	porphyry
Kelar-6	*	*	-	*	-	-	-	*	-	-	-	-	silty
Kelar-7	*	*	-	*	*	-	-	-	-	-	-	-	silty
Kelar-8	*	*	*	-	*	-	-	*	*	*	*	-	porphyry
Kelar-9	*	*	*	-	*	-	-	-	-	*	*	-	silty
Kelar-10	*	*	*	*	*	-	*	-	-	-	-	-	porphyry

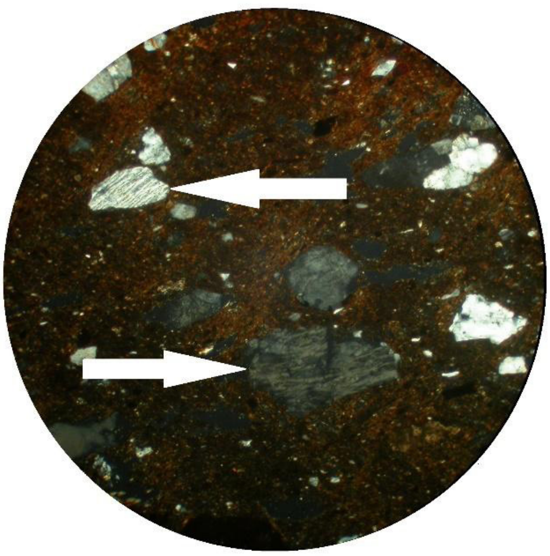

Figure. 3: Sample No. 3, X 40 magnification. Light XPL. Feldspar of perthite and antiperthite (photo by authors)

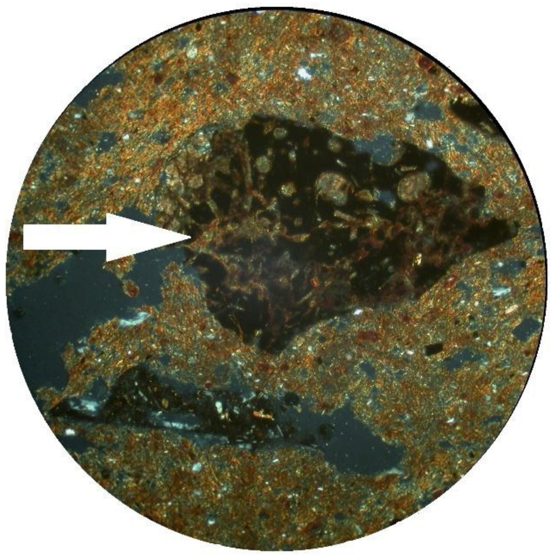

Figure. 4: Sample No. 8, X 40 magnification. Light XPL, large agate at center (photo by authors).

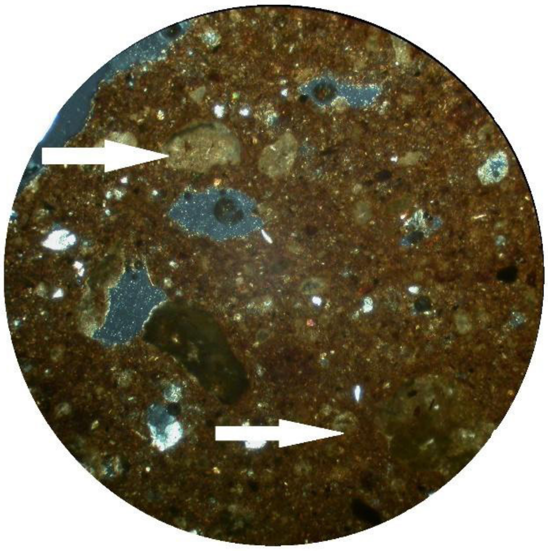

Figure. 5: Sample No. 2, X 40 magnification. Light XPL, heterogeneous porphyric texture, coarse-grained calcite in the paste (photo by authors).

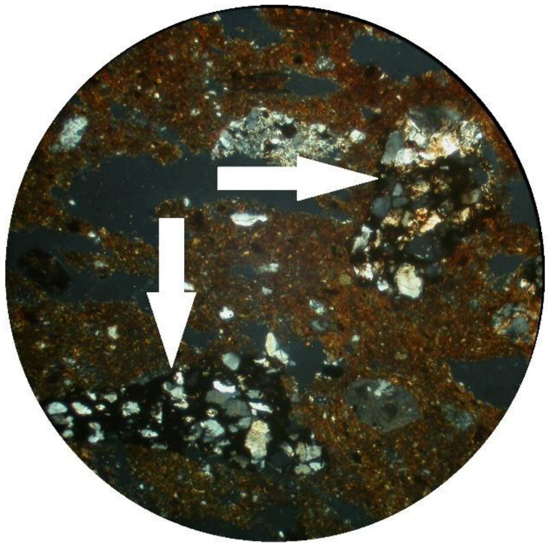

Figure. 6: Sample No. 5, X 40 magnification. Light XPL. Siltstone in paste (photo by authors).

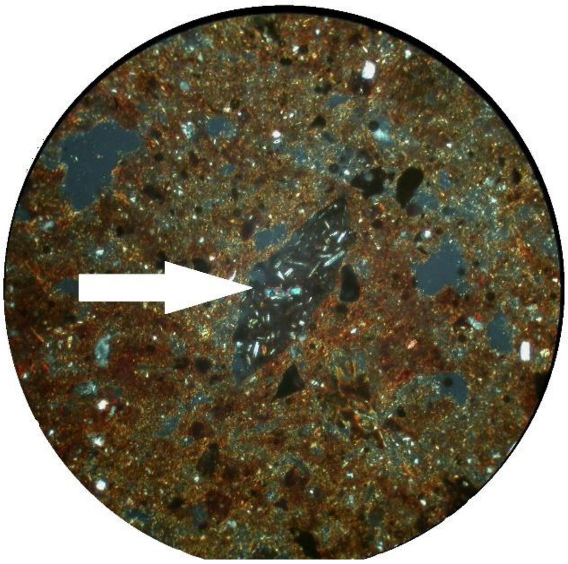

Figure. 7: Sample No. 4, X 40 magnification. Light XPL. Igneous rock at center (photo by authors).

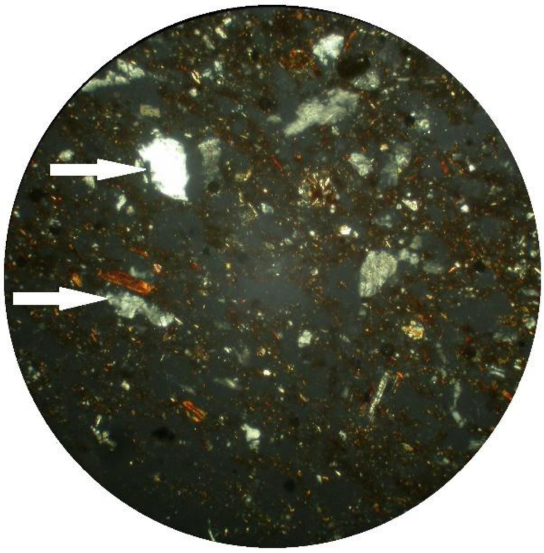

Figure. 8: Sample No. 1, X 40 magnification. Light XPL, heterogeneous porphyric texture, quartz and mica (photo by authors)

Samples with calcite or carbonate-rich matrix have temperature lower than 800 degrees in heating time. Samples 2, 3, 4, 5, 6, 7, 8, 9, and 10 heated (Fig. 5; 6; 7) below 800 degrees and only sample number 1 (Fig. 8) heated at more than 800 degrees[17]. Four samples of this batch have volcanic rocks (Table. 3). This proportion changes significantly in the samples of the Early Bronze Age (Kura-Araxes).

Thin section description of Kura-Araxes Pots

Kura-Araxes pots divide into two types in terms of their texture. The kind that has porphyric texture and another that has silty texture (Table 4). Sample 4, which has a silty texture, is structurally different from the others (Fig. 9). In this sample, the size of the particles is less than 0.5 mm, and the average size is between 20-30 micrometers. Unlike the other pieces, the main mineral in this sample is quartz, which is generally found in phenocryst. This mineral comprises something around 20% of the total mass of the sample. In addition to quartz, amphibole and

[17] Montana 2017, 88.

Table. 4: Summary of the minerals that exist in every sample potsherds of Kura-Araxes of Tape Kelar (Table by authors).

N. Sample	Qz (Clean)	Qz (Cloudy)	Plg	Am & Py	Fe-oxid	Mic	Cc (Mic)	Cc (Sp)	P.Rock V.Rock	Silt Shale	chal-cedo-ny	Texture
Kelar-1	*	*	tr	*	*	-	-	-	*	-	-	porphyry
Kelar-2	*	*	tr	-	*	*	-	*	*	-	*	porphyry
Kelar-3	*	*	tr	*	*	-	-	*	*	-	-	porphyry
Kelar-4	*	*	tr	*	*	-	-	-	-	-	-	silty
Kelar-5	*	*	tr	*	*	*	-	*	*	-	*	porphyry
Kelar-6	*	*	tr	*	*	-	-	*	*	-	*	porphyry
Kelar-7	*	*	tr	-	*	-	-	-	*	-	*	porphyry
Kelar-8	*	*	tr	*	*	-	tr	-	*	-	-	porphyry
Kelar-9	*	*	*	*	*	-	-	-	-	tr	-	porphyry
Kelar-10	*	*	tr	-	*	-	*	*	*	-	-	porphyry

mica (biotite and muscovite) were also found in the form of microcrystals. This sample lacks volcanic rocks and calcite. In other samples, big fragments of igneous rocks exist in the form of large crystals. Sample 1, for example, has intrusive igneous rocks in the pot matrix (Fig. 10); also, in sample 7, extrusive igneous rocks were used for inclusion (Fig. 11).

As another instance of difference in the pots, one can refer to sample number 3. This sample has two colors: it is red on one side and gray on the other. This sample has a porphyry texture, and there exists igneous rock, along with quartz and calcite in the form of phenocrysts (Fig. 12, 13). In addition, pyroxene, plagioclase, and iron oxide are found in this sample. It is worth mentioning that most of the big crystal exists in the red part. The field has a relatively harmonious composition. On the darker side, however, a sort of stream texture is seen, which most probably was created due to high temperature.

Figure. 9: Sample No. 4, X 40 magnification. Light XPL, silty paste with numerous pieces of small quartz (photo by authors).

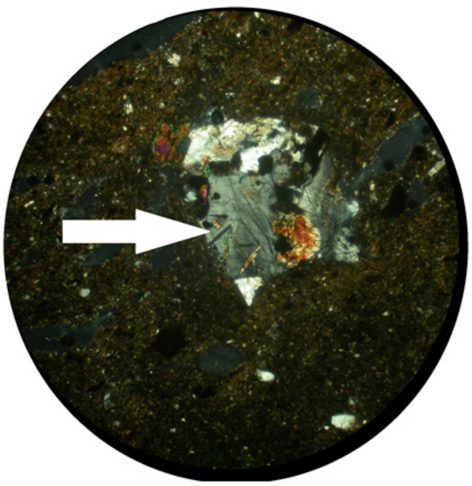

Figure. 10: Sample No. 1, X 40 magnification. XPL Light, large piece of intrusive volcanic stone is visible (photo by authors).

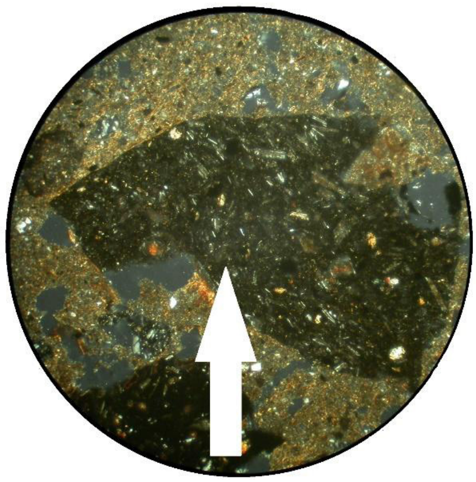

Figure. 11: Sample No. 7, X 40 magnification. Light XPL, Large volcanic stones are visible in photo (photo by authors).

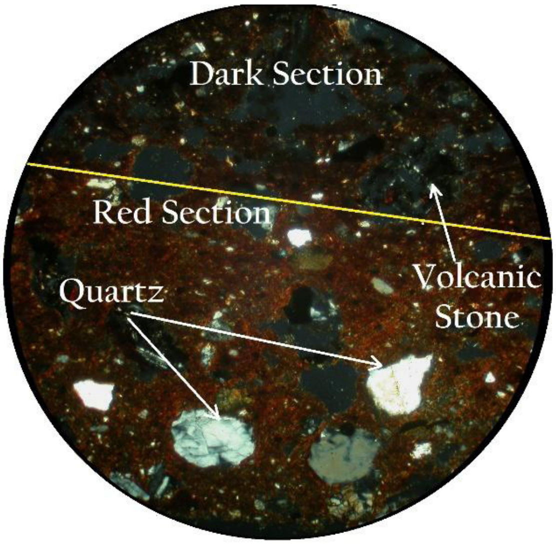

Figure. 12: Sample No. 3. X 40 magnification. Light XPL, Porphyry texture, large quartz and volcanic stone are seen (photo by authors).

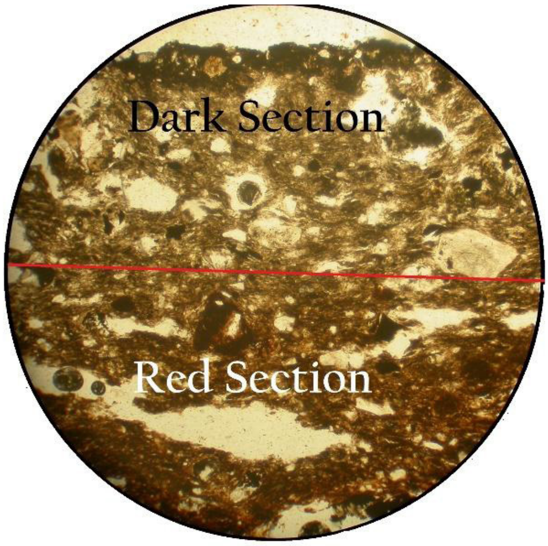

Figure. 13: Sample No. 3. X 40 magnification. Light XPL, in dark section a melted state that is because of high temperate is visible (photo by authors).

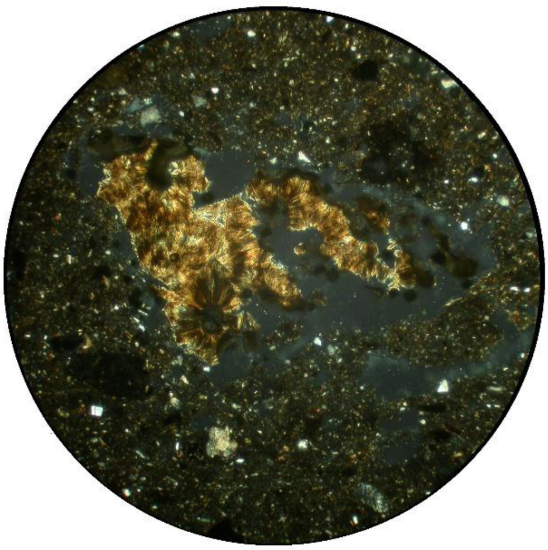

Figure. 14: Sample No. 7. X 40 magnification. Light XPL, porphyry texture, large chalcedony at center (photo by authors).

Figure. 15: Sample No. 6. X 40 magnification. Light XPL, residue of nepheline (photo by authors).

In addition, igneous rocks and quartz were used as fillers in most samples. In some other samples, such as numbers 2, 5, 6 and 7, chalcedonies were used as tempers (Fig. 14). Samples 6 and 7 are interesting in that they contain nepheline (Fig. 15) and are thus distinct from others because of the existence of this mineral. By searching for the origins of nepheline, one can find out whether the pots are local or not. Nepheline is a feldspathoidal mineral made when silica is missing in the magma. Nepheline (Na, K) $AlSiO_4$ is colorless in polarized light and is seen as dark in XPL. The nepheline was found along with the remains of igneous rocks in samples 6 and 7. Sample 9 is also structurally different from the other samples. In this sample, igneous rocks were not seen, but instead, the sample delivered phenocryst plagioclase which is found in other samples only in minor proportion (Fig. 16; 17). Also, large pieces of quartz polycrystalline and a bit of siltstone were the other ingredients in this sample. Samples 1, 4, and 7 did not contain calcite, even if it exists in other samples. But the interesting point is that calcite exists in these samples as big crystals (calcite sparite), and its microcrystal exists only in samples 8 and 10 (Fig. 18; 19).

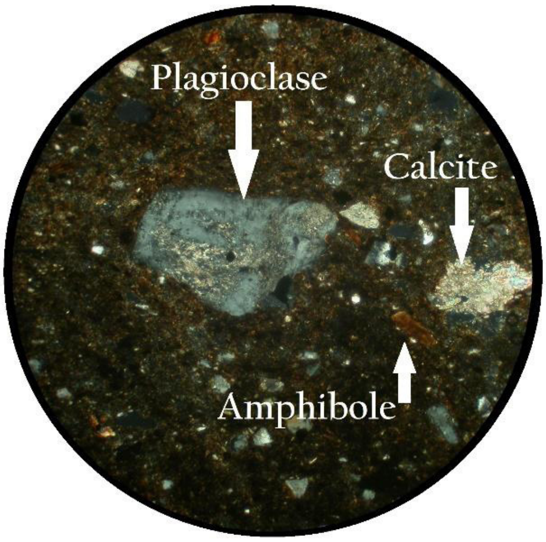

Figure. 16: Sample No. 9. X 40 magnification. Light XPL, large eltrated plagioclase at center with calcite and amphibole (photo by authors).

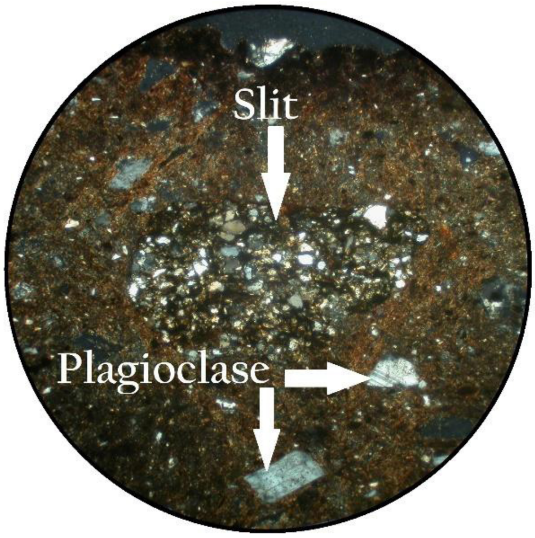

Figure. 17: Sample No. 9. X 40 magnification. Light XPL, slit and plagioclase (photo by authors).

Figure. 18: Sample No. 10. X 40 magnification. XPL Light, porphyry texture, residue of calcite and volcanic stone (photo by authors).

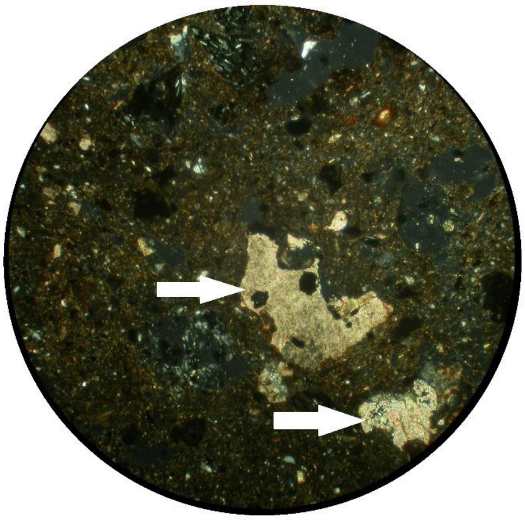

Figure .19: Sample No. 5. X 40 magnification. XPL Light, piece of large calcite (photo by authors).

Thin section description of the Middle Bronze pots of Tape Kelar

In this section of the study, five samples were chosen. The five samples are dark and have a dark paste. Two types of silty and porphyry texture are found here (Fig. 20). There were found no signs of grog in these samples (Table 5). The existence of calcite in the samples shows that the potsherds were heated below 800 degrees. The same is found in the potsherds of the Late Chalcolithic and Early Bronze Age in Tape Kelar, and this indicates that pottery kilns in these ages had no increase in temperature. There is agate in sample 3, and although it shows a decrease in comparison to the number of potsherds with agate in Early Bronze samples, it proves that the pots made from the same source of soil used in the same area. Sample number 3 has intrusive igneous rocks (Fig. 21) of basic (diorite or gabbro). Sample number 2 has carbonate margins with bits of siltstone used as temper (Fig. 22). In sample number 5, the margins are darker than the center (Fig. 23). It can be due to the high temperature in the process of heating.

Table. 5: Summary of the minerals that exist in every sample potsherds of Middle Bronze Age in Tape Kelar (Table by authors).

N. Sample	Qz (Clean)	Qz (Cloudy)	Plg	Am & Py	Fe-oxid	Mic	Cc (Mic)	Cc (Sp)	P.Rock V.Rock	Silt Shale	chal-cedo-ny	Texture
Kelar-1	*	*	*	*	*	*	-	-	*	-	-	porphyry
Kelar-2	*	*	-	-	*	-	-	*	-	*	-	silty
Kelar-3	*	*	*	*	*	-	*	-	*	-	*	porphyry
Kelar-4	*	*	*	*	-	-	*	-	-	-	-	silty
Kelar-5	*	*	*	*	-	-	*	-	-	-	-	silty

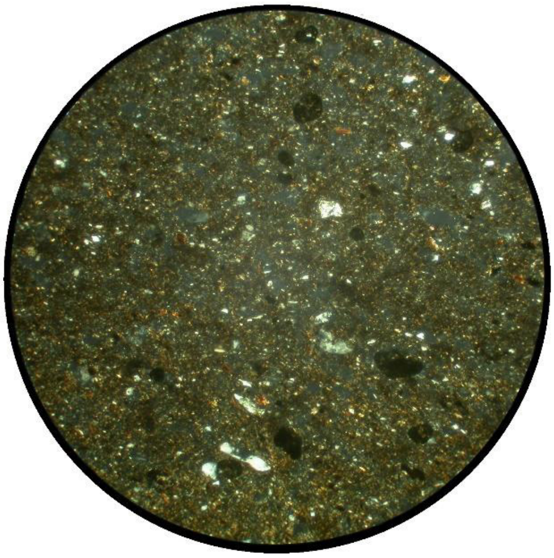

Figure. 20: Sample No. 4, X 40 magnification. Light XPL, silty paste with quartz pieces (photo by authors).

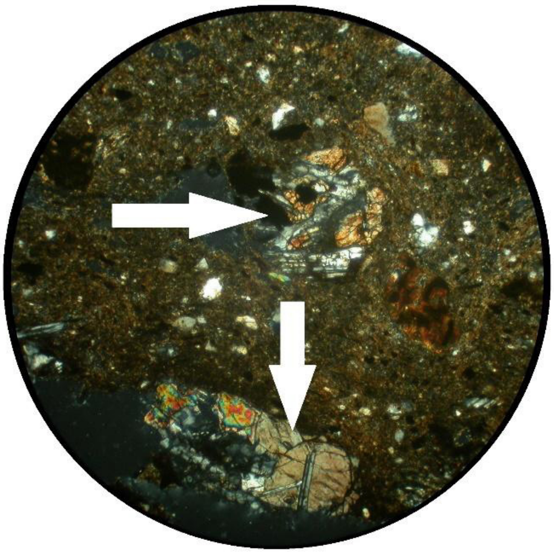

Figure. 21: Sample No. 3, X 40 magnification. Light XPL, porphyry paste with Intrusive igneous rocks of basic (photo by authors).

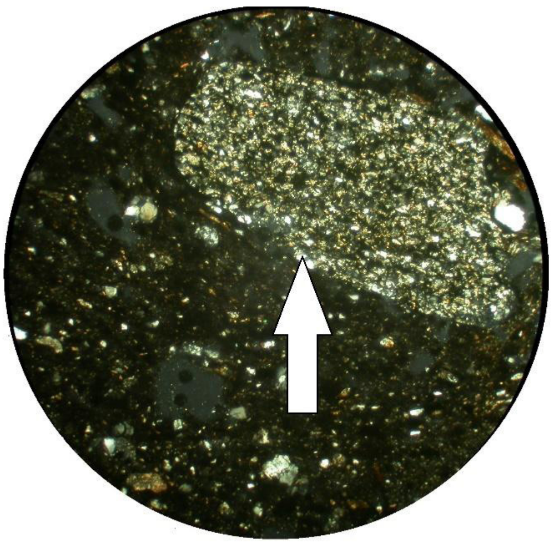

Figure. 22: Sample No. 2, X 40 magnification. Light XPL, silty paste with slit (photo by authors).

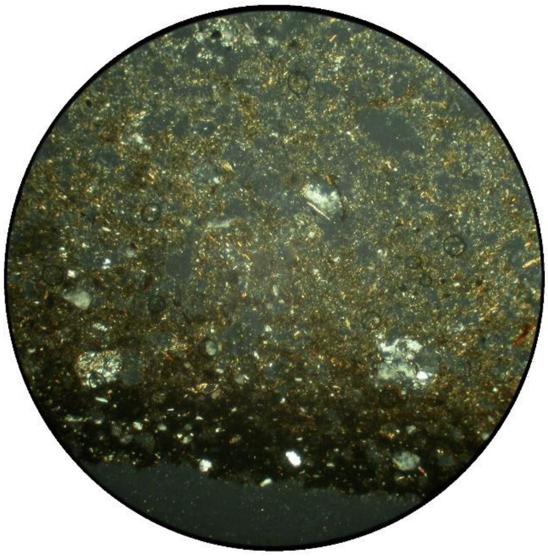

Figure. 23: Sample No. 5, X 40 magnification. Light XPL, silty paste and different color at bottom (photo by authors).

Discussion

The studied area is geographically in the Central Alborz Mountains. The Kelardasht region have various compositions of igneous rocks (intrusive igneous rocks such as quartz, monzonite, and extrusive igneous rocks such as basalt andesite), pyroclastic igneous rocks, feldspathoid (nepheline), various forms of sedimentary rocks such as limestone, dolomite, coal limestone, sandstone, slit stone, shale, quartzite along with sediments of the present days (Fig. 24). Modern sediments exist in riverbanks and waterways (Organization of Geological Survey of Iran, Marzan Ababd Map scale 1: 100 000).

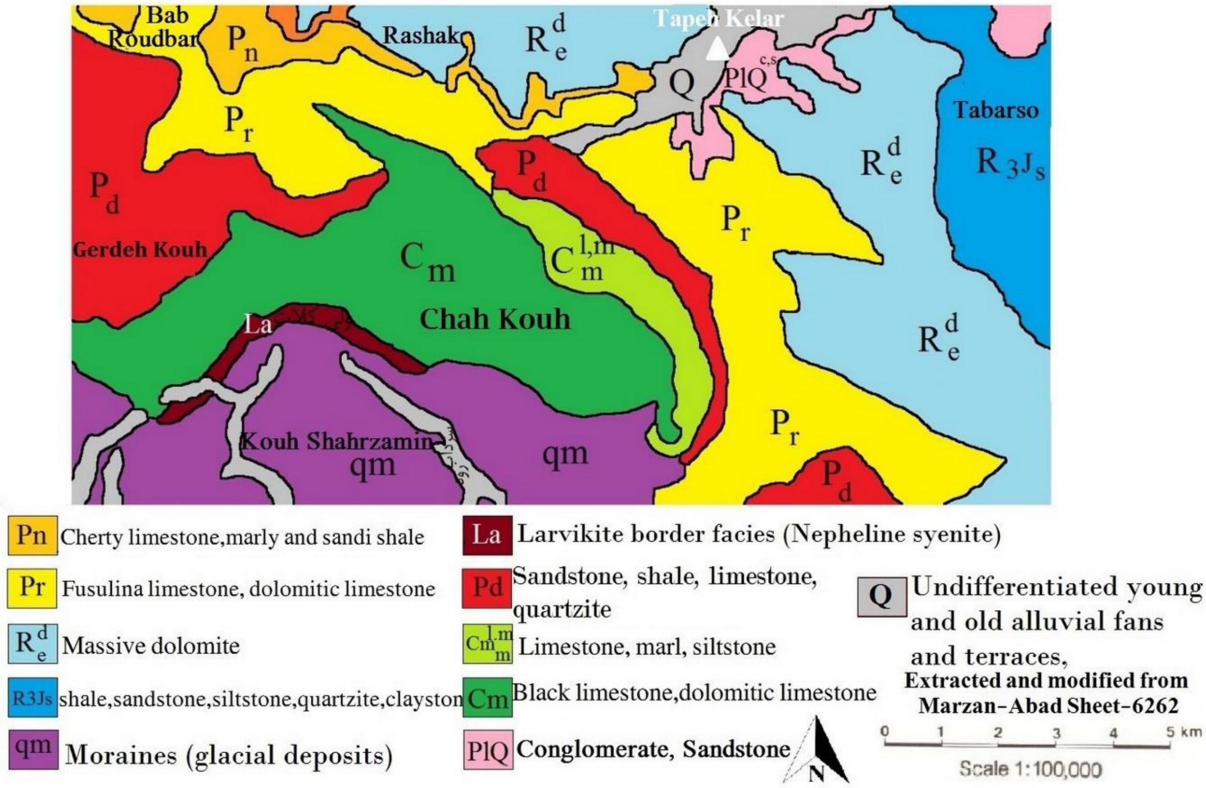

Figure. 24: Geological map of the studied zone (Kelar Dasht),
(photo by authors based on the geological map 1: 100 000 Marzan Abad, Organization of Geological Survey of Iran)

In Kelardasht, a granitoid mass (SW of Kelardasht) is reported. Plagioclase, amphibole, feldspar[18] were found in the potsherds. In the south of the Kelardasht, in granitoid mass of Alam Kooh, pyroxenes, garnet, amphibole, sphene, sericite, and chlorite were reported[19]. Although in the geological map of the Kelardasht and the studies of Esmaeily and his colleagues, the existence of chalcedony has not been reported in the southwest of Kelar Dasht (it should be considered that this research has not been done on all the minerals of the area), its existence has been reported in the nearby zone in Baladeh Noor[20], that can be found about 40 km away from Kelardasht, in a straight line. Also, in a study on Nikooye region in Ghazvin in central Alborz, the existence of c*halcedony* in the texture of the soil has been reported.[21] Accordingly, this mineral is expected to exist in the geological zone in Kelardasht. Nepheline is scarce in Iran. For the production of alumina and other items that required nepheline, it was imported from other countries due to its local scarcity. From the 1960s onwards, some sources of nepheline were reported in the northwest, such as Kalibar, Razgah, Bozqush, and Azarshahr (in the Northwest of Iran), and in another region, namely Soltan Meidan, in the north of Shahroud city and the central Alborz region. However, since the spread of Kura-Araxes culture did not reach Shahroud city, the existence of Shahroud nepheline mineral has no role in the subject of this article. To better understand the differences between pottery inclusions in different regions, it is better to compare some published reports.

18 Esmaeily, Khalaj, Valizadeh 2007.
19 Vahdati 1976; Hajalilou *et al*. 2013.
20 A'laie Bakhsh *et al*. 2013; A'laie Bakhsh and Sham'anian 2015.
21 Aghajani *et al*. 2016.

Batiuk studied the samples of the Bayburt region in northeastern Turkey[22]. He selected 20 sites. He chose one sample from each site and mentioned the existence of specific non-local examples such as Felsic volcanic, plagioclase, amphiboles, epidote, grog, olivine, limestone, quartz, biotite, and muscovite.[23]

In a 2011 study by Kibaroglu *et al.*, at Sus Hyuk site, the following inclusions were reported in the composition of the potsherds' texture: andesite, volcanic glass, basalt, micritic limestone, quartz, plagioclase, pyroxene, and olivine.[24]

Another study was conducted in 2015 on Kura-Araxes potsherds, in the Tsaghkasar archaeological site. This site is in Armenia, which is considered one of the birthplaces of this culture.[25] The potsherds included sanidine, plagioclase, quartz, orthopyroxene, clinopyroxene, dacite, tuff, obsidian, volcanic ash, pumice, grog, organic material, and bone.

In the 2009 article, Iserlis studied the Kura-Araxes samples of the Bet Yerah site. The researcher reported inclusions such as calcite, straw, grog, crushed basalt, soil balls, and carbonatic sand.[26]

In another study, samples of a Bet Yerah and samples from two sites from Armenia were studied. In the samples of Bet Yerah, chalk, basalt, calcite, quartz, plagioclase, olivine, and chert observed. Inclusion reported from Karnut I is Plagioclase, dacite, pumice, trachytic tuff, basanite, andesite, apatite, orthoclase, quartz, feldespathoids, amphiboles, grog, organic temper, rhyolite, volcanic ash, obsidian, and olivine.[27]

And finally, samples of Aparan III had quartz, tuff, plagioclase, biotite, calcareous grains, volcanic glass, grog, basalt, obsidian, anorthoclase, volcanic ash, pumice, andesite, hornblende, dacite, and apatite.[28]

Mason and Cooper conducted the first study of this type of pottery in Iran in the Godin Tapeh area. They reported the following inclusions: quartz, shale, mica, muscovite-quartz shist, feldspars, pyroxenes, fossiliferous micrites, grog, sandstone, siltstone, and argillite.[29]

In another study, Khazaie Kouhpar studied the pottery of Kura-Araxes in Tapeh Gourab Malayer as a doctoral dissertation.[30] In his research, Gourab samples had the following inclusions (Table. 6). Although we see differences and variations in the inclusions of different regions, we nevertheless see a sudden and noticeable change in the texture of the pottery during the transition from the Late Chalcolithic to the Early Bronze Age (Differences are illustrated in Figure 25).

The amount of inclusions in most of the studied samples varies between 5 to 20%. This frequency is less in some of samples (samples from the E.B.A). In addition, in some cases of the E.B.A, xenolith can be seen among the inclusions (samples no. 2, 7, and 8).

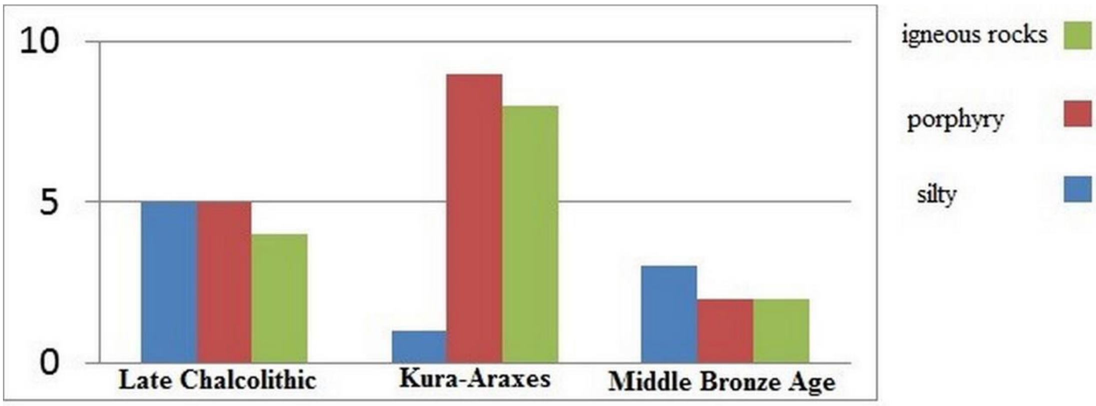

Figure. 25: *Diagram of changes in the texture of potsherds of Tapeh Kelar (photo by authors).*

22 Batiuk 2000.
23 Batiuk 2000.
24 Kibaroglu, Sagona, Satir 2011.
25 Iserlis *et al.* 2015.
26 Iserlis 2009.
27 Iserlis *et al*. 2010.
28 Iserlis *et al*. 2010.
29 Mason and Cooper 1999.
30 Khazaie Kouhpar 2011.

Table. 6: Potsherds inclusions of Kura Araxes sites from Iran and other regions.
1- quartz, 2- plagioclase, 3- amphibole and pyroxene, 4- fe-oxid, 5-mica, 6- calcite (mic), 7- calcite (sp), 8- p.rock v.rock, 9- sand & silt stone, 10- shist, 11- muscovite, 12- limestone, 13- basalt, 14- shale, 15- biotite, 16- chalk, 17- argillite, 18- basanite, 19- hornblende, 20- andesite, 21- epidote, 22- fossil, 23- orthoclase, 24- chalk, 25- sanidine, 26- apatite, 27- tuff , 28- pumice , 29- dacite , 30- organic temper, 31- anorthoclase, 32- olivine , 33- chert , 34- obsidian , 35- volcanic glass , 36- volcanic ash , 37- rhyolite , 38- felsic volcanic , 39- nepheline, 40- grog (table by authors).

Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Bybort	+	+	+			+					+	+			+						+											+						+		+
Sos hyouk	+	+	+									+	+							+												+				+				
Tsaghk asar	+	+	+																						+		+	+	+	+				+		+				+
Karnut I	+	+	+															+		+			+			+	+	+	+	+		+		+		+	+			+
Aparan III	+	+											+		+				+	+						+	+	+	+		+			+	+	+				+
Tapeh Kelar	+	+	+	+	tr	tr	tr	+	+							+																							+	+
Gourab	+	tr	+	+	+	+	tr	tr	+																															+
Godin Tapeh	+		+		+				+	+	+			+			+					+																		+
Bet Yerah	+	+				+	+						+			+																+	+							+

Table. 7: Potsherds inclusion description according to Whitbread system (Table by authors).

Sample No	**Boundaries**	**Degree of sorting**	**Roundness/ Angularity**	**Shape (eq or el)**	**Dominant shape**	**Estimation of percentage**
L.Ch-1	Diffuse	Very Poorly Sorted	Sub-Angular	Elongate & equant	Anhedral	5-10% (Few)
L.Ch-2	Diffuse	Poorly Sorted	Sub-Angular	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-3	Diffuse	Very Poorly Sorted	Sub-Angular	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-4	Diffuse	Poorly Sorted	Sub-Angular	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-5	Diffuse	Very Poorly Sorted	Sub-Angular >>Sub-Rounded	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-6	Diffuse	Well Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	15-30% (Common)
L.Ch-7	Diffuse	Moderately Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	15-30% (Common)
L.Ch-8	Diffuse	Very Poorly Sorted	Sub-Angular	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-9	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-15% (Few)
L.Ch-10	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	30-50% (Frequent)
E.B.A-1	Diffuse	Very Poorly Sorted	Sub-Angular >Sub-Rounded	equant & Elongate	Anhedral	5-10% (Few)
E.B.A-2	Diffuse	Very Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
E.B.A-3	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
E.B.A-4	Diffuse	Well Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	30-50% (Frequent)
E.B.A-5	Diffuse	Moderately Sorted	Sub-Rounded> Sub-Angular	Equant & Elongate	Anhedral	5-10% (Few)
E.B.A-6	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
E.B.A-7	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
E.B.A-8	Diffuse	Moderately Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
E.B.A-9	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	15-30% (Common)
E.B.A-10	Diffuse	Moderately Sorted	Sub-Angular >Sub-Rounded	Elongate	Anhedral	5-10% (Few)

Sample No	Boundaries	Degree of sorting	Roundness/ Angularity	Shape (eq or el)	Dominant shape	Estimation of percentage
M.B.A-1	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-15% (Few)
M.B.A-2	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
M.B.A-3	Diffuse	Moderately Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	5-10% (Few)
M.B.A-4	Diffuse	Poorly Sorted	Sub-Angular >Sub-Rounded	Elongate & equant	Anhedral	15-30% (Common)
M.B.A-5	Diffuse	Moderately Sorted	Sub-Angular >Sub-Rounded	Equant & Elongate	Anhedral	30-50% (Frequent)

The studied inclusions divide into two categories based on appearance: Equidimensional (eq) and Elongated (el), among which elongated inclusions are more common. Based on the Whitbread' method, the inclusions in most of the sections studied are in the el & eq group.

Also, most of these inclusions in terms of appearance and roundness or angularity of sedimentary-detrital grains are in the sub-angular (sa) category. A smaller percentage of these inclusions are also visible as almost sub-rounded (sr). Therefore, it seems that these sedimentary grains have traveled a shorter distance from their primary source.

The sort of inclusions also varies from poorly/very poorly sorted in samples with porphyry texture to moderately sort in samples with silty texture. The boundary between coarse-grained and medium-grained inclusions in these sections is obvious. Also, the optical density of these sections is higher than that of the matrix. However, this boundary is diffuse and integrated with fine-grained inclusions. The optical density of inclusions in these sections is evaluated as weak compared to the matrix (Table 7).

The clay matrix is the most abundant part in the studied sections. The voids in these sections are mostly in the form of long channels with parallel walls. Some voids are also visible in the planar shape. Generally, voids can be described as large voids and irregular medium voids. The predominant inclusions in these sections are mostly sandstone and slate and, to a lesser extent, iron ores and calcite.

Conclusion

Based on the geology of the zone and the existence of various inner and exterior igneous rocks, various limestone and shale, sandstone, slit stone, charcoal limestone, intrusive igneous rocks, nepheline syenite in the area, and the existence of these in the potsherds of the Tapeh Kelars' Kura-Araxes potsherds, one can reach the local origin of them. Except for being native, the studied potsherds have differences in texture, composition etc. In some of the Early Bronze Age potsherds, various igneous rocks were used as tempers. However, igneous rocks were not found in other samples. Some of the samples have chalcedony in their paste.

Texturally speaking, two contexts, namely, silty and porphyric or phenocryst are found in the potsherds. In samples that have calcite, these exist in the form of phenocryst and microcrystal. The existence of this mineral in the potsherds shows that their heating temperature had not exceeded 800 degrees Celsius. In samples that lack calcite, baking temperature had been more than 800 degrees. On the whole, the texture of potsherds indicates tangible changes from the Late Chalcolithic Age to the Early Bronze Age (Kura-Araxes) in such a way that out of 10 samples of Late Chalcolithic Age, 6 contain porphyric, and four others have calcite texture. In the Early Bronze Age (Kura-Araxes), nine samples out of ten have porphyric texture. In the Middle Bronze Age, only two of the five samples are porphyric.

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Figura 19: Proba nr. 5, mărire X 40. Lumină XPL, bucată mare de calcit (fotografie realizată de autori).

Figura 20: Proba nr. 4, mărire X 40. Lumină XPL, pastă nisipoasă cu bucăți de cuarț (fotografie realizată de autori).

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Figura 23: Proba nr. 5, mărire X 40. Lumină XPL, pastă nisipoasă și culoare diferită în partea de jos (fotografie realizată de autori).

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