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Archaeometric Study of Pottery Finds Obtained from the Surface Survey of Naderi Tepe (Southeast of Mashhad)

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Abstract: Naderi Tepe is located at the foot of the northeastern mountain of the Binaloud mountain range in the southeast of Mashhad and is located next to a communication route. According to the typology, the wares of this site include the variety of species and the quantity of pottery pieces from the Chalcolithic period to the historical period, but this site is considered as one of the most important settlement during the Chalcolithic and Bronze Age periods. During the study of this site, based on the obtained wares, 10 pieces of the sherds and two pieces of stone quern were analyzed by petrography and their thin sections were examined in order to find the minerals in them. The purpose of this experiment was to identify the components of each sherd, the difference in composition and materials between samples, determine the percentage of each composition, determine the temperature of pottery firing according to the available minerals, and investigate the origin of the raw materials that make up wares. In the laboratory, a thin section was prepared from the pottery and then studied with an optical microscope. The results of the studies show that the mineralogy of the sherds from the site shows the better quality and purer paste of the sherds produced from the middle Bronze Age to the end of this period, which shows the high skill of the potter in making and knowing the raw materials in the production of pottery. The mineralogy of quern stones obtained from this site and granite intrusive masses around it and the presence of angular granite pieces in the fabric of some ware species increase the possibility of producing some species in the site or areas close to granite masses. The results of this research can be the basis for the comparison of ware types in terms of construction techniques and compounds used in them in the surrounding areas, especially in the Mashhad Plain.

Keywords: *Mashhad plain, Naderi Tepe, Archaeometric, Chalcolithic, Bronze, Pottery.*

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Introduction

One of the most important and abundant finds in the ancient sites are pottery, or clay handi-crafts in general, which contain valuable information related to cultural developments in a re-gion. The study of soil and objects which are made of clay for the first time was began and ex-panded in Europe. Sedimentology, petrology, relationships between archaeological remains and the ecosystem are among the fields used in soil science studies (Sageidet, 2000: 21). One of these widely used methods in soil science is the use of thin section (descriptive mineralogy) in order to describe the materials which have been used in soil or pottery (Rapp, 2009: 189). De-scriptive mineralogy in the course of geology is the study of thin section of stone, but in the course of archaeology, it is the study of many inorganic materials which are used in making materials such as plaster, mortar, cement or cultural objects such as stone tools, pottery, bricks, stone, furnace slag, etc. are used (Reedy, 1994: 115). The descriptive mineralogy of pottery enables the researcher to describe, interpret and classify the fabric and the paste of the sherds and by microscopic study the physical properties of the compounds which have been used in pottery such as color, fabric (grooves on some minerals), the shapes of its ingredients and to identify the effect Light reflections on minerals (Freestone, 1995: 111). It can also study the microscop-ic structure of ware samples based on the four components of clay materials, adhesive materi-als (including mineral pieces, stone components, and the sherd pieces), organic materials, and empty spaces. In addition to this, the microscopic study of ware fabric can be used to 1-Determine the types of geological resources for providing wares and their changes through the time, 2-The nature of adhesives added to the sherds and to search its changes in time and place and its relationship with the technology used in the production of pottery, 3- Identification of local and imported pottery, as well as the identification and origin of recycled pottery added to the paste as an adhesive, 4- And checking behavioral patterns (for example, did the potter know about the thermal and unique characteristics of a certain soil deposit to produce a sherd with a specific usage?) (Amini et al., 2012: 100).

Research goals and the importance of the research:

The main goal of this research is to identifying the fabric of the wares in terms of the compounds which have been used in the sherds to compare with the geology of the region in order to know whether they are local produced pottery in the region or they are imported wares.

Question and hypothesis (main and secondary):

In this research, by using some common methods of analysis in archaeometry of ancient pottery has been tried to answer some questions like the following questions

a) What type of mineralogical compositions do the analyzed wares from Naderi Tepe have?

b) What kind of process do the structural and archaeometric studies of the produced ceramics show in the way of making and baking pottery?

Research method:

In this research, using thin section petrography (OM) studies and machine analyzes with SEM-EDX and XRD methods have been done to analyze the data in order to achieve the goals of the research.

Geographical and geological situation of the region:

Naderi Tepe is located in 5 kilometers southeast of Mashhad city and on the edge of the old road from Mashhad to Neishabour (Figure 1). This site is limited to the Mashhad plain from

the north, to Granite Mountains in the east, from the south to the foothills of the northeastern Bi-naloud mountain range, and from the west to the old road from Mashhad to Neishabour and the seasonal river which is running to the Torogh river. The Torogh river (as one of the branches of Kashfroud) flows at a distance of about 400 meters from the northwest of the site and after passing through the mountainous areas, it joins the Mashhad plain and finally connect to the Kashfroud river.

The northeastern mountain ranges of Iran consist of two parallel mountain ranges that are sepa-rated by the Atrak-Kashfroud depression. The northern mountain ranges are called Hezar Mas-jed (Kope-dagh) mountains, and the southern mountain ranges are called Binaloud-Aladagh mountains. Between these two mountain ranges are the plains of Mashhad, Quchan, Shirvan and Bojnord from east to west (Sheikhul-Islami et al., 2012). Meanwhile, the Binaloud moun-tain range, which is located in the south of Mashhad, includes various geological formations from the Precambrian to the fourth era (Sharki,2005: 8), which have created a complex set of geological transformations (Sheikhul-Islami et al., 2012: 6). Alavi considers the Mashhad met-amorphic complex is the remnants of a growing complex that was formed during the subduc-tion of the Paleotethys oceanic crust under the southern margin of Touran, on the edge of Tou-ran is formed, and after the collision of the Iran sheet and Touran in the Late Triassic period, it was replaced on the northern edge of the Iran sheet (Hemmam and Rahimi, 2010: 126). In gen-eral, the stones of Binaloud area can be identified in the form of eight groups, sedimentary and metamorphic groups, which include:

1- Non-metamorphic stones of the Late Precambrian to Lower Paleozoic which are comparable with similar formations in Alborz and Central Iran.

2- Sedimentary stones with the origin of sedimentary and igneous.

3- Triassic sedimentary stones.

4- Granitic intrusive masses.

5- Late Triassic-Early Jurassic low metamorphosed stones (known as Mashhad phyllite).

6- Destruction sediments of Jurassic age.

7- Carbonate stones as old as Lower and upper Cretaceous

8- Collection of sedimentary stones and volcanic of the third period (Sheikhul-Islami et al., 2012: 132) (Map 1).

Alavi also presented the following classification of the stones of this collection, which includes:

A) Ophiolite stones whose origin is the oceanic crust.

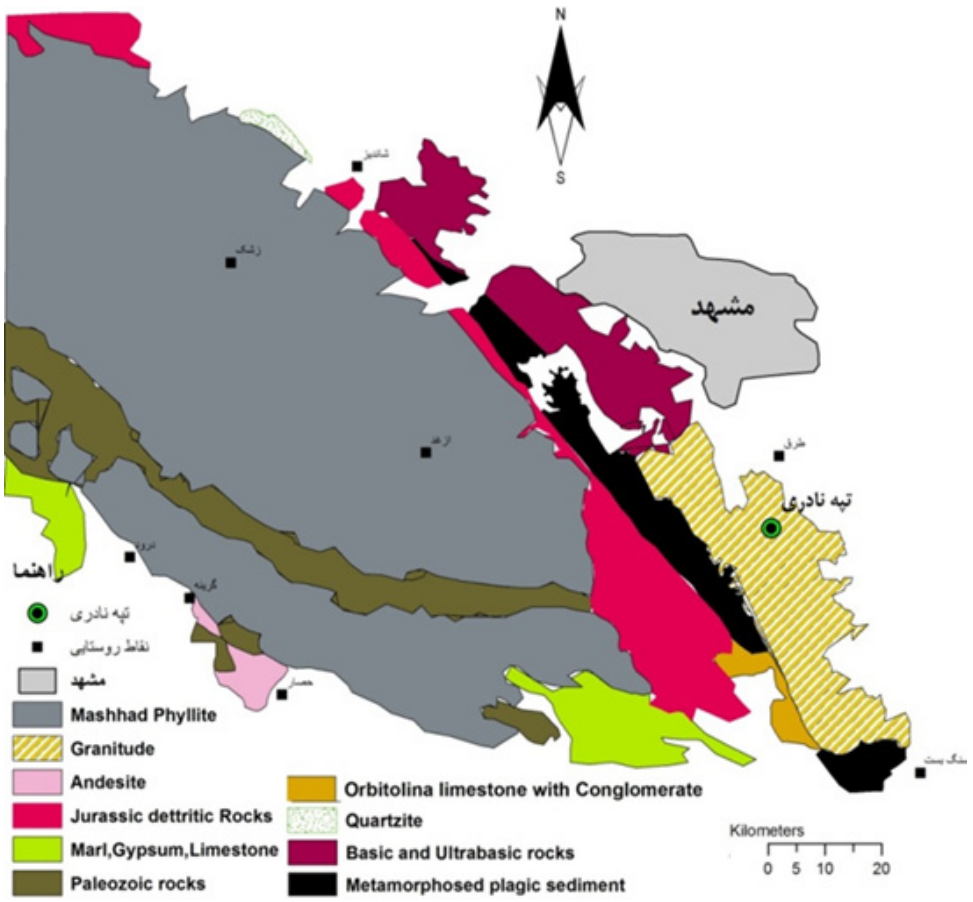
b) Metamorphic sediments: includes a thick set of Phyllite, slate, marble, carbonate conglom-erate, etc.

c) Igneous stones: the presence of these stones in the metamorphic complex of Mashhad is the result of volcanic flows in dry conditions (Hemam and Rahimi, 2010: 127).)

The materials and studying the methods

In the summer of 2013, Naderi Tepe was surveyed in order to identify settlement periods and cultural materials were collected in 16% of the total grids on the Tepe (Habibi, et. Al, 2015a), a large amount of which was made up of pottery and two items of stone Quern, among which

Figure 1: Naderi Tepe from the west side (Granit masses are visible) (authors).



Map 1: geological bed of Mashhad south and Naderi Tepe situation (early map: Sheikhul-Islami(2012) and the new map authors).

10 pieces of wares (figure 2) and two stone Quern samples (figure 3) were studied in order to iden-tify their compounds. Pottery is one of the most important handicrafts in human life. Pottery from the old layers of ancient sites are studied after hundreds of years without their overall shape being changed. Most of the pottery cannot be recycled, but they have preserved their shape, color and even their stable decorations so far and have not been damaged much. The past inhabitants of the earth have been producing it based on the application that these containers had for them. This durable product has undergone metamorphosis, diversity and extensive changes since the beginning of its production, which can be understood through the study of different dimensions and periods of pottery production (Rice, 1987: XXII). These transfor-mations over time are sometimes the result of the internal evolution of cultures and sometimes the result of economic and cultural connections with the surrounding societies. Therefore, the more detailed and systematic study of these documents can lead archaeologists to know more about the past of human societies in different dimensions. Despite the importance of pottery in archaeological studies, the methods and tools for describing and classifying pottery in Iran have not made the same progress which one of the reasons for this weakness perhaps the lack of sci-entific data in the field of pottery study is the lack of Persian sources. The existence of these study sources can limit and specify extensive personal descriptions of pottery; therefore, the use of scientific criteria can be helpful in this field.

During the survey of Naderi Tepe, while the site surface was gridded by a mapping camera, the grids were named (Habibi et al., 2015b) and all the pottery obtained from the survey after washing, their numbering and general characteristics were recorded in the database in Access software (table 1). In the description of the obtained wares, we tried to use the standard methods used in pottery studies, especially fabric description. For this purpose, to introduce the col-or of pottery, reference was made to Mansell's color table and to describe the texture and shape of pottery refer to the book Pottery in Archeology (Orton et al., 2007). In the description of the contents of the pottery fabric, it has been tried to benefit by applying the methods used in the field of geology to describe the data more scientifically. After classification of the sherds, some species identified based on relative dating were selected for mineralogical studies. So, due to the lack of excavations in the surrounding areas and the lack of excavation in Mashhad plain, the dating of some types of pottery from Naderi Tepe was not completely possible, and for this reason, these types have not been used in mineralogical studies.

Mineralogical description of pottery finds obtained from Naderi Tepe

Type one

This type of pottery includes a large number of wares obtained from the surface survey, and due to the large number of this type, four thin-section samples of this type of the sherds were prepared. In the description of this type, it should be said that the color range of most of the species varies between red, orange and brown. Most of them have a muddy slip on the inner and outer surface of the vessel, and most of the wares have been slipped irregularly on the outer surface (some pieces are completely polished), which is probably to cover the defects and holes and portions inside the fabric. White seeds of different sizes are densely seen in the fabric of this species. In terms of firing, the paste of most pottery tends to gray, and some samples are close to glassy due to exposure to high heat. In the samples whose edge is turned outside, the interior of the containers tends to be gray, this kind of pottery belong to the early Chalcolithic period, according to these definitions about this kind of ware it has been gotten from Anau site which is in the southern Turkmenistan (Hiebert & Kurbansakhatov, 2003). Another characteris-tic of this species is the presence of black spots on their outer surface, which can be seen in dif-fer-

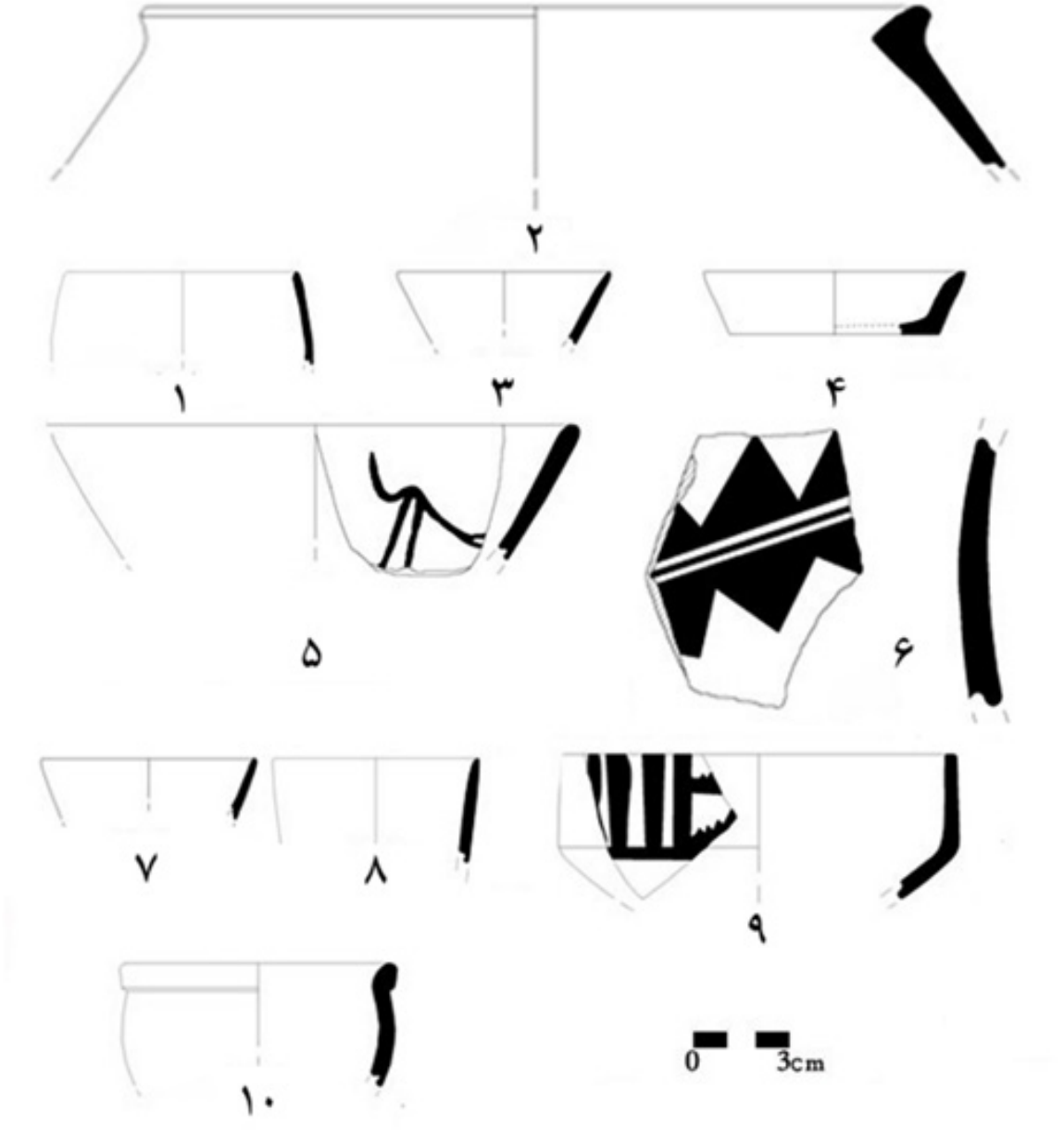


Figure 2: types of testing wares from Naderi Tepe (authors).

Figure 3: a- The shape of stone saddle quern made of acid internal porphyry stone (Granit); b- the shape of the stone Muller from stone Quartz genesis (authors).

ent sizes and in different parts of the body of the dish, but the spots do not follow a specific pattern, and these spots were probably created intentionally during cooking in the oven. This type of pottery with black spots probably appears from the end of Middle Chalcolithic period (Yalangash) and the beginning of the late Chalcolithic period (Geoxiur) (Salvatori, 2008: 75) and continues until the Old Bronze Age (Dana et al., 2011: 57). This type of pottery is geo-graph-ically widely distributed from the south of Turkmenistan (Hiebert & Kurbansakhatov, 2003: 61) to the Mashhad plain and its neighboring and other areas, especially Neishabour (Da-na et al., 2012: 57), Guchan and Shirvan, Sabzevar, Torbat Jam, Dargaz, Dargaz, Bakharz and Serakhs (Habibi, 2023: 166) and it has been found in 14 sites of Mashhad plain so far (Ibid, 129). From this type of pottery, four thin-section samples were prepared, and the results of the studies are as follows:

Pottery type one (texture number 1)

The study of the thin section of this type, which has an abundance of pieces of the sherds about 70%, is as follows:

Pottery fabric: black clay

The study of the fabric shows that the soil has been taken from almost the same place, has a lot of carbonate and, secondly, a lot of quartz (figure, 4: N.1). Carbonates are coarser and more rounded, while quartzes are more angular due to their higher hardness. In the carbonates found in this texture, a type of fossil can be seen that is similar to an echinoderm (this type of fossil is a branch of invertebrates and echinoderms) (table, 2: N.1).

Type one (section number 2)

Pottery fabric: Carbonate with carbonate pieces

This sample is noticeably free of any clay and between 70 and 80% of the pottery fabric is lime and quartz pieces (figure, 4: N.2). This pottery was most likely made in an area surrounded by carbonate (limestone) stones. The size of limestones is between. /1 to 3 mm and the average size of the pieces is about 1 mm, quartz between. /1 to ./4 mm are visible. This type does not have any igneous stones and some metal minerals are also present in the pottery texture (si-mi-lar to section 1) (table, 2: N.2).

Type one (section number 3)

Pottery texture: with low clay and many carbonate pieces

It has a clay background and the slip used on the external and internal surface of this pot-tery shows a significant difference from the mineralogical point of view with the fabric inside it, such that the texture of the covering is full of hematite and can be seen well in the corre-spond-ing shape, but in the inner texture of the pottery, pieces of Carbonate (lime) as angular can be seen (figure, 4: N.3). The next mineral that can be seen in the texture is zircon (a type of heavy sub-mineral) that can be seen occasionally in the pottery texture and its frequency is more than that of sample 1 (table, 1: N.3).

Type one (cross-section number 4)

Texture of pottery: dark clay (heterogeneous)

This piece has a background of dark clay in a heterogeneous form, containing pieces of quartz, carbonate, mica schist and plagioclase inside the fabric. Carbonates are probably more rounded due to being transported (figure, 4: N.4), and the size of their pieces is between ./1 to./5 mm.

Mica schist pieces between ./3 to 1 mm and also some granite pieces are observed inside the fabric (table, 1: N.4).

According to the mentioned materials, in the different samples of type number one, although many similarities can be seen in this type in terms of appearance features, but the study of their texture shows that the production of some samples took place in different geographical areas. For example, sample 2 is made in a bed of calcite (lime) and a possible additive of calcite, and its clay percentage is very low and insignificant, which is remarkable in its kind. Calcium car-bonate is found in a wide variety of mineral environments, including calcite veins, limestone, chalk, oyster shell, and coral (table, 3: sample. 1).

Calcium carbonate typically has the thermal features of ware loam (Rapp, 2009: 190). This is probably one of the reasons for their widespread use in making pottery. Also, due to the pres-ence of carbonate compounds, especially calcite with a high percentage in some species, it shows that these pottery were produced at a temperature lower than 600 Celsius degree, which is a sign of calcite melting at a temperature higher than 600 degrees (Mohammadifar and Arab, 2013: 75). (the figure of section number 4).

Type two (cross-section section number 5)

This type of pottery with a red to brown color spectrum has a thick clay slip on the inner and outer surface of the pottery and it has been fired in order to cover the porosity of the ware tex-ture on it, both on the inner surface and on the outer surface. In addition, motifs are created with black paint on the surface of the pottery. This type of pottery was first introduced under the name Marron and then under the name of plum ware, and its presence in the areas around the Naderi Tepe (Habibi et al., 2015a), including Borj Tepe in the Neyshabour plain (Dana et al., 2012: 56) and the Neyshabour site (P) (Hiebert & Dyson , 2002: 119) is reported. A radio-car-bon dating sample from layer 21 of Borj Tepe, from which this pottery was obtained, dates to 3090 BC. (Dana, 2015: 51). Microscopic study of pottery shows ingredients of granite, quartz, carbonate and pyroxene stones (figure, 4: N.5). Compared to or unlike some other sam-ples that had granite pieces, the granites in this pottery are rich in albite (a type of mineral that is usually seen in white color), while in the granites reported in other samples, there is more quartz and in addition the highest amount of granite reported in the texture of pottery is related to this species. In the context of the fabric, iron oxide can also be seen (table, 1: N.5).

Type three (cross-section number 6)

This kind of pottery, few sherds of which have been obtained, is wheel-made and has a red paste with a pale yellow cover (according to Munsell's color table) on the external surface, on the yellow covering, triangular geometric motifs are engraved in brown. On the inner surface of the sherds, deep holes can be seen, which the result of not kneading its past is probably. The type of decorations, slipping, compositions and manufacturing techniques of this pottery show a noticeable difference from other types and in terms of motifs, it belongs to the Chalcolithic period vessels (Masson, 1981: 9). Microscopic study shows that it lacks certain homogeneity in the fabric and a high frequency of sherds and porosity is observed in the fabric (figure, 4: N.6). Plagioclase, mica schist, quartz, granite pieces, silica, alkaline feldspar are among the miner-als and sherd pieces that can be identified in this ware. The white pieces in the texture, which looked similar to limestone grains, are of silica type, which has a volcanic origin, and general-ly, the carbonate of this sample is low (table, 1: N.6).

Type four

This kind of pottery, wheel-made, delicate and of good quality have been produced. The outer surface of this pottery has a thin slip and like type number one, it has black spots on the outer surface, but it does not have white grains inside the texture. The inner surface of this type has a thin covering like the outer surface, but it does not have external surface smudges, and no abrasion or polished sample was found in this type. These pottery probably belong to the Old Bronze Age. The pottery tradition of this period is a developed model of Geuxior pottery style (Type 1 pottery), but they have differences in terms of form and texture compared to their pre-decessors. Kohl refers some pottery indicators of the old Bronze Age to the newer samples of Late Chalcolithic pottery (Kohl et al., 1982: 9). Although the pottery is not very thick, but compared to some other species, pieces and minerals in the size of about 2 mm are observed in its texture. In this way, two sample sections were studied, which are as follows:

Type four (thin-section number 7)

Pottery fabric: Iron clay

Pieces of quartz, mica schist, carbonate and pyroxene can be seen in the texture of pottery (fig-ure, 4: N.7). The most abundant ingredients in the sample are mica schist and in the next grades are quartz and carbonate (table, 1: N.7).

Type four (cross-section number 8)

Microscopic study shows that this pottery has an iron clay background with about 40% abundance in the pieces where carbonates are in the first place. In terms of similarity and the compounds used in the pottery paste, it is similar to another sample of this type (section number 7), with this difference that the size of the pieces is smaller (figure, 4: N.7), but the frequency of its compounds is greater (table, 1: N.8).

Type five (cross-section sample 9)

This type of pottery, which represents mass-produced workshop pottery, is a wheel-made type, its clay is well kneaded, and the particles inside the texture cannot be recognized with the na-ked eye. The shape of the vessel is in the form of an angular bowl, which has a painting from the angle part to the lip. In terms of design and painting, it is similar to the Chalcolithic (Masson, 1981: 9; Hiebert & Kurbansakhatov, 2003: 42: fig. 7/4. N. 23).

Pottery texture: clay

The study of the texture shows that the type of soil used has a lot of iron oxide and a red color, which probably its color has been changed during the baking process, in addition, it has homo-geneous quartz mineral dispersion in the texture. There is also a certain homogeneity between the context and the sherds. Porosity is in the form of holes and in general, due to the purity of the paste, there are no recognizable materials or other special description (figure, 4: N.9). The only other identifiable mineral in the fabric of this pottery is zircon (a type of heavy secondary mineral) which is observed and is scattered in the fabric (table, 4: N.9)

Type six (cross-section number 10)

This type of cream-colored pottery without motif, which does not have much difference between the external and internal surface and the potter paste, is uncovered and does not have any abrasion or polishing. These features, along with the specific forms of this type of pottery, are placed in the Middle Bronze Age. This pottery was used for the first time in the culture of the late 3rd and early 2nd millennium BC. It was chosen as Bacteria-Margina archaeological complex by Sarianidi and then Hiebert (Hiebert and Karlovsky 1992), Karlovsky (Karlovsky, 2002:

65) used this title. Some researchers (Francfort, 1994: 406; 2004: 182) named it as Oxus civili-zation. Also, some researchers use the Greater Khorasan Civilization to introduce this culture (Biscione and Vahdati, 2020 ; Habibi and Hesari, 2019). Findings of the Great Khorasan culture in a wide area, from the northwest of Afghanistan, the south of Uzbekistan, Tajikistan, Turk-menistan, and in the northeast of Iran in Khorasan, from the cities of Chenaran, Mashhad (Habibi et al., 2015b; Habibi and Hesari, 2019; Eshghi and Mehrafrin, 2023). , Neishabour (Labaf Khaniki, 2002; Basfa, 2013: 14; Hiebert and Dyson, 2002: 119), Sabzevar (Vahdati and Frankfurt, 2010), Jajarm (Vahdati and Bishone, 2013: 393) and Ferdows (Farjami, 2014) has been achieved the peak of urbanization was in Namazga V or Middle Bronze Age in southern Turkmenistan. At the end of this period, important changes took place and urbanization sudden-ly collapsed, and areas such as Namazga Tepe and Altin Tepe were suddenly deserted. The col-lapse of the ur-banization period happened at the end of Namazga V and the beginning of Namazga VI. Tejan, Margiana, Oxus and Syr Darya rivers and the branches that flow into these rivers have played an important role in cultural development. In all dry areas, population dy-namics and econom-ic activities can be measured by the surface water network and especially related to the river waterway (Salvatori, 1998: 47). In southern Turkmenistan, there was a sig-nificant decrease in population around 1800 BC. (Biscione, 1977: 114). The collection of ob-jects related to this culture include: sticks of power, miniature columns, stone weights, female stone figures, marble vessels and silver and gold vessels with special relief motifs, all of which indicate specialization and exchange economy in this culture (Vahdati, 2014: 44). According to new investigations, traces of this type of pottery have been found in 9 sites of Mashhad Plain (Habibi and Hesari, 2019: 4; Habibi, 2023: 168). Microscopic study shows that this sample is homogeneous and does not have specific granularity. The ingredients used inside are mostly quartz and their size is less than ./1 mm. The sample of limes observed inside the texture shows that it is very likely that loam and lime (carbonate) are mixed together (figure, 4: N.7). Porosi-ties in the texture of pottery in the form of holes is visible which are between ./1 to ./8 mm. Calcite crystals have been observed around the holes inside the clay texture, which is the result of calcite solution penetrating into the empty space of the holes. In geology, there is a term called "marl", which refers to a type of very fine-grained sedimentary stone, about 40 to 50% of its composition is carbonate. This geological term is similar to this type of potter fabric in terms of grain size and type of composition (table, 4: N.10)

Studying the thin section of stone querns:

During the investigation carried out on the Naderi Tepe, two samples of stone chips for crush-ing grains were obtained from the investigated networks. In order to check the type of stones, a thin section sample was prepared from each stone and studied (Figure 6-7).

Sample number 1 (saddle-shaped quern):

According to the natural sediments in its lower part, this type of sample shows that it was tak-en from surface granite mines and after cutting, it was given the necessary shape according to the type of use. Considering that granite is a symbol of hardness, strength and resistance to cor-ro-sion and is known as "Khara stone" in the historical literature of the country, but due to the ex-tensive use of this stone, its thickness has decreased and it has approached the point of fragil-ity, the reason is that it has not been used more than this. In many ancient centers of the world, the use of granite stone for grinding grains has been reported (Rapp, 2009: 52). This sample is composed of acidic igneous stone, internal with a granular - mirmekiti - graphic texture, whose main constituent minerals are from the alkali feldspar family (orthoclase + microcline) and in addition, it has a high amount of quartz (fig, 6: sample 1). The amount of plagioclase in the

Table 1: description of the sherds

Design N.	Firing quality	Fabric grain	Thickness in mm.	External color	Fabric color	Internal color	External cover	Internal cover	Pottery N.	Sample	Type
1	low	Very low	6mm	pale red	grey	Light brown	Thick Slip-burnished	slip	I.12-06	1	1
2	low	low	8mm		pale red	grey	Thick Slip	Thick Slip	B.15-02	2	
3	low	low	5mm	red	Light grey	red	Thick Slip	Thick Slip-burnished	I.9-20	3	
4	low	low	8mm	Light grey	pale red	pale red	Thin slip	Thin slip	G.13-18	4	
5	Enough	low	10mm	red	Yellowish red	red	Thick Slip-burnished	Thick Slip-burnished	I.12-02	5	2
6	Enough	low	11mm	Pale yellow	Reddish brown	Reddish brown	Thick Slip	Thick Slip	B.13-24	6	3
7	Enough	Very good	5mm	red	Pale yellow	Yellowish red	Thin slip	Thin slip	I.15-07	7	4
8	Enough	good	7mm	Pale yellow	Pale yellow	Yellowish red	Thin slip	Thin slip	B.15-33	8	
9	Enough	good	7mm	Pale yellow	pink	Pale yellow	Thin slip	Thin slip	I.9-02	9	5
10	Enough	Very good	6mm	light cream	light cream	light cream	-	-	I.5-10	10	6

sample is low, therefore, the alkali stone is named Sino granite. This is a prototype and shows a slight transformation. Zircon is a secondary mineral of this unit and most of the plagioclase in this sample is of albite type, 30% of plagioclase has been transformed into Cercite and 10% of orthoclase has been transformed into clay minerals and Sericite (table, 3: N.1).

Sample number 2 (stone muller):

This sample with the name of quartzite and granular-Concertal texture is completely composed of quartz mineral and is a very hard sample, so that more than 90% of the stone is composed of quartz mineral (fig, 7: sample 9). Due to its high hardness, the amount of powdering and abra-sion of this sample is extremely low. This sample was probably close to the fault zone, so that the crushing of quartz minerals is evident in it, and in general, the endurance of this sample against abrasion is higher than the previous sample. (table, 3: N.9).

Conclusion

Naderi Tepe is located at the foot of the northeastern of the Binaloud mountain range. Due to its high altitude, this mountain range has created a wide communication barrier between the Mashhad plain (in the north) and the Neishabour plain (in the south) and the central plateau. Therefore, communication routes through areas with a low slope and close to the plains enable the easiest access routes. This site is also located on the communication route to the east of the

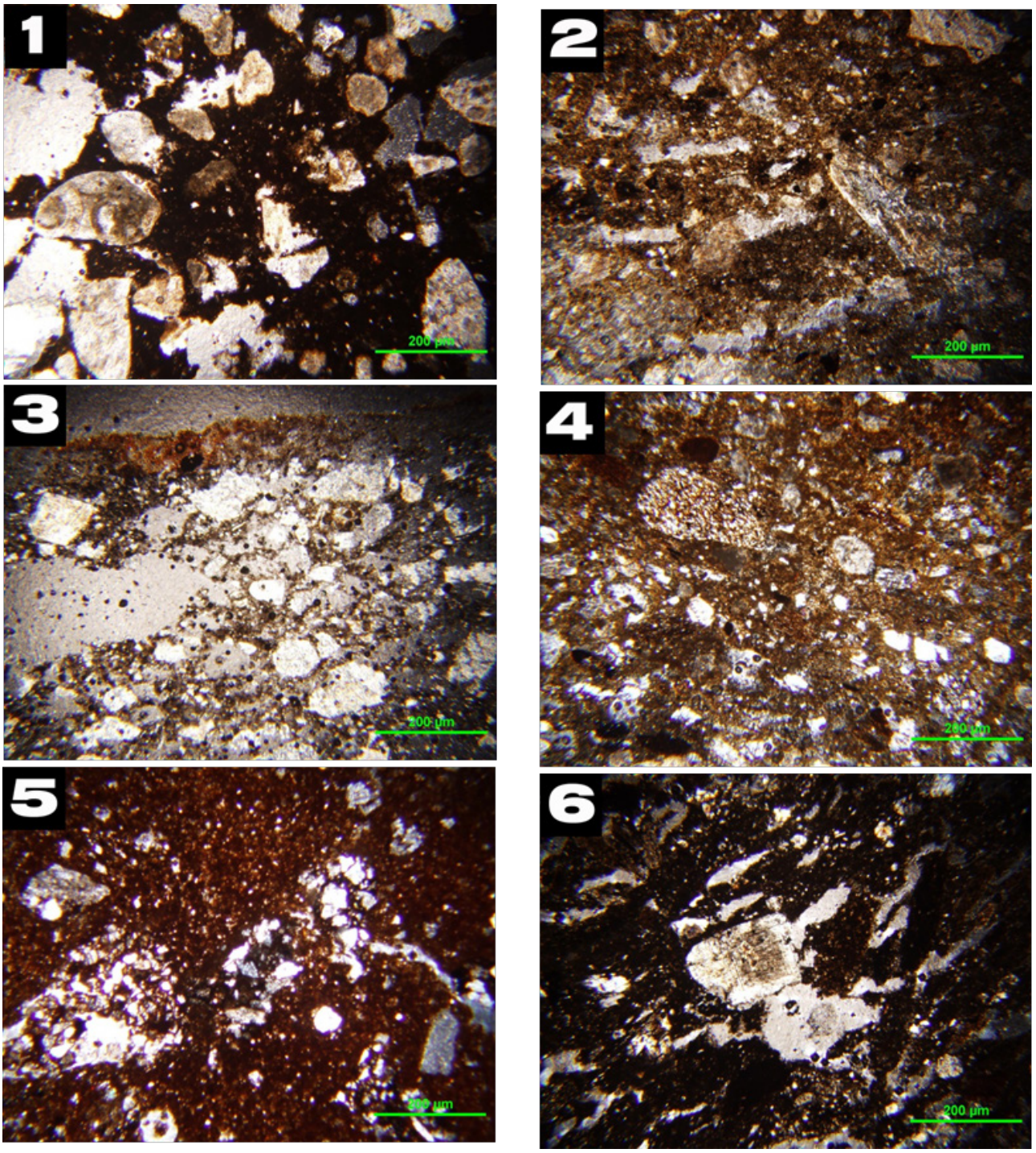


Figure 4: thin sections of the ware pieces and their explanation as follow (authors).

1- The cross-section of sample one: carbonates and quartz pieces along with a part of invertebrate fossils in the soil with which the pottery was made.

2- Cross-sectional shape of sample two: carbonate and quartz pieces make up more than 50% of the texture. The clay texture has little soil. In terms of the type of stones in the texture of the pottery, it is similar to sample one.

3- The cross-sectional shape of sample three: the carbonate pieces in the pottery texture and the upper margin of the hematite red coating on the outer surface of the pottery.

4- The cross-sectional shape of sample four: Carbonate, mica schist, quartz and granite shows the components of the texture of this pottery.

5- Cross section of sample five: iron oxide background with albite granites (plagioclase) and longitudinal porosity.

6- Cross-sectional shape of sample six: longitudinal porosity, abundance of micaschist (brown) and heterogeneous texture.

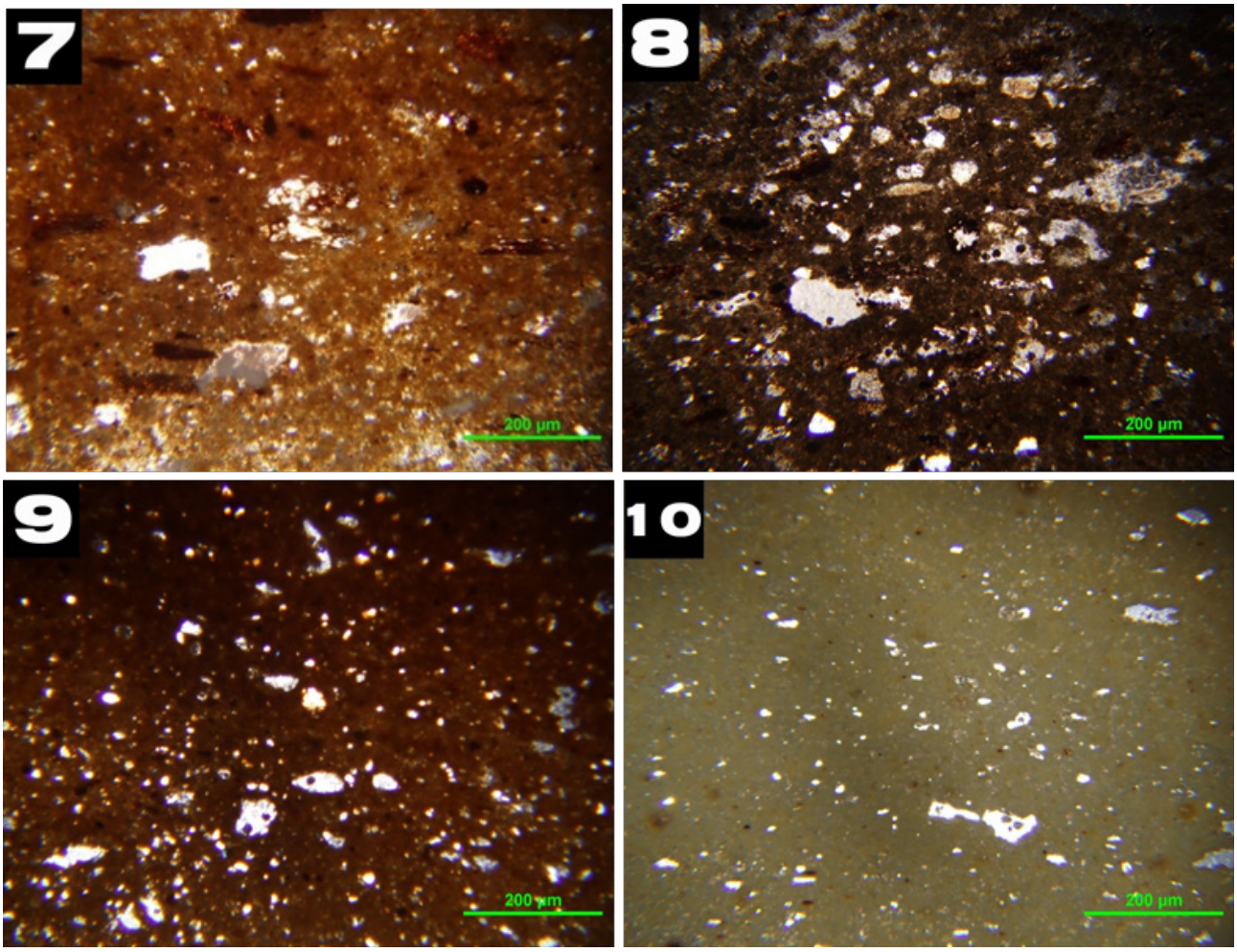


Figure 5: thin sections of the ware pieces and their explanation as follow (authors).

7- Cross-section figure seven: iron-bearing clay, abundant mica schist, quartz and carbonate can be seen in the texture.

8- The shape of cross-section number eight: iron clay soil with abundant carbonates, mica schist and quartz is similar to cross-section seven in terms of types of compounds, but it has a slightly coarser graining.

9- Cross-sectional shape number nine: clay ground with abundant iron oxide, pores in the form of holes, has a special ho-mogenous texture with parts.

10- Cross-sectional shape of sample 10: Homogeneous sample without special graining, porous porosity, small pieces of carbonate are probably mixed with clay.

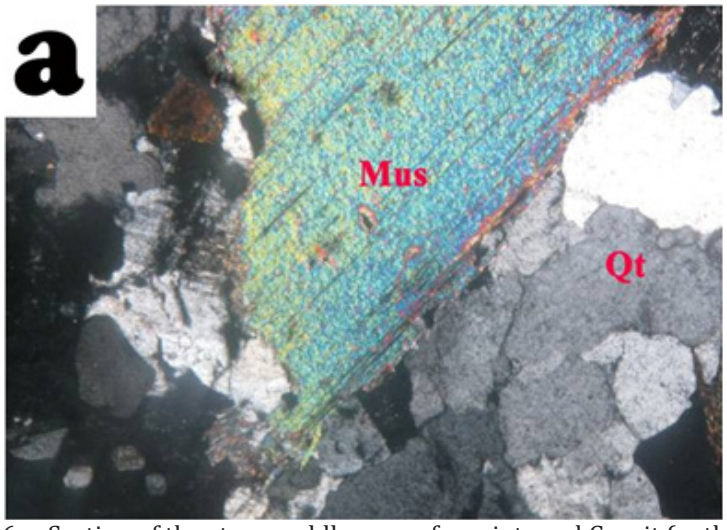


Fig.6.a: Section of the stone saddle quern from internal Granit (authors).

Table 2- description the compounds of pottery texture

Grain quality	Compounds figure	Average size	Mineral size	Redundancy percent	Early minerals	sample	Type
Very low	angular	1.5mm	./3-2.5mm	47%	Carbonate	1	one
	very angular	./7mm	./1-1mm	10-15%	Quartz		
	angular	./5 mm	./5-1mm	8-10%	Granite		
Very low	angular	1mm	./1-3mm	50%	Carbonate	2	
	rounded	./1mm	./1-./4mm	25%	Quartz		
low	angular	./7mm	./1-2mm	50%	Carbonate	3	
low	rounded	./3 mm	./1-./5mm	30%	Carbonate	4	
	semi-rounded	-	./1-./4mm	30%	Quartz		
	rounded	-	./3-1mm	15%	Mica schist		
	angular	-	1-2mm	20%	Granite		
low	angular	2mm	./5-3mm	50%	Granite	5	two
	semi-rounded	./2 mm	./1-./5mm	10%	Quartz		
	angular	1 mm	./5-1.5mm	10%	Plagioclase		
	-	-	./5mm	5%	Carbonate		
	-	-	1.5mm	5%	Mica schist		
	-	2mm	1-2.5mm	10%	Porphyry diorite		
	-	-	./3mm	3%	Pyroxene		
low	angular	2.1mm	./3-2.5mm	45%	Mica schist	6	three
	angular	./2 mm	./1-./5mm	10-12%	Quartz		
	angular	1 mm	./5-1.5mm	20%	Granite		
	-	-	./3mm	5%	Carbonate		
	-	-	./7mm	5%	Albit		
	-	-	./5mm	2%	Dispersed iron oxide		
	-	-	./3mm	3%	Pyroxene		
Very fine	semi-rounded	./3 mm	./1-./5mm	20%	Quartz	7	four
	semi-rounded	./5 mm	./2-1.5mm	15%	Carbonate		
	angular		1mm	2%	Granite		
	angular	1mm	./3-2mm	40%	Mica schist		
			./4mm	2%	Pyroxene		
medium	semi-rounded	./2 mm	./1-./4mm	25%	Quartz	8	
	semi-rounded	./3 mm	./1-1mm	30%	Carbonate		
	-	-	1mm	2%	Granite		
	angular	./6 mm	./3-1mm	25%	Mica schist		
	-	-	./2mm	2%	Biotite		
Fine	semi-rounded	./1 mm	./1-./3mm	30%	Quartz	9	five
Fine	-	-	1.1mm	30%	Quartz	10	six
	-	-	1.1mm	40%	Carbonate		

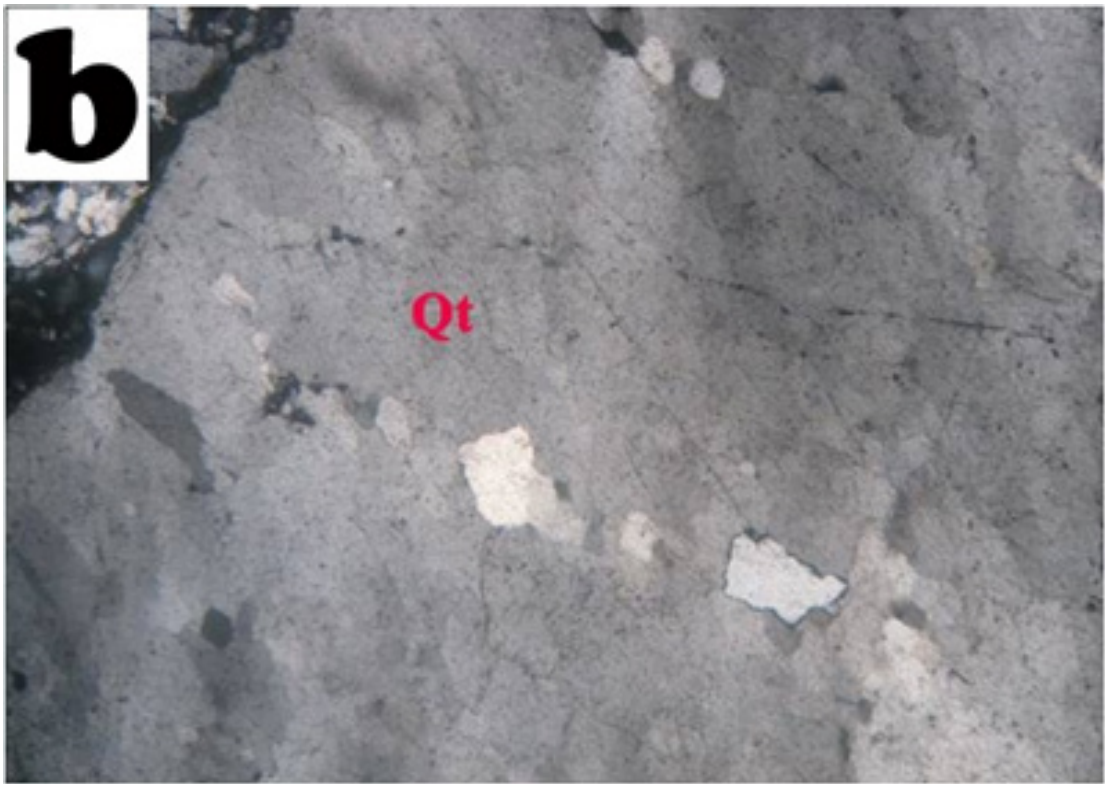


Fig.7.b: section of the stone Muller from stone Quartz (authors).

Table 3- description the compounds of grind stone

Metamorphosis	Size (mm.)	Type of conversion	Second minerals	Redundancy percent	Early minerals	Sample
weak Sericitic	./3-2.2mm	-	Sericitic	35%	Quartz	1
-	./5-3mm	Sericitic	Clay minerals	7%	plagioclase	
-	./5-3mm	Sericitic + Clay minerals	-	30%	Orthoclase	
-	./5-2mm	Sericitic		15%	Microcline	
-	./2-1.5mm	-	-	4%	Mesquite	
-	./2-2mm	-	-	7%	Biotite	
-	./1-10mm	-	-	90%	Quartz monocrystal	2
-	./5-1.5mm	-	-	10%	Quartz polycrystal	

Binaloud mountain range. According to the typology of the pottery of this area, in terms of the variety of species and the quantity of pottery pieces, the early Chalcolithic period and Bronze Age are considered the most important settlement periods in this site. The expansion of the population and extra-regional trades, especially in Bronze Age and in the following periods, and the specific geographical location of this site are among the reasons for the remarkable di-versity of the pottery samples of this area. In addition, the mineralogy of the pottery in the area shows the better quality and purer paste of the pottery produced from the Middle Bronze Age to the end of the Bronze Age, which shows the high skill of the potter in making and knowing the raw materials in the production of pottery. Every environmental body in which humans live, despite many similarities with the surrounding environments, has its own natural body, which has various differences from the vegetation and fauna to the geology of the region. For this reason, the study of the texture inside the pottery makes it possible for archaeologists to simulate the geological environment of the area where the pottery was made, in terms of the stones and minerals used in the texture of the wares. The mineralogy of stone quern obtained from this site and granite intrusive masses around the site and the presence of angular granite pieces in the texture of some potter species increase the possibility of producing some species in the site or areas close to granite masses. This possibility is especially related to type 2 pottery due to the similarity of some minerals in the granite stone-quern sample made from the surrounding mines and the minerals inside the potter texture as well as the geological position of the region, along with some similar rock motifs in Mashhad plain is strengthened. In addition, building and carrying out mineralogical activities in the field of archeology, especially in relation to pottery, while obtaining useful information on the use of minerals and wares by potters, requires miner-alogy in neighboring areas to identify pottery production traditions. Therefore, the results of this research can be the basis for the comparison of pottery types in terms of manufacturing techniques and the compounds used in them.

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