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A Reading on Kalpuregan Pottery Using Petrography

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Research Article

Abstract

The lifespan of Kalpuregan's pottery goes back to 3,000 BC and is probably one of the few areas in the country where the same traditional methods of designing and making pottery are done there now. Recognition of indigenous phenomena is possible by understanding human activities in the environment around them. Laboratory studies for analyzing pre-historic pottery in Iran will give us a better understanding of the production and distribution process. In the meantime, pottery items in Kalpuregan come from technology and firing clay. Clay is abundantly found on the surface of the earth. So far, no reports have been published on the recognition of elements that form containers or potteries in the Kalpuregan, district of Saravan. Most of researches have been done on the motifs and ways of making this pottery. The aim of this study was to identify Kalpuregan pottery using petrographic test. The results showed that Kalpuregan soil is secondary clay. These types of clays include various types such as ballclay, stoneware, red clays, marl, bentonite and refractory clay. The components of pottery comprise the following three major categories: clays, fillers, and fluxes. Clay has other elements such as titanium oxide, potassium oxide, sodium oxide, magnesium oxide, iron oxide and calcium oxide, the percentage of which is different depending on the type of soil. In the process of research, after the petrographic examination, it was found that most of the elements of the clay for pottery in Kalpuregan are Quartz minerals, which are seen as phenocryst and polycrystalline. This type of mineral makes up 20% of the sample volume. In the course of research on the type of fire in Kalpuregan pottery kilns, it was found that the color change of pottery after firing is due to the temperature conditions of pottery kilns in this area.

Keywords: Pottery; Kalpuregan; Saravan; Petrography; Structural Analysis; Instrumental Analysis

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1. Introduction

Potteries are derived from technology and firing clay. Clay is abundantly found on the surface of the earth. This soil is the result of thousands of years of severe erosion of igneous rock and metamorphic rock like granite that abound in the earth's crust. The simplest way to classify soils is to classify them based on their origin, so there are two types of clay. One of the primary clays deposited alongside the parent rocks and remained in its place of origin. These soils have no chance of mixing with other minerals and are pure. The origin of these clays is rocks that have been eroded by contact with surface water, steam, and various gases. This type of soil is found as irregular veins in the rocks that its erosion caused the soil. Other types are secondary clay or sedimentary soils that have been transferred to other environments after decomposition from the main rocks. Secondary clays are much more abundant than primary clays. Type II clays may include iron, quartz, and other impurities. Organic matters are found in type II clays (Basiri, 1363, 23). Understanding 'what substances and minerals were used in making pre-historic pottery and what are the physical and chemical properties of these substances?' leads to an understanding of more complex and useful aspects of prehistoric cultures. For this information, thin sections of pottery can be used in petrographic tests. Petrography is the science in which thin sections of rocks and minerals are studied under an optical microscope. Using thin sections, the stones can be better understood and light, type, texture, grading, and other properties can be found. This technique is the most common scientific method in geological studies (Zare, 2004: 97). It is also widely used in archeology in which it is used to determine the origin of pottery, to examine the minerals in each pottery, and to determine its degree of firing. History of Microscopic studies of pottery thin sections of pottery goes back to the pioneering work of Anna Shepard, who aims to study the microscopic structure of pottery samples using polarizing microscope in four components: clay, adhesives (minerals, rock components and pottery fragments), organic materials and empty spaces. Microscopic study of texture of pottery samples can help 1) determining geological types for clay supply and their changes over time; 2) The nature of the adhesives to the pottery, examining their changes in location and time and their relationship to the technology used to produce the pottery, 3) Identification of local and imported pottery as well as identification and origin of recycled pottery which is added to the modeling clay as adhesives, 4) examining the patterns of behavior. Metallic minerals used to produce glaze in pottery can also be identified by using polished thin-section and reflective polarizing microscope (Amini et al., 2013: 100). Pottery in the village of Kalpuregan has features that distinguish it from other potteries in Iran; one of these features is the color of soils, which they are greenish gray in the Kalpuregan area prior to firing but after firing, they become red in kilns (Nazari et al., 2014: 45).

2. Instruments and Method

The purest type of clay is called kaolin or kaolinite, which is hydrated aluminum silicate. Kaolinite has a regular crystal structure consisting of relatively large (one micron) hexagonal crystals. Clay has other elements such as titanium oxide, potassium oxide, sodium oxide, magnesium oxide, iron oxide, and calcium oxide, the percentages of which are different depending on the type of soil. Chinese or kaolin soil is the most important primary clay type, which has coarse grains and less plasticity in comparison to secondary clays. The most important feature of kaolin soil is its high purity, which makes it white after firing and if it is highly purified, it has a high refractive index (about 1750 degrees Celsius). Secondary clays are displaced by water, wind, or glacier and exposed to severe erosion; their particles are shattering and accumulating elsewhere.

Secondary clays include various types such as ballclay, stoneware, red clays, marl, bentonite and refractory clay. The components of potteries contain three major categories: clays, fillers, and fluxes. What distinguishes clay from other minerals is its extremely small size of particle and chemical ability to absorb water. When the clay is completely wet, each particle of soil is covered with a layer of water. Due to the flatness of the particles, the water gives them the ability to stick together and slip on each other under pressure, which is why the collection of these particles has the properties of ductility and flexibility. The flexibility of the clay depends on the amount of water in it. If the water evaporates, the mud will quickly harden so that it can no longer get a form, because water forms a large volume of mud. As water evaporates, the volume of mud decreases. Depending on the soil type and particle size, the volumetric contraction will range from 5% to 7%. Fillers are designed to prevent body deformation during firing, to provide proper thermal expansion, to control the contraction of wet to dry and dry to firing, and also create a frame-work role in the mud, allowing us to make delicate containers. They have used sand, shell powders, pottery powder (chamotte), straw, chopped vegetables and animal hair such as goats as fillers (Haddadi, 2008: 3).

Fluxes are substances that are added to raw materials to reduce the melting point of the body or glaze. The mechanism of this action is that when the body or glaze is firing, the fluxes melts and forms a glass phase during cooling and in fact creates a solid mass. Potassium oxides, sodium, magnesium, calcium are the most important fluxes. One of the most important steps in making pottery is preparing raw materials and preparing mud with the necessary features. To do this, they pour the clay with water into a pond where its impurities and coarse particles precipitate, and then the slurry in this pond containing clay particles is transferred to another pond. Where small clay particles are deposited and their excess water evaporates over time and the mud reaches the desired stiffness. They are then kneaded and the needed fluxes and lava fillers are added. Once you have the mud with the necessary features, it is the mud-forming stage that is done by hand (in the form of a tubular, a finger, a board or a sheet) or with a pottery wheel. After the process of mud formation, drying and polishing the pottery is one of the most important stages of pottery making. At this stage, before entering the product into the kiln and firing, the water in the body must be removed, either by locating it in natural air which is very time consuming or in a dryer. The pottery firing process is a general one and all the pottery products must be fired at least once, but the glazed products go into the kiln twice. The firing stage includes all that happens from the moment the raw pottery is put in the oven to the extracted fired pottery. It also includes the duration of the kiln cooling down, temperature changes, pottery status, and any climate change that occurs in the kiln. The color of the pottery, its degree of hardness and porosity all depend on the temperature of the kiln, the type of aeration, and the process of cooling the glaze after firing. Sudden changes in temperature lead to high water vapor and the breaking of the item. At room temperature to 120 ° C, the water in the pottery evaporates. When the temperature reaches 200 degrees Celsius, all of its water must be drained. Natural organic matter in the soil is also on the verge of decay. The water contained in the chemical structure of the material molecule is also released from the pottery between 400 and 600 degrees Celsius. At this stage, the temperature rise should be gradual (100 ° C / hr) so that the sudden increase in water vapor does not damage the item (Haddadi, 2008: 4). From 500 ° C onwards, dehydration will be complete. At this stage, the soil becomes ceramic in an irreversible reaction and will no longer dissolve in the water and the water will not penetrate in it. Theoretically, the dry particles of pottery have little contact points with each other and are joined by a method called sintering. At temperatures between 700 and 900 ° C, carbon and sulfur in the pottery soil were removed by the production of the corresponding oxide gas, dioxide and trioxide (Ibid, 2008: 4).

The origin of these gases is carbonate and sulfate impurities as well as carbon residues of organic matter that are not broken down at low temperatures. Each time the pottery is warmed and cooled; a reversible change occurs at 573 ° C. At this point the Quartz within the pottery is altered. This change occurs when the molecules are incorporated into the material's crystal, causing a slight (2%) increase or decrease in volume. Between 600 and 800°C, calcium carbonate is converted to calcium oxide, and till this stage, all the iron in the pottery has been converted to red water-free iron oxide. The pottery at this stage will be red and porous. Full firing will take place between 950 and 1100 degrees Celsius depending on the soil type and resistance, but starting point is at 800°C. At this temperature, the fluxes and free silica are gradually melted in the pottery. At 950°C, Spenils begin to form. They are short-lived and absorb at 1000°C in a glass-like structure.

At 1000°C, mullite (aluminosilicate), such as microscopic needle-like crystals, dissociates into a glass-like environment and merged and strengthens the ceramic structure. At 1100°C the pottery contracts substantially while the primary pores are closed and the clay firing is completed, so that when the temperature reaches 1250°C, there will be no open pores in the pottery and the pottery will be stony at the stage of completion of the firing. At 1300°C, the expanse of mullite stop and at 1400°C no pores remain. Until now, only pottery was examined in the presence of oxygen in the kiln. If oxygen levels decrease, two important factors come into play, first, the kiln fuel may not completely burn and the kiln environment will be covered by smoke, and this smoke will sit on the surfaces inside the kiln like soot. In addition, organic matters in the soil composition due to lack of oxygen may not be completely burned, resulting in remaining carbon or the so-called Black core in the pottery building. Another important phenomenon caused by the lack of oxygen is the revival (chemical reduction) of some of the materials in the pottery. For example, red iron oxide may be converted to black iron oxide until a pottery that was originally red is now completely black (Haddadi, 2008: 4).

3. Research Process

Thin section petrography is a method for studying and classifying clay structures. This method is used in the study of a wide range of materials, including rocks, minerals, pottery, concrete, and brick, plastering (mixture of lime or gypsum). The information obtained from petrography gives insight into some important aspects of pottery studies, including the origin and technique of production. The thin section was made by cutting a small piece of the studied sample, then glued to the flat surface of the glass microscope blade(slide) and its surface polished to a standard thickness (25-30 mm). Finally, the prepared sections are studied by using the polarizing microscope. At standard thickness, the minerals components in the pottery texture which are appeared with different color spectra are identified based on specific optical properties.

The petrographic experiment was carried out here on the object obtained from the Kalpuregan Pottery (Sarvan District) at the Tehran Institute of Cultural Heritage and Tourism on 21/12/97. The test report is as follows (Author).

Fig 1 Smoothing the sample surface (Petrolap device) (Source: Authors)

Fig 2 Preparing Slide (Source: Authors)

Fig 3 Polarizing Microscope (Source: Authors)

Table 1 Kalpuregan's Pottery Building (Source: Authors)

Row	XPL Light Color	Elements of Kalpuregan Pottery
1	White	Quartz (phenocryst and polycrystalline)
2	Red	Iron oxide mineral
3	Black and white like the stars of sky at night	Chert Stone
4	Dark colors like red	Grog
5	Grayscale	Plagioclase
6	Biotite minerals (red, brown) and muscovite minerals (colorless)	Mica
7	Red, pink, green	Amphibole
8	Purple	Pyroxene (partially)

4. Structure Analysis

To understand the structure of the pottery in petrography experiments, we use polarizing microscopes with xpl and ppl light. The desired images are as follows:

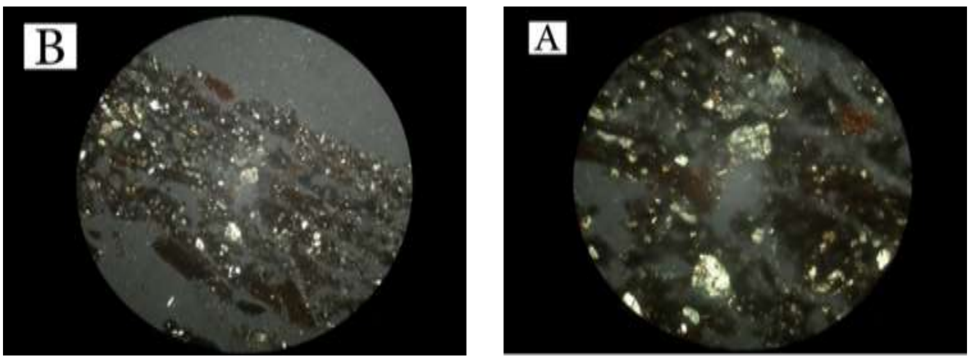

Fig 5 Photography with XPL Light: Image A: photography with XPL light, size 10x: Plagioclase mineral in the center of the image; Image B: Same image, size 4X: Plagioclase minerals and mica minerals (Source: Authors)

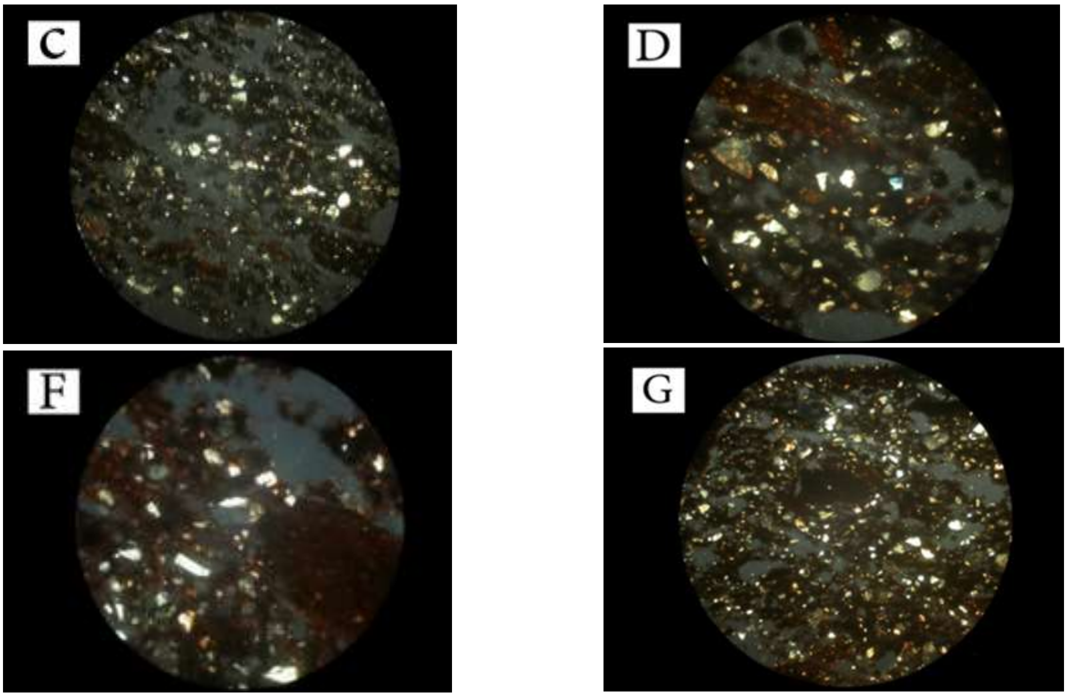

Fig 6 Photography with XPL Light; **Image C**: Photography with XPL light: size 10x: pyroxen Mineral (purple), edge is Chert + Grog fragments; **Image D**: photography with XPL light, size 4X: Quartz (white minerals), Iron oxide (red); **Image F**: Photography with XPL Light: size 4x: Grog in Center of image and Blank Space; **Image G**: Photography with XPL Light: Size 10 X; Polycrystalline Quartz (multicrystal) in the middle of the image (Source: Authors)

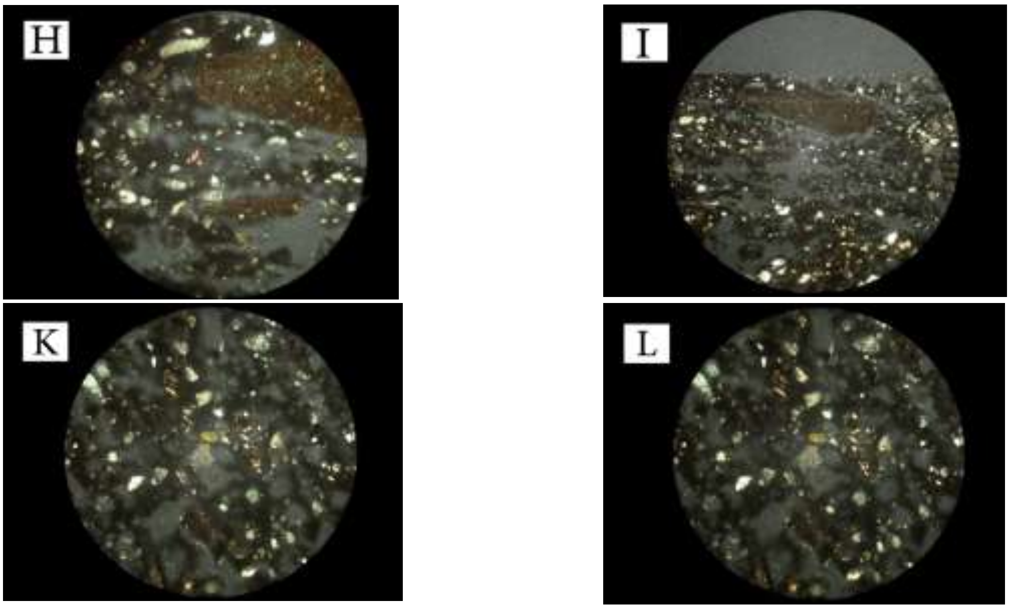

Fig 7 Photography with XPL Light; **Image H:** Photography with XPL Light: Size 4X: modeling clay; **Image I:** Photography with XPL Light: Size 10 x, Amphibole Minerals (Red and pink), Grog (Red in the Corner); **Image K:** Photography with XPL Light: 4x size: Amphibole + Grog + Amphibole abundantly; **Image L:** Photography with XPL Light: Size 10 X. Amphibole Mineral (Green) Next to chert rock Photography with PPL Light (Source: Authors)

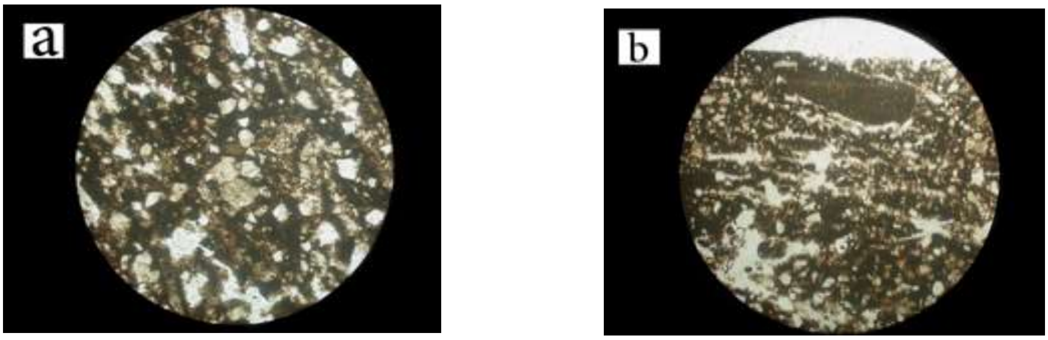

Fig 8 Photographer with PPL Light; **Image a:** in PPL light; **Image b** in PPL light (Source: Authors)

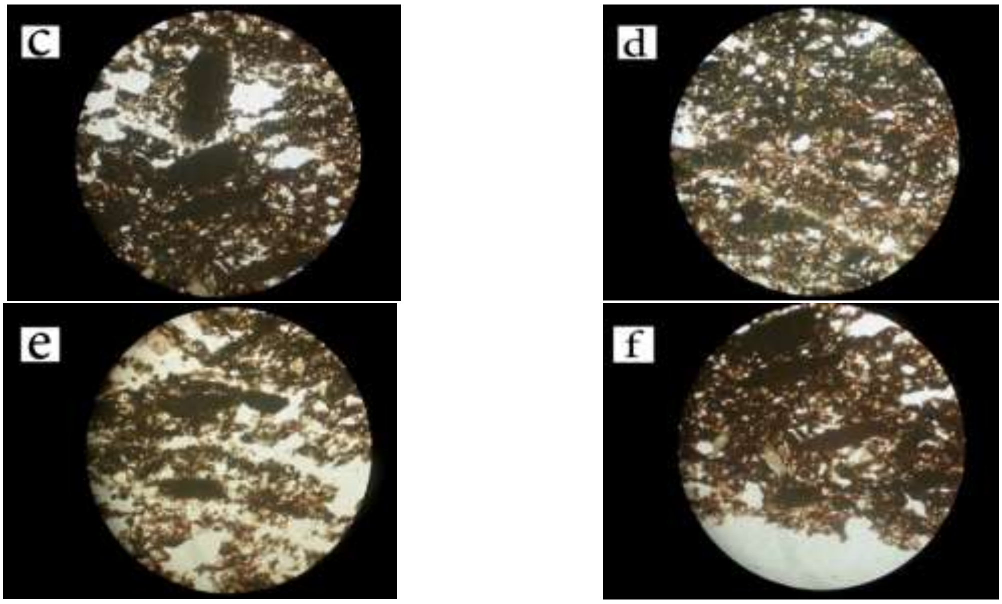

Fig 9 Photographer with PPL Light; **Image c:** Grog parts in PPL light; **Image d:** iron Oxide fragments (Brown and Black) in PPL Light; **Image e:** iron Oxide fragments (dark brown) in PPL light; **Image f:** Grog fragments in PPL Light (Source: Authors)

Table 2 Description of the structure of the Kalpuregan pottery (Source: Authors)

Row	Elements	Percent	Explanation
1	Quartz	2%	Quartz is the most abundant mineral in this sample, forming about 20% of the sample volume. Quartz mineral occurs in two forms: phenocrysts (monocrystals) and polycrystalline (polycrystals). Of course, it is necessary to explain that the fenoquartz (monocrystals) is the most abundant.
2	Grog	3%	These fragments are remnants of earlier pottery or fragments of clay and silt that can be seen separately and coarse-grained in the modeling clay. These fragments are dark brown in color with 1 mm dimensions and 3% abundance.
3	Iron oxide	2 to 3%	Iron oxide is brown to dark in the modeling clay. This mineral forms about 2 to 3 percent of the sample volume
4	Other components	Partial and limited	Amphibole, plagioclase, pyroxene, mica is partially and limitedly present in the modeling clay and there is plenty of space in the sample.

5. Conclusion

Given the purpose of this study and the geological study of the Sarvan as described above and according to the petrographic analysis of the Kalpuregan pottery, it can be deduced that the sample has domestic origin and its production is related to the region itself. The information obtained from petrography will identify some important aspects of pottery information. The thin section has a standard thickness (25-30 mm) by cutting a small piece of the sample under study. Standard sections were studied by polarizing microscope. In this experiment, any component of the minerals in the pottery texture appears with a different spectrum and the properties of the color spectrum and light are examined. Elements of pottery include quartz, iron oxide minerals, Chert rock, grog fragments, plagioclase, mica, amphibole and pyroxene. As mentioned earlier, this experiment shows how the origin and technique of the Kalpuregan pottery production was. Its Origin goes back to the same constituent elements, with the color spectra specified in Table 1. Kalpuregan's potteries come from technology and clay firing, Secondary clays are much more abundant than primary clays. Type II clays may include iron, quartz mica, and other impurities. Organic matters are found in type II clays.

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