ARCHAEOMETRICAL AND GEOARCHAEOLOGICAL STUDIES IN PREHISTORIC SETTLEMENT OF DOMUZTEPE (KAHRAMANMARAŞ-TURKEY)

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ARCHAEOMETRICAL AND GEOARCHAEOLOGICAL STUDIES IN PREHISTORIC SETTLEMENT OF DOMUZTEPE (KAHRAMANMARAŞ-TURKEY)

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ABSTRACT

ARCHAEOMETRICAL AND GEOARCHAEOLOGICAL STUDIES IN PREHISTORIC SETTLEMENT OF DOMUZTEPE (KAHRAMANMARAŞ-TURKEY)

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The aim of this study is to investigate pottery and stone vessels from Domuztepe, a Late Neolithic settlement in southeast Turkey, located to the south of Kahramanmaraş by means of archaeometrical and geoarchaeological methods in an attempt to understand the local resource use and production technologies. Domuztepe represents the northwestern border of a unique material culture distribution commonly known as "Halaf culture" which had influenced vast regions of northern Mesopotamia during the Late Neolithic period (6000-5200 cal. B.C.). Halaf material culture is best known through its elaborately decorated pottery and stone vessels which have long been speculated to originate from a center in northern Iraq. An important portion of the potteries and other material culture show close affinities with the material found in other parts of northern Mesopotamia, they are also an integral part of independent traditions of local production. Understanding the relationships between local technologies and interregional style preferences has been an important research question. However, the studies so far have not involved archaeometric investigations and thus remained within the limits of stylistic focus of archaeological methods. Thus, it is the aim of this thesis study to apply archaeometrical and geoarchaeological methods to support the wider research questions regarding Domuztepe‘s social and economic importance during the Late Neolithic period.

The study mainly consists of field and laboratory investigations. Pottery and stone vessel samples are provided from Kahramanmaraş Archaeology Museum. Field samples for the provenance analysis are collected at the outcrops in the vicinity of the Domuztepe site. Field studies are also supported by remote sensing analysis. Laboratory studies comprise visual classification of the Domuztepe pottery samples, petrographic and mineralogic analyses of both pottery and stone vessel samples by using optical microscopy, X-ray powder diffractometer (XRD) and scanning electron microscopy coupled with an energy dispersive X-ray spectrometer (SEM-EDX). Geochemical composition of the samples is determined by inductively coupled plasma-optical emission/mass spectrometer (ICP-OES/MS) and the data is evaluated by statistical method.

A total of 300 pottery samples are visually classified in two groups called as painted “Halaf” and burnished “non-Halafian” local pottery. They form, stylistically, into 11 main and 65 sub-groups. Geochemical and statistical analysis revealed 5 ceramic raw materials, as #1 to #5, including clay and temper, for pottery samples. During the chronological period from 6100 BC to 5300 BC, except for #2 and #4, these raw materials were used continously for ceramic manufacturing at Domuztepe. Organic and inorganic tempers were used in the clay paste which includes also quartz, feldspar, calcite, mica and serpentinite. Illite, smectite, chlorite and kaolinite were detected as the clay minerals. The mineralogical compositions of both burnished and Halaf ceramics found to be similar to the clay material collected from the alluvial sedimentary units in the vicinity of Domuztepe, showing that the local raw material sources were used for the ceramic production. There is no significant difference in the firing temperatures between Halaf and local burnished type ceramics. They were fired at temperatures below 900^0C in the first half of the 6th millennium. This suggests that potters focused on other color controlling factors such as the firing atmosphere:

reducing-oxidizing, firing and cooling duration. This care is shown especially to obtain the colors of dark burnished ceramics and buff-color (Halaf) ceramics, suggesting that these two types of ceramics may be different cultural usage areas.

A total of 47 stone vessel samples were studied using the above mentioned archaeometric methods. Mineralogic and petrographic analysis revealed that Fe-rich chlorite mineral is common in the raw stone material of the Domuztepe vessels. No such Fe-chlorite rich stone sources was found during the field studies. In contrast, antigorite–type serpentine mineral were detected in the field samples collected from possible sources of raw materials. This suggests that the source area for the stone vessel raw material is located outside the area of investigation.

Domuztepe stone vessels were produced from at least 5 different petrogenetic types of possible source rocks namely, ultramafic, basaltic-gabbroic, trachy-andesitic,rhyolite-dacitic and alkali-basaltic. The use of these resources varied periodically in all chronological periods from 6100BC to 5400BC. Most commonly, the vessel raw material sources of basaltic-gabbroic origin were used continuously for about 900 years, whereas sources of ultramafic origin were utilized for shorter time periods about 300 years.

Keywords: Pottery, Stone Vessel, Fe-Chlorite, Halaf, Late Neolithic, Domuztepe, Kahramanmaraş, Archaeometry, Geoarchaeology.

ÖZ

DOMUZTEPE (KAHRAMANMARAŞ-TÜRKİYE) TARİHÖNCESİ YERLEŞMESİNDE ARKEOMETRİK VE JEOARKEOLOJİK ÇALIŞMALAR.

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Bu çalışmanın amacı Türkiye güneydoğusunda, Kahramanmaraş'ın güneyinde yer alan Domuztepe Geç Neolitik yerleşimine ait çanak çömlek ve taş kapları, arkeometrik ve jeoarkeolojik metodlarla araştırarak, yerel kaynak kulanımı ve üretim teknolojileri hakkında bilgi edinmektir. Domuztepe, "Halaf Kültürü" olarak bilinen ve kuzey Mezopotamya'da Geç Neolitik dönemde (MÖ 6000-5200) geniş alanları etkileyen benzersiz bir malzeme kültür yayılımının kuzeybatı sınırını temsil etmektedir. Halaf malzeme kültürü, ince işçilikli çanak çömlekleri ve taş kapları ile iyi bilinmekte olup ve kuzey Irak'da bir merkezden kaynaklandığı, uzun zamandan beri yorumlanmaktadır. Çanak çömleğin ve diğer malzeme kültürünün önemli bir bölümü kuzey Mezopotamya'nın diğer alanlarında bulunmuş olan malzemelerle benzeşmekte olup, aynı zamanda yerel üretimin bağımsız geleneklerinin de ayrılmaz ve bütünleyici bir parçasıdır. Yerel teknolojiler ve bölgeler arası stil tercihleri ilişkilerinin anlaşılması önemli bir araştırma konusu olmaya devam etmektedir. Ancak bugüne kadarki çalışmalar, arkeometrik araştırmaları içermemiş ve böylelikle arkeolojik metodların biçimsel odaklanma limitleri içerisinde kalmıştır. Bu nedenle, bu tez çalışması arkeometrik ve jeoarkeolojik metodları uygulayarak, Domuztepe'nin Geç Neolitik dönemdeki sosyal ve ekonomik önemine ilişkin daha geniş araştırma sorularını yanıtlamayı amaçlamaktadır.

Bu çalışma arazi ve laboratuar araştırmalarını içermektedir. Çanak çömlek ve taş kap örnekleri Kahramanmaraş Arkeoloji Müzesi tarafından sağlanmıştır. Kaynak analizleri için arazi örnekleri Domuztepe çevresindeki yüzleklerden toplanmıştır. Arazi çalışmaları uzaktan algılama analizleri ile de desteklenmiştir. Laboratuvar çalışmaları Domuztepe çanak çömlek örneklerinin görsel sınıflandırılması, çanak çömlek ve taş kap örneklerinin optik mikroskop, X-ışınları toz difraktometre (XRD) ve enerji yayılımlı X-ışınları difraktometre ile birleşik tarama elektron mikroskopu (SEM-EDX) ile mineralojik ve petrografik analizlerini içermektedir. Örneklerin jeokimyasal bileşimi indüktif eşleşmiş plazma kütle/optik emisyon spektrometresi (ICP-OES/MS) ile belirlenmiş ve veriler istatistiksel metodlarla değerlendirilmiştir.

Toplam 300 çanak çömlek örneği görsel olarak boyalı "Halaf" ve perdahlanmış "Halaf olmayan–yerel)" çanak çömlek olarak iki grup olarak sınıflandırılmıştır. Seramik örnekler, stilistik olarak 11 ana ve 65 alt grupta toplanmıştır. Jeokimyasal ve istatistiksel analizler sonucunda #1 - #5 olmak üzere kil ve katkı malzemesinden oluşan 5 seramik hammaddesi belirlenmiştir. Bu hammaddeler, #2 ve #4 dışında, MÖ 6100-MÖ 5300 kronolojik dönemleri arasında Domuztepe'de seramik üretiminde devamlı olarak kullanılmıştır. Kil hamurunda; Kuvars, feldispat, kalsit, mika ve serpentin içeren inorganik ve organik katkı malzemeleri kullanılmıştır. Kil mineralleri olarak illit, simektit, klorit ve kaolinit tanımlanmıştır. Perdahlanmış (Halaf olmayan - yerel) ve Halaf seramiklerinin mineralojik bileşimleri Domuztepe dolaylarındaki alüviyal sedimanter birimlerinden örneklenen kil malzemesindekilerle benzer olup seramik üretiminde yerel kaynakların kullanıldığını göstermektedir. Halaf ve perdahlı yerel seramiklerin pişirme derecelerinde belirgin bir farklılık bulunmamaktadır. Seramikler 6. binyılın ilk yarısında 900^0C altındaki sıcaklıklarda pişirilmiştir. Bu durum çanak çömlek ustalarının renk kontrolünde indirgen-yükseltgen pişirme atmosferi, pişirme-soğutma süreleri gibi faktörlere odaklandıklarını göstermektedir. Bu özen özellikle koyu renk perdahlanmış seramikler ve deve tüyü renkli (Halaf) seramik renkleri için gösterilmiş olduğundan, bu iki tip seramiğin farklı kültürel kullanım alanları olduğunu akla getirmektedir.

Toplan 47 taş kap örneği yukarıda bahsedilen arkeometrik metodlarla incelenmiştir. Mineralojik ve petrografik analizler Fe-klorit mineralinin Domutepe kaplarının taş hammaddesinde bol olduğunun göstermiştir. Arazi çalışmaları sırasında Fe-kloritçe zengin taş kaynakları bulunmamıştır. Bu duruma karşıt olarak, potansiyel hammadde kaynaklarından toplanan arazi örneklerinde antigorit-tipi serpantin minerali tesbit edilmiştir. Bu bulgu taş kap hammadde kaynaklarının çalışma alanı dışında bulunduğu fikrini vermektedir.

Domuztepe taş kapları, ultramafik, bazaltik-gabroik, traki-andezitik, riyolit-dasitik ve alkali bazaltik, olmak üzere en az 5 değişik petrojenetik tipte kaynak kayaçtan üretilmiştir. Bu kaynakların kullanımı 6100 BC-5400BC kronolojik döneminde periyodik olarak değişmiştir. Bazaltik-gabroik kökenli hammadde kaynakları yaklaşık 900 yıl, ultramafik kökenli hammadde kaynakları ise yaklaşık 300 yıl en sık şekilde değerlendirilmiştir.

Keywords: Çanak çömlek, Taş kap, Fe-klorit, Halaf, Geç Neolitik, Domuztepe, Kahramanmaraş, Arkeometri, Jeoarkeoloji.

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CHAPTER 1

INTRODUCTION

The site of Domuztepe which is located on 30 km south east of Kahramanmaraş, was first recorded in 1993 as part of the Kahramanmaraş regional survey, under the leadership of Elizabeth Carter, University of California-Los Angeles. The first field survey of the settlement was completed in 1994 and excavations from 1996 until the 2011. The site was co-directed under the leadership of Elizabeth Carter of the University of California Los Angeles, and Stuart Campbell of the University of Manchester. It is currently excavated by the Hacettepe University collaboration directed by Halil Tekin.

The position of Domuztepe, at the juncture of routes to the Mediterranean coast in the west, the Amuq region to the south, the Syro-Mesopotamian plain to the east and the Anatolian plain to the north may have made other regions accessible. Therefore influences in style and possibly manufacturing techniques in the assemblage might be reasonably expected to come from a variety of directions (Campbell, 2013).

The höyük is quite large, at 20 hectare in total area, and rising twelve meter above the current level of the plain, though it likely was even higher originally, as alluviation raised the level of the surrounding plain while erosion farming shrank the mound itself over time. Nevertheless, Domuztepe of the largest known Halaf period sites in all of the ancient Near East (Campbell et. al., 1999). If the whole site was occupied simultaneously, the population may had been as high as 1500 people, substantially larger than any other known Halaf - Chalcolithic site in Anatolia or contemporary Mesopotamia (Kansa et. al., 2009; Selover, 2015).

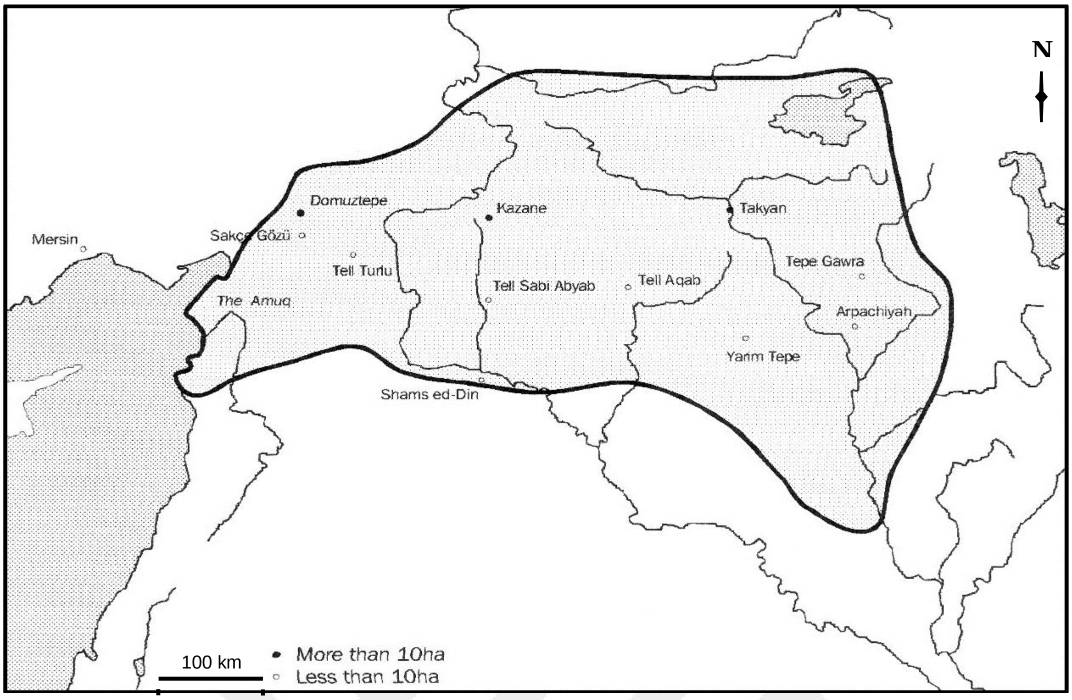


Figure 1.1. Distribution of the Halaf Material Culture in the Near East. Domuztepe and some other major Halaf settlements.

Domuztepe Höyük, represents the Northwestern border of a unique material culture distribution commonly known as "Halaf culture" which had influenced vast regions of Northern Mesopotamia (Figure 1.1) during the Later Neolithic time period (6000-5200 cal. B.C.) (Figure 1.1).

At the Domuztepe which excavation is ongoing, has been uncovered a rich collection of materials belonging to the Halaf period. The findings are evaluated together with the findings of other studies carried out in the western part of northern Mesopotamia and brings forth the revised reviews of this period. For example, against the idea that the objects of the Halaf culture, was born in Northern Iraq and spread from here, especially in the west, it is thought that, Halaf objects must be perceived as a continuation of the local Neolithic period (Carter, 1996). In this context, it is thought that Kahramanmaras and Domuztepe's may be one of the major regional centers of the Halaf period and are considered to have strategic importance in this period in the network of cultural exchange (Figure 1.2) (Carter, 1997).

In this scope, as priority, the issues in the site archaeologists agenda, is moving towards to understanding that, place of Domuztepe in trade and cultural network and its technological knowledge at that period.

Figure 1.2. Domuztepe Höyük

Archaeometric and geoarchaeological studies include methods for this purpose. In particular, artefact studies can provide important evidence for the solution of these problems. Artefact studies are one of the most widely applied areas of archeology of basic sciences after the dating methods. The aims of these studies are to obtain information in three main areas. One of these provenance studies which involve characterizing and locating the natural sources of the raw materials used to make artefacts and thus establishing the pattern of trade or exchange. Second, there are technological studies which involve identifying the materials and techniques used to make the artefacts. Third, there are usage studies which involve investigating the ways in which the artefacts were used (Tite, 1991). There are few studies on the raw material properties and production technology of Halaf ceramics. There are very few analytical studies on stone vessels of this period. This study aims to contribute to thr first and second main areas using domuztepe ceramics ant stone vessels of Halaf period.

1.1. Purpose and Scope

The major aims of this study are to investigate a selected corpus of archaeological pottery and serpentinite craft items (stone vessels) recovered from the site of Domuztepe through archaeometrical and geoarchaeological methods in an attempt to understand the local resource use, production technologies and their changes in time. The excavations and studies conducted until a period generally remained limited as archaeological methods and apart from some individual initiatives, has not formed a research team for geoarchaeological and archaeometrical studies. This study will try to eliminate these deficiencies and will look for answers to the following key questions:

- Which clay resources are used in the production of pottery in the region and what is the geographical relationship between the settlement of these areas of resources?
- How many different sources of raw materials, used by pottery and stone masters?
- Are the pottery and stone material resources used in the Domuztepe vary through time?
- What are similarities and differences between Halaf-type pottery and local pottery in terms of the use of source of raw material and technological production stages?

To solve the problems mentioned for this study, integration of some of geoarchaeological (field survey for provenance studies), archaeometrical (artefact studies) and archaeological methods are required. Although the comprehensive archaeological studies continued to be developed in the area for a long time, many of these studies have not yet been integrated with archaeometric methods for several reasons. Labor-intensive studies of archaeologists may had been limited by the temporal and financial reasons and the study of archaeometrical and geoarchaeological experts are also usually more away from the solving the archaeological problems by methodological reasons. In this study, an approach to fill the integrational gap in the literature has tried to adopted. For this purpose, mineralogical and petrographic analyses (Thin Section, XRD, SEM-EDX analyzes) were carried out to determine the qualities of the stone vessels and ceramic finds firstly. Field studies (regional geology and geomorphology studies and sampling) were conducted to prepare the provenance analyses. Lastly, chemical analyses (ICP-OES/MS) of all sample groups (stone and ceramic finds, field rock and soil samples) were performed for provenance analyses and statistical (cluster analysis) and geochemical methods were used to interprate these chemical data.

1.2. Location of the Study Area and Description of Domuztepe

Domuztepe is located close to the northwestern edge of the Narlı alluvial plain in south-central Turkey (Figure 1.3) about 45 km from the town of Kahramanmaraş. Narlı plain where the Domuztepe setlement is located, can be considered as an extension of the Amuq plains. Narlı Plain is a depression area as well as deposition area in East Anatolian Fault Zone (EAF) and is one of the four plains (Narlı, Türkoğlu, Gavur and Maraş Plains) in the Maraş plains system in south of the Kahramanmaraş. The region consists of plains divided by elevation due to active horst-graben tectonics.

Due to this tectonic activity continues today, embeding of Narlı Plain continues (Yiğitbaş, 1996). Because of the descending to the valley floor, a large part of the Domuztepe settlement is believed to be buried.

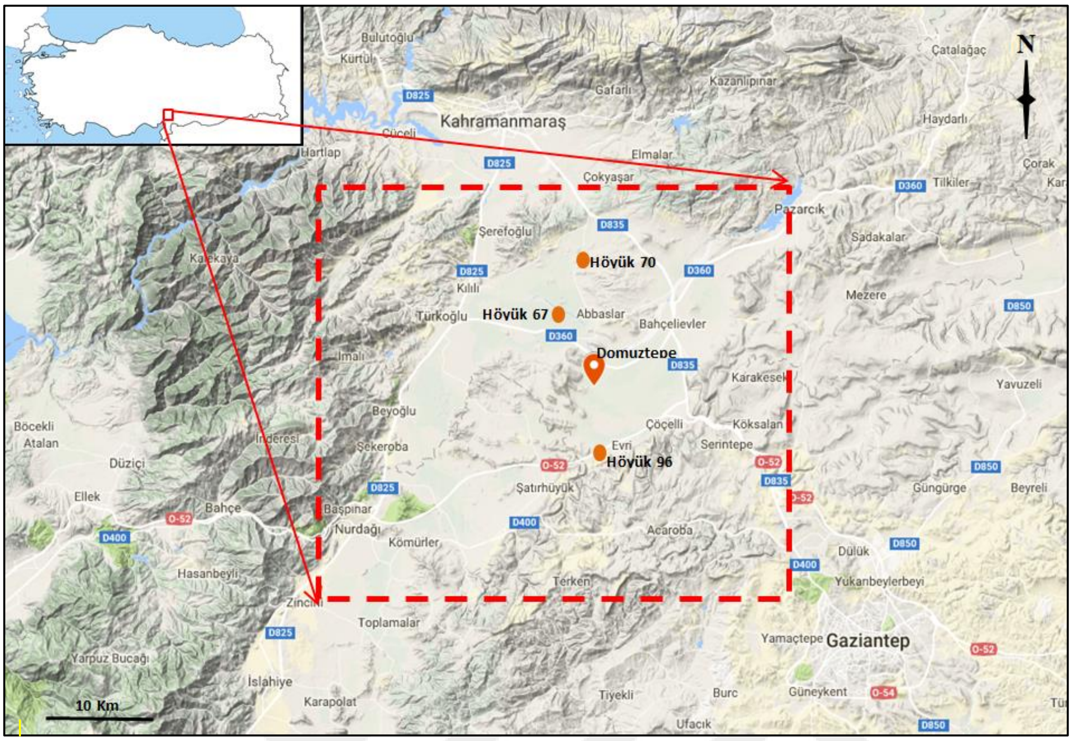


Figure 1.3. Location of the Domuztepe site and surrounding geomorphological features (GoogleMaps, 2018).

1.2.1. Domuztepe Settlement

Domuztepe is a large settlement with a size of 20 hectares, dating to Halaf period of the 6th millennium BC. In the late period of the Halaf almost all of the 20 hectares of the area was probably inhabited. The site was definitely founded at the Ceramic Neolithic (c.6400 BC) but may had been settled before. Prehistoric inhabitation ended towards the end of the Halaf period (c.5450 BC). It has widespread prehistoric architectural, burial, and occupational remains. The site also has findings of Roman and Medieval habitation. The joint excavations under the leadership of Elizabeth Carter of the University of California at Los Angeles and Stuart Campbell of Manchester University had been began in 1995. After E. Carter retirement in 2008, he also worked at the excavation committee since the beginning Prof. Stuart Campbell took over the excavation and continued this mission until 2012. In 2013, the British-American excavation team, Domuztepe excavations, were tranferred to the Dr. Halil Tekin from HÜ Department of Archaeology (Tekin, 2016, 2017).

The excavated part of the prehistoric sequence of Domuztepe, starts at the transition between the Ceramic Neolithic and the Early Halaf (c.6100 BC) and continues until 5450 BC. The fifth millennium is a key period in the development of complex societies in the Near East. Domuztepe situated in the northwestern edge of the center of the Halaf tradition, is one of the largest sites known from this period.

The Halaf inhabitation was observed in a series of trenches across the site. This trenches providing rich evidence for both circular and rectangular buildings, ceramics, stone bowls, beads, figurines, chipped stone, bone tools and stamp seals, and a rich assemblage of animal bones and botanical remains. The investigations are providing new details of the organization of society at the site and, its relationship with the near vicinity. The settlement seems to had been a focus of long-distance exchange, with evidence for the manufacture of status items. Stamp seals occur remarkably frequently and ceramics seem to had been used in a complex way. This situation indicating that shifting external relations over time (Campbell, 2004).

The excavations has concentrated on Operation I, which on the summit of the southern mound. In the Early Halaf phase, east-west terrace was built up from red clay layer, with a series of occupational deposits to the south, and maintained in subsequent phases (Campbell, 2004).

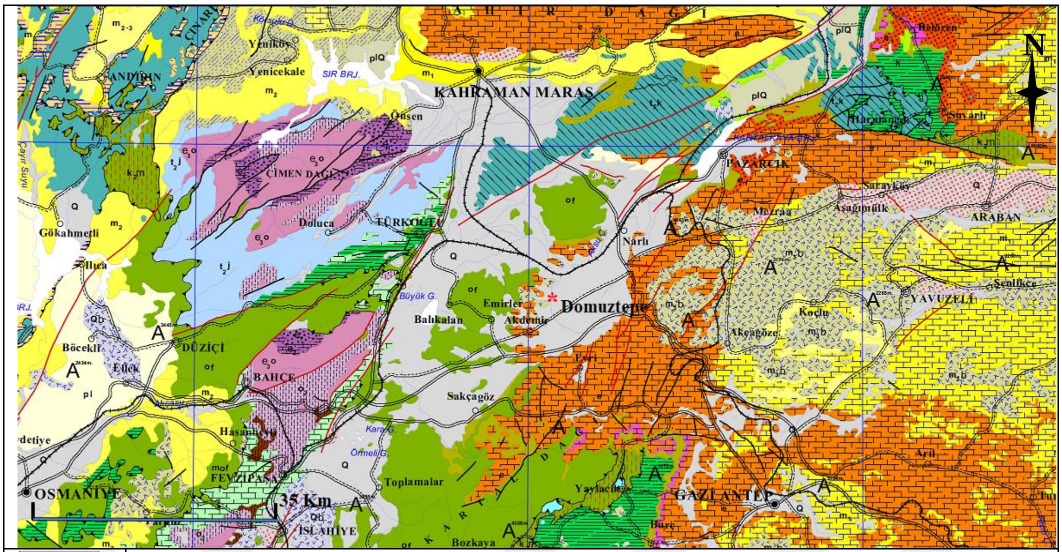
It is thought that, a large burial pit (the "Death Pit"), may have evidence of feasting/butchery of cattle and other animals. Apart from these, a large number of human remains, representing at least 40 individuals, was also recovered from the Death Pit (Campbell, 2004).

1.3. Regional Geomorphology and Geology

Aksu River which is a branch of the river Ceyhan passes through the north of the Domuztepe. Kahramanmaraş plains (Narlı, Türkoğlu, Gavur and Maraş Plains) are an average of 400-500 m above sea level and lies between the mountains (which are extension of the Taurus Orogenic Belt) reaching heights of 3000 meters. These plains located within the East Anatolian Fault Zone began to appear together at Lower Pliosen (nearly 4-5 billion year ago) and is still active today (Gül, 2000). Narlı segment of EAF has led to the development of Narlı Plain. Aksu River is connected Narlı Plain with a wide floor plain. Plain floor is alluvial and located in shallow swamps in the valley floor. There are also fan deposits around the Narlı Plain and Narlı Fault has cut this fan deposits. Rivers in the region has been shifted due to the faults. Domuztepe Höyük, located in a swampy area of the western side of the Mizmilli stream which a branch of the Aksu River and also on a fallen fault block its on westen side. Aksu River carries sediment into the study area, passes Narlı Plain in the east-west direction. While river leaves from the Narlı Plain, it merges with Mizmilli Stream. Than it turning towards the northwest and enters the Türkoğlu Plain. Mizmilli stream derived from Midyat Limestones is one of the main water sources of Narlı Plain and it's caused by faults. There are various sizes of water resources in the form of underground water around the Mizmilli swamp. According to hydrological research, groundwater flow direction is toward the west, in other words toward the swamp where also in the Domuztepe (Gül, 2000).

The southern of Kahramanmaras lies within the Eastern Anatolian Fault Zone (Figure 1.4). This zone has developed as a result of Alpine Orogeny, which is actively deformed and long-lived triple junction (Maraş Triple Junction). (Karig & Kozlu, 1990; Yılmaz 1993). Classified three different geological units are seen in this region. These units are Autochthonous Arabian Platform, Ophiolite Nappes and Cover Units. The Autochthonous Arabian Platform consist of limestone with a sandstone, quartzite and shale alternation at its base, which indicate that Lower Cambrian to Upper Ordovician aged. Upper Triassic-Lower Cretaceous dolomite and dolomitic limestone unconformably overlain on these basement rocks (Tekeli & Erendil, 1986; Yılmaz et al., 1988).

The southern Kahramanmaraş region (Figure 1.4) is located in the Eastern Anatolian Fault Zone. This zone has developed as a result of Alpine Orogeny, which is actively deformed and long-lived triple junction (Maraş Triple Junction). (Karig & Kozlu, 1990; Yılmaz, 1993). There are three classified geological units in this region. One of these units Autochthonous Arabian Platform, and the others are Ophiolite Nappes and Tertiary Cover Units. The Autochthonous Arabian Platform consist of limestone with a sandstone, quartzite and shale alternation at its base, which indicate that Lower Cambrian to Upper Ordovician aged. These basement rocks are unconformably overlain by Upper Triassic-Lower Cretaceous dolomite and dolomitic limestone (Tekeli & Erendil, 1986; Yılmaz et al., 1988). The ophiolite nappes contain three slabs. This slabs have tectonic contacts with each other. These are sequentially from top to bottom; the Karadut Complex is Late Triassic-Late Cretaceousaged and, contains flysch and wildflysch containing clayey limestone with limestone, ophiolitic rocks, cherty shale and limestone. The Karadut Complex is overlain by the Kocali Complex. This is consists of ophiolitic melange composed of ophiolitic blocks and epiophiolitic sedimentary rocks (Yılmaz et al., 1993). The matrix of the Kocali Complex contains serpentinite, mudstones of varying color with radiolarites, cherts, shale and volcanics. These are indicate a Late Cretaceous age (Yılmaz et al., 1993). The ophiolites tectonically overlie the Karadut and Kocali Complex slabs in this region. These are unconformably overlain by the Upper Maastrichtian-Paleocene limestone and sandstonesiltstone-mudstone alternations. The Arabian Platform rocks (mainly Mesozoic limestone) were thrust over those ophiolites (Herece, 2008). The unit which Upper Paleocene-Lower Miocene aged, consist of dolomitic, sandy and chalky limestone and discordantly overlie all older units (Terlemez et al., 1992; Gül, 2000). This unit is nonconformably overlain by the Tortonian Yavuzeli Basalt (Yoldemir, 1987). The Upper Pleistocene-Holocene units overlie all the units with angular unconformity.



	Undifferentiated Quaternary / Quarternary
	Basalt / Quaternary
	Basalt/Upper Mıocene
	Continental Clastic Rocks / Mıddle - Upper Mıocene
	Neritic Limestone / Mıddle Miocene
	Clastic And Carbonate / Lower Miocene
	Neritic Limestone / Eocene
	Pillow Lava And Sedimentary Rocks / Upper Cretaceous
	Ophiolitic Melange / Upper Cretaceous
	Neritic Limestone / Upper Jurassıc - Lower Cretaceous
	Ophiolitic Sheetin Places / Mıddle Trıassıc – Cretaceous
	Pelagic Limestone, Clastic Rocks, Radiolarite, Chert Etc. / Cretaceous
	Undifferentiated Harzburgite, Dunite, Serpantinite Etc. / Mesozoıc
	Peridotite / Mesozoıc
	Gabbro / Mesozoıc
	Gabbro, Dunite Etc. (Cumulative Rocks) / Mesozoıc
	Sheeted Dyke Complex / Mesozoıc
	Basalt – Spilite / Mesozoıc
	Clastic Rocks / Upper Ordovıcıan
	Clastic Rocks / Upper Cambrıan – Ordovıcıan
	Carbonate Rocks / Mıddle Cambrıan
	Active Fault
	Fault

Figure 1.4. Geological map of the Narlı Plain and its surrounding area (MTA, 2002, Hatay-1/500.000).

The ophiolitic rocks from the study area in southern Kahramanmaraş region are highly dismembered and composed of undifferentiated mantle tectonites and gabbroic rocks (Figure1.4). Cropping out throughout the study area, the highly serpentinized mantle tectonites are composed mainly of dunite and harzburgite, and display foliation and lineation, which reflect plastic deformation. Pyroxenite dykes, ranging in thickness from 10 to 40 cm, cut the mantle tectonites. The chromitites display a great variety of textures: massive, nodular, schlieren and disseminated (Uysal et al., 2007; Uysal, 2008). The cumulate rocks are defined as gabbroic cumulate and hornblendites at north of Şeferoğlu (Figure 1.4) (Kısakurek, 1988). Small-scale outcrops of the ultramafic-mafic cumulates, isotropic gabbros and amphibolites are limited by tectonic boundaries and seem to be irregularly dispersed in the study area. The ultramafic-mafic cumulate rocks display an igneous layering lamination and graded bedding and include very thin pegmatitic bands (5–10 cm in thickness). The massive to weakly foliated isotropic gabbros are dark green and fine to medium grained. The amphibolites have no pronounced foliation or schistosity along the contact with harzburgitic tectonites (Bağcı, 2013).

1.4. Literature Survey

Domuztepe is located in southern Kahramanmaraş region. When the look at the geology of the region, Kahramanmaraş and its near vicinity show the effects of the collision of two continental plates. There are many studies on the tectonic activity in this region located on the South Anatolian Orogenic Belt. (Şengör, 1981, Yılmaz et al., 1993). Due to this activity, two large fault zones appeared in the region. One of them is the Eastern Anatolian Fault Zone (Arpat & Şaroğlu, 1972) and the other is the Dead Sea Fault Zone (Garfunkel, 1981; Karabacak et al., 2010) in the south of the region. There are also many studies on these two major fault zones and their impact on the region (Yönlü et.al., 2011, 2012, 2013; Perincek, 1990; Şaroğlu, 1992). This area, where these two faults intersect, is the area also known as Maras Triple Junction where Arab, African and Eurasian plates are joined (Karig & Kozlu, 1990; Yılmaz, 1993). These data show that the study area has a highly critical tectonic regime and paleogeography. In other words, Maras basin is a typical example of tectonically controlled basins in South and Southeastern Anatolia (Robertson, 1994; Perincek, 1990; Terlemez, 1992). This dynamic tectonic avtivity also shaped the geomorphology and geology of the region (Akyüz et al., 2006; Yergök, 1975; Terlemez, 1992; Karabacak & Altunel, 2013;

Karabacak et al., 2010). The Narlı Plain in which the settlement is located is shaped by the effect of the horst-graben tectonics as a result of the above-mentioned tectonic motions (Yiğitbaş, 1996).

Tethyan ophiolites belonging to Alpine - Himalaya orogeny are widely observed in the region. There are a number of studies on the mineralogical and geochemical characteristics of these units, their formation patterns and their distribution in the region. (Robertson, 1986, 2002; Dilek, 1998, 2011; Pişkin, 1990; Bağcı, 2004, 2013). It is thought that the source of the raw materials of the stone finds, which is one of the research subjects of this study, may be the rock types belonging to the ophiolite units (Rosenberg, 2010; Kohl, 1979).

It is known in the archeological literature that mafic - ultramafic rock species known as soapstone or steatite, or some metamorphic rocks (talk, chlorite, meta-basalt, meta-gabbro, meta-serpentinite vb.), are used in the production of such stone findings (Jones, 2007). For this reason, the rocks belonging to the ophiolitic units in the region are considered as possible raw material sources of the stone bowl findings recovered from Domuztepe excavations.

There are many archaeometric and geoarchaeological studies related to the determination of the raw material characteristics and possible source areas about the stone findings which has different forms. (bowl, bead, statue, figurine, seal etc.) (Bar-Yosef Mayer et al., 2004; Truncer, 2004). Provenance studies for a raw materials used in the production of archaeological finds has long been a one of the main work areas of archaeometry and geoarchaeology (Rapp, 2002, 2006).

The societies that developed in the eastern Mediterranean during the prehistoric periods has the most prolific and diverse range of stone vessel traditions. Therefore stone vessels are important artefact in the early history of this region. As a form of archaeological evidence, they offer important analytical advantages over other artefact types - virtual indestructibility, a wide range of functions and values, huge variety in manufacturing traditions, as well as the subtractive character of stone and its rich potential for geological provenancing.

Some of the studies has focused on stone vessel industries in great detail. These are also offers a highly comparative and value-led perspective on production, consumption and exchange logics throughout the eastern Mediterranean over a period of two millennia during the Bronze Age (ca.3000–1200 BC) (Bevan 2007).

Steatite which known as soapstone or softstone in archaeology, has been one of the difficult materials of archaeological interest to characterise by physico-chemical methods of analysis with a view to identifying its origin. İn the some of the archaeometrical studies presents a new protocol for the chemical characterisation of steatite based on rare earth elements (REE) (Jones, 2007).

Despite a general interest in studying technological change, archaeologists have only rarely attempted to explain the rise and fall of steatite vessel manufacture. Explaining steatite vessel manufacture requires that all information on age and spatial distribution be extensively sampled and accounted for. Documenting spatial distribution shows that steatite vessels are not restricted to a single environmental or depositional context, nor were they manufactured at all steatite outcrops (Truncer, 2004).

The analysis and interpretation of lithics and lithic technology is an important part of reconstructing cultural development in prehistoric societies. Some of studies are about as more general discussions of methodology, chaîne opératoire, and the behavioural aspects of lithic procurement and production. Concomitant changes in subsistence, settlement, social and economic organisation are also discussed within the context of the Neolithic period in the Near East (Nishiaki, 2000).

Geoarcheology has become interdisciplinary work area, increasingly growing of importance in the last half century (Rapp, 2002, 2006). The archaeometry focuses on the application of scientific methods in archeology and one of the first examples of interdisciplinary studies in archeology (Martinón-Torres & Killick 2015; Killick & Young 1997).

Archaeometry can be divided into the several study areas. Among these, artifact studies have an important place and have a wide application area. For the all kinds of archeological finds, identification of raw materials, understanding of production technologies and research and identification of raw material source areas are among the one of the main application areas.

Undoubtedly, one of the largest group of finds recovered in archaeological excavations is also fired clay finds (pottery, birck, figurine etc.). In this respect, archeometric studies on fired clay materials also have a considerable place in archeology literature. Ceramics is a material culture object that is accepted by some researchers as a starting point for civilization and culture. Some comprehensive researches bring to new approaches to the study of pottery such as archaeological, ethnographic, stylistic, functional, and physico-chemical analysis (Rice, 2015). In the literature of ceramics, there are also studies that bring together ethnographic, archeological and archaeometric approaches. In archeology, ethnographic methods had been used effectively since the 1970s and this also has a led to the emergence of ertnoarchaeology. Ethnographic methods are used to understand the production processes of ceramics (such as clay preparation, shaping techniques, decoration and firing and post-firing treatments), and to reconstruct and interpret production processes (Livingstone, 2005). Such studies also include research that explores how human communities have shaped their preferences for production techniques. According to some of these, demonstrates that in any society, such choices result from cultural values and social relations, rather than inherent benefits in the technology itself (Lemonnier, 2002). One of the study areas in which human community's differences in technological preferences can most clearly be seen is the material culture objects. In the archaeology, by looking at the technological characteristics of material culture objects (including pottery, lithics, stone, bone and terracotta objects, figurines, engraved and decorated objects), it is possible to identify the geographical regions inhabited by the human communities that produce them. Similar studies had been carried out to understand the location of bounded territories of Neolithic (before and after the year 8000 cal BC) communities in the Near East. In these studies, geomorphologic data are taken into account as well as the distrubution of material culture objects (Kozlowski, 2005).

One of these studies (The Development of 'Cultural Regions' in the Neolithic of the Near East The 'Dark Faced Burnished Ware Horizon) focused on the ceramics (Neolithic Near East Dark Faced Burnished Ware - DFBW) discovered during the excavations at Yumuktepe in Mersin. Such ceramics also have an important place (40 percent of the total) in the Domuztepe ceramic collection (Restelli, 2006). In the above-mentioned work, where archaeometric methods are also used, ceramic artifacts have interpreted by using areas of production, architectural, economic and environmental information. In light of this information, the existence of a certain Dark Faced Burnished Ware (DFBW) zone were being defended. In addition, the distribution of such ceramics outside the DFBW region was examined and the relations between the regions were tried to be understood (Restelli, 2006).

With the help of organic residue analysis, it is possible to understand what kind of materials are stored in the ceramics of prehistoric periods. Such data, when combined with the stylistic and technological properties of these ceramics, can also provide important information about the intended use and usage of ceramics (Gibson, 2003).

In the past fifteen years, archaeologists have focused on food and eating habits of the pre-historic period. The aim of such studies was to bring together the different archaeological interests - from archaeological science and humanities perspectives - in food as cultural artefact/ecofact, to examine the potential of the new and developing scientific techniques for reconstructing prehistoric food habits, and to foster an integrated approach to the archaeology of food regardless of different researchers specialisms (Pearson, 2003).

There is a great importance of material culture studies for the prehistoric periods (no writen culture) like the Neolithic period. For this reason, production technologies has considered as areas where social identities such as sex can manifest themselves through concrete evidence for no writen culture periods (Dobres, 2000).

One of the most important reference to the recent regional study for over 20 years is based on data obtained from the results of archaeological research carried out in Balikhan Valley in northern Syria. Studies in Balikhan Valley has produced data, against the idea that Halaf Pottery spread from a single center and these studies, also provided new information on the dynamics of the Halaf settlements and social organization (Akkermans, 1995).

The Halaf culture is a prehistoric period which lasted between about 6100 BCE and 5100 BCE (Liverani, 2013). The period is a continuous development out of the earlier Pottery Neolithic and is located primarily in south-eastern Turkey, Syria, and northern Iraq, although Halaf-influenced material is found throughout Greater Mesopotamia. While the period is named after the site of Tell Halaf in north Syria, excavated by Max von Oppenheim between 1911 and 1927, the earliest Halaf period material was excavated by John Garstang in 1908 at the site of Sakce Gözü, then in Syria but now part of Turkey (Gessner, 2011). Small amounts of Halaf material were also excavated in 1913 by Leonard Woolley at Carchemish, on the Turkish/Syrian border. However, the most important site for the Halaf tradition was the site of Tell Arpachiyah, now located in the suburbs of Mosul, Iraq (Campbell, 2000).

The ceramics of the Halaf period are characterized by their superior workmanship and eye-catching decorations. It is possible that such high-quality pottery was exchanged as a prestige item between local elites. The Halaf culture also produced a great variety of amulets and stamp seals of geometric design, as well as a range of largely female terracotta figurines that often emphasize the sexual features

(Gessner, 2011). Among the best-known Halaf sites are Arpachiyah, Sabi Abyad, and Yarim Tepe, small agricultural villages with distinctive buildings known as tholoi. These rounded domed structures, with or without antechambers, were made of different materials depending on what was available locally: limestone boulders or mud and straw (Liverani, 2013). The Halaf period was succeeded by the Halaf-Ubaid Transitional period which comprised the late Halaf (c. 5400-5000 BC), and then by the Ubaid period (Gessner, 2011). Studies about Halaf Period are mostly based on excavations made in the Sabi Abyad mounds and these studies are approached with archaeological methods to the development of pottery and settlement fiction. The overall comprehensive assessment at regional level is discussed in the publication of P. Akkermans 1996 (derived from his doctoral dissertation). Recently, studies has become even more intensity on pre-Halaf period in this region. Publications of the Halaf period is concentrated in the 1990s (Akkermans, 1995,1996; Nieuwenhuyse, 1995).

The discovery of Halaf Pottery and publications concerning the definition are seen in the first 1930s. Studies of Braidwood's are among the pioneering approaches and this studies still maintains its validity as a reference. The studies of Garstang's at the Sakça Gözü and Yumuktepe are also used in the assessment of the Halaf Pottery in some ways (Mallowan, 1935; Oppenheim, 1933, 1943; DuPlat&Taylor 1950; Garstang, 1937, 1953; Braidwood, 1937, 1960). With the discovery of Halaf Pottery, publications about investigations and evaluations made on case-Halaf covers a major part of the last century. These publications are often the studies focused as typological-chronological synthesis about Halaf Pottery (Breniquet, 1996; Campbell, 1992, 1998; Davidson, 1997; Hijara, 1980; Kaplan, 1960; LeBlanc, 1973; Watkins, 1987).

In addition to this studies, the some excavations covering the Halaf had been performed in various places in Turkey. Özdoğan's approach to Çayönü pottery is important for an understanding of the pre Halafian local development . Kazane

Höyük near the Urfa is one of the largest Halaf settlement known today (Özdoğan, 1993; Wattenmaker, 1994, 1997; Bernbeck, 1999).

Archaeological studies carried out since 1993 in Kahramanmaras focused on archaeological excavations carried out in Domuztepe höyük. It is thought that the settlement was an important center for long-distance exchange especially during the post-Halaf period because of the huge size of the mound (20 ha) and the qualities of the finds (status items etc.) (Campbell, 1999; Carter, 1999). The discovery of a mass burial and a ritual space associated with this in the late period of the settlement it points to the existence of some complex funerary ritual and social processes in settlement (Carter, 2003). In addition, some studies show that Domuztepe could be in a complex social and economic relationship with some smaller settlements in the immediate vicinity (Eissenstat, 2004). Obsidian is one of the few nonlocal materials at Domuztepe. As an exotic material odsidian was also likely to have a key role in shaping and maintaining social and economic relationships, both within the site and more widely (Healey, 2009). Among the researches of Domuztepe, there are also researches aiming to define the transition process between the Halaf period and the post-Halaf (Ubaid) period on the stylistic ceramic studies (Irving, 2001). There are also archaeometric studies investigating the same transition period at the regional scale (on the ceramic samples of some settlements in geographic spreading of Halaf material culture), the qualities of ceramic raw materials and the effect of these ceramics on production technology (Spataro & Fletcher, 2010). In a regional approach that of excavations and surveys, the studies carried out in northern Iraq have an important place in literature. In studies conducted in the Habur, the synthesis of pottery is made by Nieuwenhuyse (Nieuwenhuyse, 1996, 2000; Bader, 1989; Merpert, 1993a,b,c). The regional studies using a variety of archaeological methods as methodologically, were conducted in various locations at northern Mesopotamia by Tony Wilkinson. Wilkinson also used various geoarchaeological methods as well as remote sensing methods in these studies. (Wilkinson, 2000, 2003).

CHAPTER 2

METHODS OF STUDY

2.1. Sampling

The samples used in this study were taken with the offical permission of the Kahramanmaraş Museum in 2009 excavation season. Received permission for four years has been renewed at certain periods. The ceramic sample collection was chronologically clustered in 5 main groups. These groups consist of four main chronologically consecutive groups and a group that resembles these four groups but it is chronologically definitively not identifiable. Also stylistically, the samples were collected in 11 main groups. It has 65 subgroups under the stylistic 11 main groups. In these groups, there are about 300 pieces of pottery.

There are also "chronologically unidentified group" samples in statistical sample pool (Table 2.1). These samples were collected from different settlements which located in Domuztepe vicinity during field survey. Domuztepe is not a single settlement; it is formed by agglomeration of different distinct sub settlements. During the surveys at least two more agglomeration formed in this way were found which 12-15 km close to Domuztepe. Kahramanmaraş surveys have shown that at least one of a long-term settlement has been inhabited and this layout had begun in Early Pottery Neolithic (Eissenstat, 2004). These settlements are thought to be associated with Domuztepe (Höyük number 67, 70, 96). It is believed that, these settlements were inhabited at about the same time chronologically with the Domuztepe. And relationship of this settlements with the Domuztepe will be tried to understand through pottery chemical analysis.

In addition, approximately 47 stone vessel samples were obtained to analyse in the scope of this permit. In the naming of archeological samples, names of excavation inventory had been preferred.

Within this study, all of the archaeological samples (385 pottery fragment, 47 stone vessel fragment) were documented by photograph. In addition, totaly 98 field rock and field soil samples were collected from the possible potential source areas. Firstly, thin section analysis was performed on 204 of whole samples. Guided by of the thin section analysis, was decided to realize on a portion of the samples by XRD (101 samples), ICP-OES/MS (127 samples) and SEM-EDX (15 samples) analysis. The statistical analysis were focused on the chemical data obtained from 127 samples. Number of analysis for different type of samples are listed in Table 2.1.

Table 2.1. Distribution of analyzes performed by sample types

	Pottery samples	**Stone vessels samples**	**Field rock samples**	**Field soil samples**	**Total**
Photograph	385	47			432
Thin section	66	47	91		204
XRD analysis	41	16	37	7	101
ICP-OES/MS analysis	33	27	37		107
SEM-EDAX analysis	4	11			15
Statistical analysis	33	27	37		127

2.1.1. Domuztepe Pottery Samples

The history of settlement had begun in Early Neolithic Period (6800-6400BC) and lasted to the end of the Halaf Period (5500 BC). The site has been inhabited without interruption. The commonly used chronology for Halaf Period is Halaf I-II. However in Domuztepe transitional phase, Early and Late Halaf has been preferred. The stratification of the site has been investigated and named several times and each attempting was named with a letter. The last and in use attempt is named as D-attempt (Atakuman & Erdem, 2015) (Table 2.2).

Table 2.2. Halaf Period chronology of Domuztepe settlement

Cal BC	D-attempt	General phase	Traditional external parallels
6,800-6,400	Phase D-1	Early Ceramic Neolithic	Early Ceramic Neolithic
6,400-6,200	Phase D-2	Late Ceramic Neolithic	Late Ceramic Neolithic
6,200-6,100	Phase D-3	Transitional	Transitional Halaf
6,100-5,800	Phase D-4	Earlier Halaf	Halaf IA
5,700-5,650	Phase D-5	Later Halaf	Halaf IIA
5.650-5,600	Phase D-6	Later Halaf	Halaf IIB (or IIA)
5,600-5,575	Phase D-7	Later Halaf	Halaf IIB (i.e. traditional Late Halaf)
5575	Phase D-8	Later Halaf	
5,575-5,500	Phase D-9	Later Halaf	Halaf IIB (i.e. traditional Late Halaf)
5,500-5450	Phase D-10		Halaf IIB (i.e. traditional Late Halaf)

The pottery assemblage of Domuztepe is dominated by a painted ware that is similar to examples from northern Iraq and north-eastern Syria to be called “Halaf”, but a significant proportion of the assemblage consists of non-Halafian pottery. These are known that the burnished, incised and pattern burnished pottery. These pottery constitute a local tradition predating the introduction of Halaf stylistic elements to the area. Hence, the “Halaf” cannot be seen as the same phenomenon across the entire Fertile Crescent. The pottery assemblages at Domuztepe and other sites within the region are a variant of the phenomenon recognized in eastern sites (Fletcher, 2008). The ratio of painted pottery found in Domuztepe is 40%. Rest of them consists of burnished ware and this type of ware was very common in Neolithic Period (Atakuman & Erdem, 2015).

Understanding to relationship of production technology and sources material between Halaf potterytypes and local potterytypes, will provide information about the origin of these kinds of pottery and will enable us to think about evolution of painted pottery tradition which affected entire this region. In this study, based on Domuztepe, will answer the questions as that, what is the production technology, how many different sources of local pottery poduction centers supplied from in Late Neolithic period.

All the samples examined in this study were chosen from Domuztepe local pottery samples. All of the pottery which will be analyzed, had been documented and photographed (Figure 2.1). All of the samples photographs are shown in the Appendix A.

Figure 2.1. A group of the pottery samples examined in this study. Burnished pottery: a (from Kahramanmaraş Museum), c,d. Halaf pottery: b (from Kahramanmaraş Museum), e, f. For the samples analyzed, permission was obtained from the Kahramanmaraş Museum

The assemblage of Domuztepe pottery samples consist of five main groups. Four of these groups follow each other chronologically. The fifth group is similar to the others, but not definitively identified. These five groups are summarized in a chronological order as listed in the following table (Table 2.3).

Table 2.3. Chronology of pottery samples (oral interview with Prof. S. Campbell, 2011).

Chronology	**Position in excavating area**	**Group deffinition**
6800 BC	Lot 4915	Late Pottery Neolithic Period (Pre-Red Terrace-Owen Before Red Terace)
6100 BC	Lot 4928	Transition to Halaf (EarlyRed-Terrace -Transition of Halaf)
6000-5750 BC	Lot 4916	Early Halaf Period (Red-Terrace Early Halaf - Owen After Red Terrace)
5750-5600 BC	Lot 4927	Late Halaf Period (Red-Terrace Late Halaf -Later Halaf)
Chronologically unidentified group	Lot 4924, Lot 4914, Lot 4842, Höyük 67, Höyük 70, Höyük 96	A group of samples that look similar but different from DT Painted Orange and Bichrome.

Pottery assemblage collections which consist of those grups, are thought to commonly produced and used in Domuztepe, belong to a period which began in 6800 BC and lasted until 5600 BC. Analytic studies on pottery were performed on 385 experimental pottery sample (with legal permission from the Kahramanmaraş Museum).

In the Domuztepe settlement, transition from the Late Neolithic Period to Halaf Period occured in three hundred years time interval (6800 BC-6100 BC). Therefore this time period is important (Campbell et al., 1999). One of the targets of this study is to understanding the impact of this transition on pottery materials and pottery production technology.

The area where the excavation work carried out so far in Domuztepe are shown in dark on the map below. Until now, a large part of the excavation work was carried out in the “Operation I” area. All materials uncovered in this excavation area are subject to investigation (385 pottery sherds and 47 stone bowl fragments, total of 432 samples) (Figure 2.2).

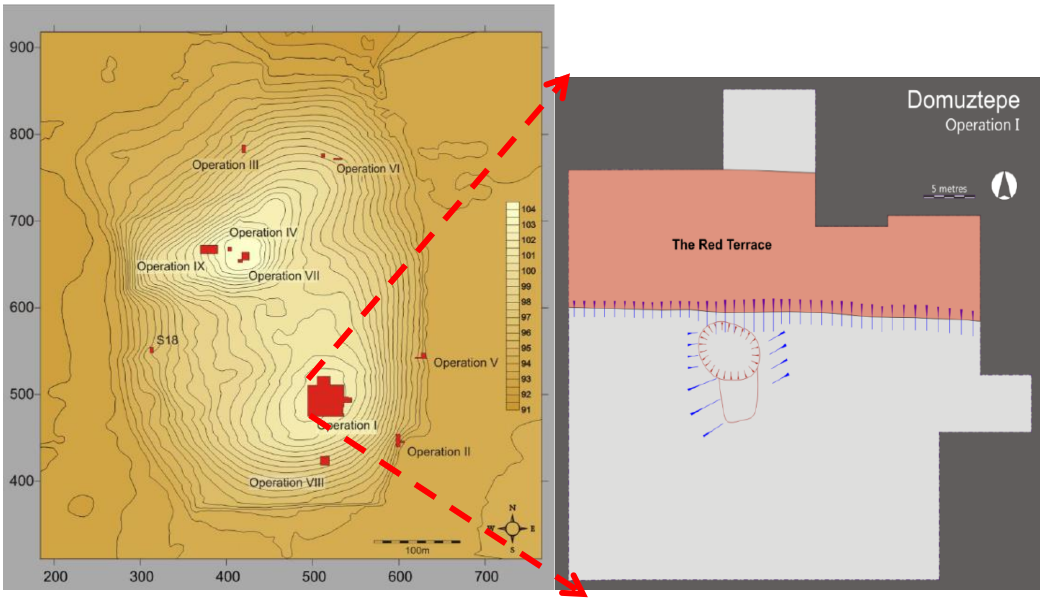


Figure 2.2. Domuztepe site plan, showing locations of excavated areas (on left) (Carter at al., 2003). Plan of Red Terrace (from Domuztepe archive).

“Operation I” area indicates a stratigraphy in the horizontal as well as vertical directions. In this stratigraphy the area called the red terrace has an important place.

Red Terrace is a prominent feature extending east-west direction in the southern part of Domuztepe. In almost entirely in the excavated area, this level shows itself as a level indicating the transition from the Late Neolithic Period to the Halaf Period. Red terrace is a mark of important boundary, which separated ritual area from the site. It is likely that it is only one of several boundaries that shape activity within the settlement (Campbell et al., 2014). This area, estimated to be 100 m, was excavated about 50 meters. During the excavation, it was marked with a distinctive red earth strip of 10-15 m wide, whereas the full width was found to had been changed at various points during use (an estimated 500–600 years) (Campbell et al., 2014). The surveys has indicated that a major feature of the Late Halaf site architecture, the Red Terrace, was constructed using distinctive red clay probably sourced from deposits located at the wetland to the west (Gearey, 2011).

The area known as “Red Terrace” zone is a decisive level in the horizontal and vertical ways (Figure 2.2). The vertical stratigraphy has been identified with the help of pottery chronology (Figure 2.3). According to this chronology, “Pre-Red Terrace” indicate that the Late Pottery Neolithic, dated to 6200 cal. BC., “Early Red Terrace” shows that the transition to Halaf Period dated to 6100cal. BC. “Red Terrace” is dated to 6000-5750 cal. BC time period, refers to Early Halaf Period, and dated to 5750-5500 cal. BC, shows that Late Halaf Period.

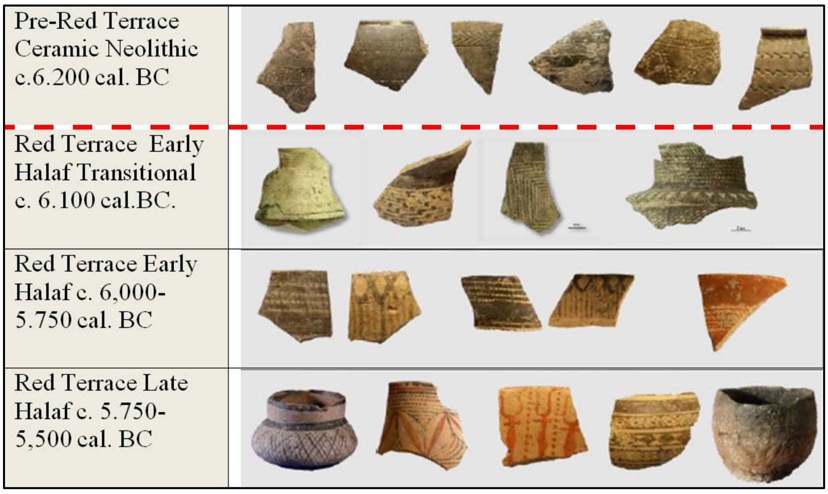


Figure 2.3. Pottery chronolgy of Domuztepe (Campbell, 2011)

Pottery groups which briefly described above and defined in this manner chronologically, are also divided in to subgroups as a stylistically. These groups are formed according to the visual characteristics of the pottery (Figure 2.3). This visual characteristics of pottery is made according to whether fine or coarse, no or have decorations (painting, finishing, scraping etc...), firing condition properties (oxidizing/redusing firing athmosphere), typology (form of bowl) etc.


Figure 2.4. Grouping of the pottery sherds using their visiul characteristics

These samples included in this study were classified by Prof. Stuart Campbell, Halaf specialist and former head of Domuztepe excavations. Subsgroups consists of 11 different clusters according to stylistics properties of pottery (Table 2.4 and

Figure 2.4). Each group does not include all of these subgroups. These subgroups are listed bellow:

Table 2.4. Ceramic subgroups list

Symbol	Subgroups
1	**Early burnished** whole mouth jars and bowls
2	**Leather burnished**
3	**Black burnished**
4	Fine **incised** burnished
5	**Red burnished**
6	Other **incised** burnished
7	**Brown burnished**
8	**Pattern burnished**
9	**Vegetable-grit coarse**
10	**Painted Halaf**
10.1.	Transitional painted (Samarra-similar to Sabi Abyad shapes and decoration butr paint is different flaky and greyish
10.2.	Pre-Halaf painted-before Samarra, reddish paint, bands-cross hatching but no Halaf symbols, may be related to transitional and Halaf painted.
10.3.	Halaf painted , lozenges, loops etc, Domuztepe Halaf looks similar to north Syrian Halaf but it seems to have more grit temper.
11	**Unpainted** Halaf, could it be linked with burnished material?

The chronological distribution of these sub-groups are presented in the following figure (Figure 2.5).

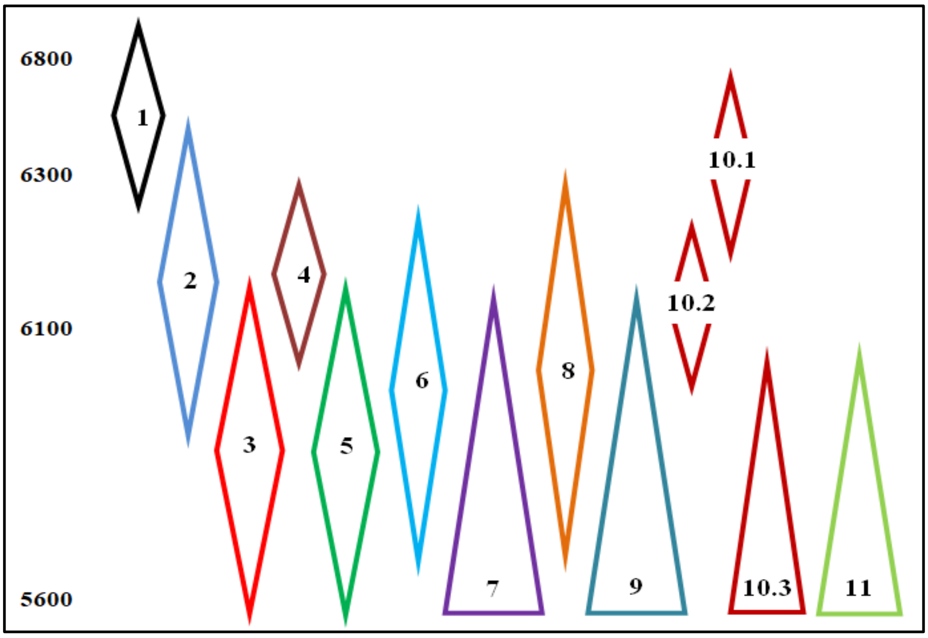


Figure 2.5. Chronological distribution of pottery groups (Campbell, 2012).

2.1.2. Field Soil Samples

Kahramanmaraş Plain system located to the south of Kahramanmaraş province; compose from Maras, Sağlık and Narlı plains. Domuztepe settlement is located in Narlı Plain which one of the these plains. In order to compare with the clay raw materials used in the production of Domuztepe ceramics and to understand the dominant clay variety in the vicinity of the settlement, field soil samples were taken from 7 different locations (Figure 2.6). During the selection of these locations, different sedimentary areas in the region had been taken into consideration.

These also include some areas within the boundaries of Maraş and Sağlık Plain. The areas shown in the blue pins on the map (Figure 2.6) are the areas where samples are collected.

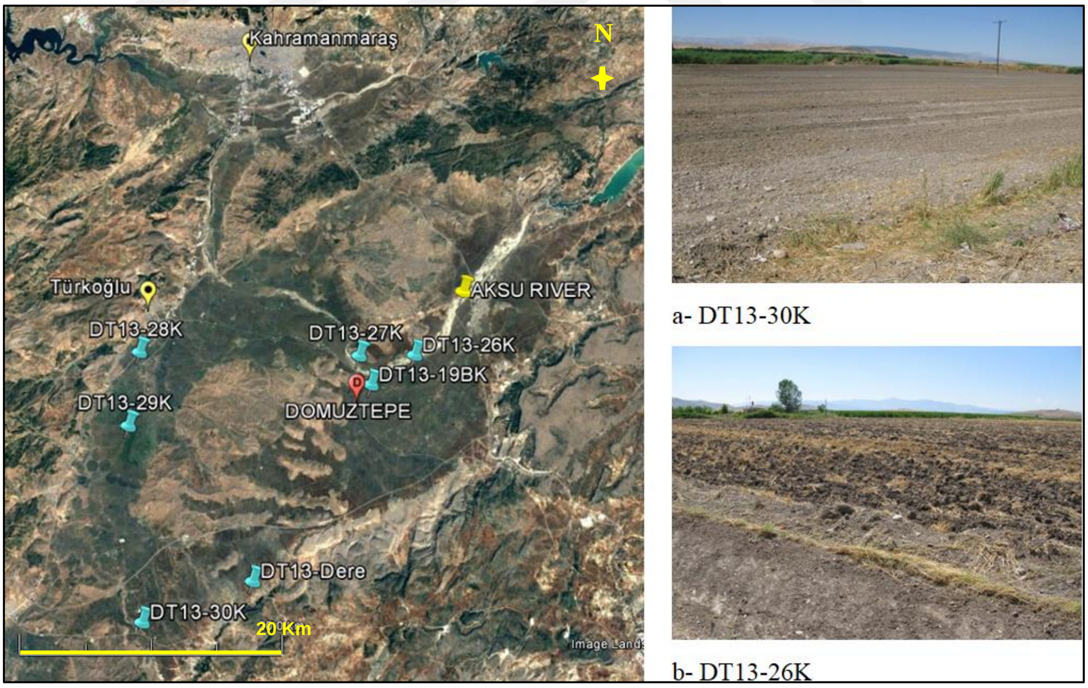


Figure 2.6. Aerial photograph showing locations where field soil samples are collected. The blue spots shown that field soil samples locations. Two of this locations (a: 37 315700E, 4138653N b: 37 331067E, 4134601N).

2.1.3. Domuztepe Stone Vessel Samples

Among the finds discovered in many archaeological excavations in the Near East, stone vessels are common. Nevertheless, the amount of such finds varies greatly between the Late Neolithic settlements in the Near East. On the other hand, these stone vessels seem to have a very low rate in the total amount of the excavated finds. Although the amount of stone vessels finds is lower than that of pottery, the life of a stone vessel is much longer than the pottery made from fired clay (Nelson, 1991; Shott, 1996; Campbell, 2013).

As summarized above, it is known that since the beginning of the Neolithic period Stone bowls existed in Northern Mesopotamia. Halaf tradition stands out especially with pottery and very decorated vessels. In Domuztepe excavations, more than 20 tons of pots were unearthed during 10 excavation seasons. During the 2009 season, the collection of stone vessels finds at Domuztepe was a bit more than 630 pieces (Campbell, 2013).

The Domuztepe settlement is 20 hectares in size. Excavation work at the Domuztepe has been carried out to an area of approximately 3,000 square meters.This area, corresponds to about one percent of the settlement. Stone vessel fragments had been recovered from every level thus far excavated at Domuztepe, from the Late Pottery Neolithic to later Halaf. Taking this data into consideration and assuming that stone vessel manufacture was a regular activity, it could be estimated that the amount of stone vessel findings to be uncovered from the entire settlement is about a few thousand (Campbell, 2013).

In a paper published by Campbell in 2013, it is stated that a large portion of the stone vessels recovered from the Domuztepe excavations are serpentine, serpentinite and basalt. Around 86% of the stone vessel fragments at Domuztepe are diagnostic: rims, bases, full profiles and complete vessels. The vast majority of the stone vessel fragments (86%) are manufactured from locally available raw materials – are mainly serpentinite and basalt. Of the remainder, gypsum (2%), limestone (6%) and obsidian (3%) are the most frequently occurring, with single examples of a number of other rock types (Figure 2.7) (Campbell, 2013).

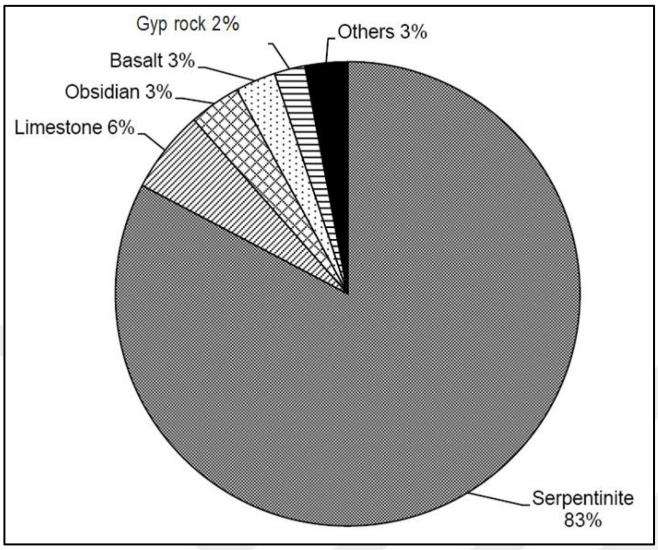


Figure 2.7. Types of rock used to make the Domuztepe stone artifacts (Campbell 2013).

It is estimated that these vessels are produced in the settlement, that is, they are local production and that the raw material resources are located in the vicinity of the settlement (Campbell, 2013). Ophiolitic units are encountered in the Narlı Plain where the settlement is located and its vicinity. This situation supports the viewpoint mentioned above. However, it is thought that secondary sources (non-in situ) such as river pebbles may have also been benefited. A numerous of artifacts were found to support this idea. It is understood that, a number of vessels are from river pebbles of different types, often shown by the flattened areas on one side. Especially the stone vessels in green color are findings of this kind (Campbell, 2013).

As briefed above, since the beginning of the Neolithic period, stone vessels had been known presence in North Mesopotamia. Stone vessels have had an important place also in Domuztepe excavation findings. Preliminary research in Domuztepe show that us, the raw materials used in stone vessel production are selected consciously, and these raw material known as “soft stone” or “soap stone”. The findings manufactured from these stone raw materials are encountered in Domuztepe. These stone findings which were considered seal, vessel or figurine have a fine workmanship (Figure 2.8). See the Appendix B for photos of all stone vessel samples.

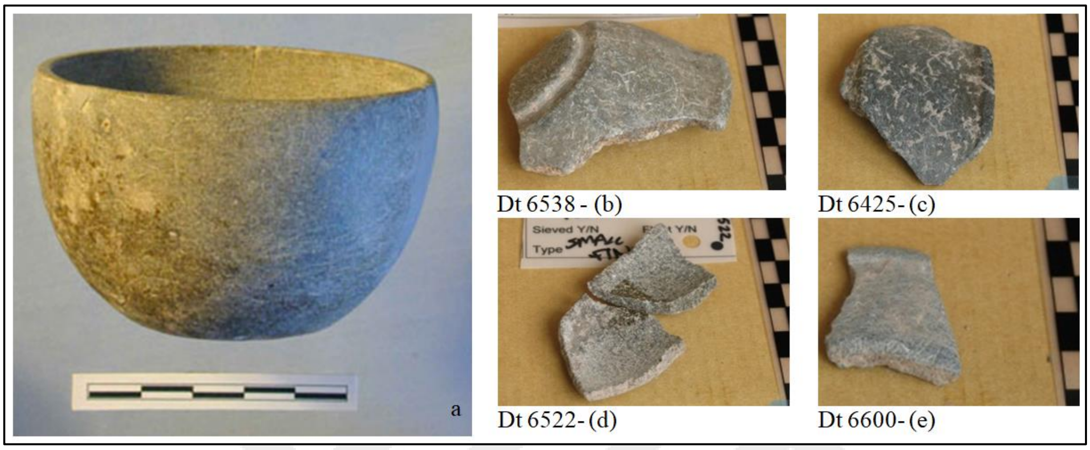


Figure 2.8. A group of the stone vessel samples examined in this study. a (from Kahramanmaraş Museum), b, c, d, e (stone vessel fragments). For the samples analyzed, permission was obtained from the Kahramanmaraş Museum.

The sample of the 47 stone vessels which were the subject of our research is classified according to the archaeological stratigraphy of the Domuztepe settlement. This chronological distribution are presented in Table 2.5 According to this table, chronological data for example 6436 is not exact and 5 samples are surface finds and therefore there is no chronological data of them. The remaining 42 samples are distributed over a period of about a thousand years.

Table 2.5. Chronological distribution of Domuztepe stone vessels findings.

Chronology	Sample Pop.	Sample Number
6,400-6,200	1	6538
6,200-6,100	2	6608, 6436?
6,100-5,800	4	6425, 6524, 6435, 6436?
5,700-5,650	2	374, 634,
5.650-5,600	8	602, 629, 592, 636, 627, 2098, 2106, 2200
5,600-5,575	11	3511, 6446, 6487, 6522, 6567, 6535, 6600, 6607, 6618, 6605, 6611
5575	2	637, 1479
5,575-5,500	3	1313, 1315, 1480
5,500-5450	10	330, 261, 501, 962, 960, 2444, 1457, 2125, 3616, 3867
No time data	5	338, 1308, 379, 2093, 1475

Stone vessels, due to their fine workmanship and rare archaeological material, are sometimes described as a prestige ware by archaeologists. This situation suggest that Domuztepe plays an important role in production and distributing of these kind of stone objects. Therefore, it is important to determine the quality and sources of raw materials of stone vessel.

In interviews with the excavation team, it was understood that the small stone findings that emerged during excavations produced from 10-12 different rock types and there has been an exchange of views on distrubution of these rock types on Domuztepe and its vicinity. It is thought that the vast majority of stone vessel findings produced from ultramafic type rocks (Campbell, 2013). A high ratio of vessels made of ultramafic type rocks, suggesting that Domuztepe could be one of the stones vessel production centers for their regions.

During the literature survey it has been found in some publications to support this idea.The stone vessel tradition in the Mediterranean has been mentioned above. It is known that this type of stone vessels found in excavations in Syria, North of Iraq and Levant. The raw materials for these stone vessels is believed to be obtained from the long-distance and middle-distance source area (Rosenberg et al., 2010; Kozlowski & Aurenche, 2005). Even one of the this publications is shown as one nearest possible source areas in south-east of Domuztepe (Figure 2.9) (Rosenberg et al., 2010). This geologic units are known as Koçali Complex and it is located 30 km west of Gaziantep (Robertson, 2002). Koçali complex is composed of upper cretaceous ophiolithic. Furthermore, some geological units commonly observed in the region is also considered as source areas of raw material. The scope of the our field work has been determined by considering this information.

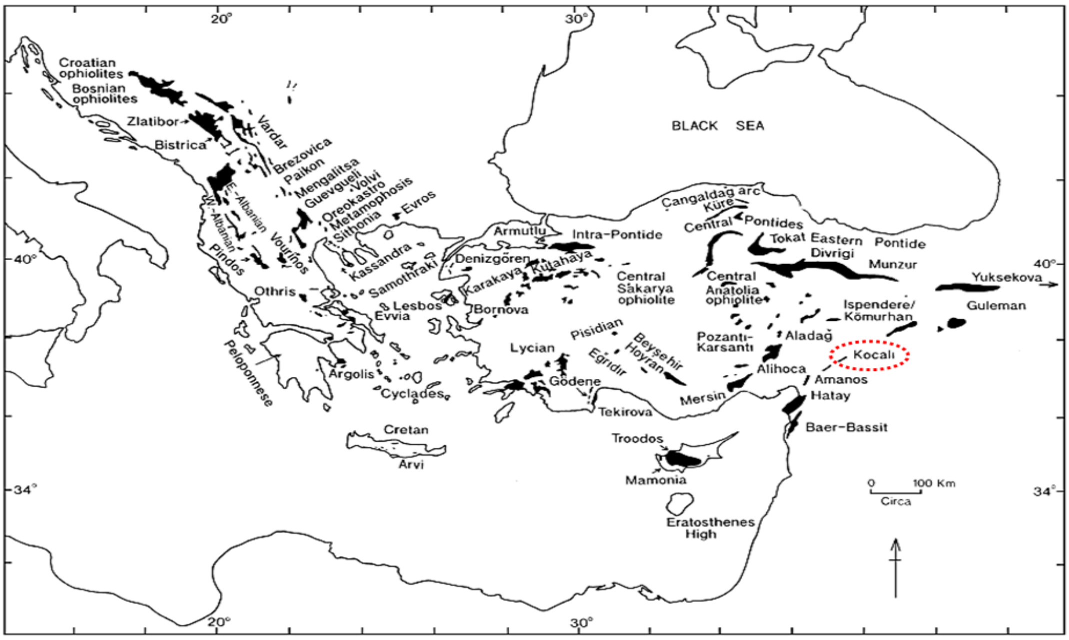


Figure 2.9. Map of spreading ophiolites in the Eastern Mediterranean Region (Robertson, 2002). The Koçali Complex is marked with red.

In this study, thin section, XRD, SEM-EDX and ICP-OES/MS analyzes were performed on the all samples. Thus, the qualities of the raw materials used in the manufacture of stone vessels been tried to determined and in the production of vessel, is to determine how many different raw materials used. In addition, by geological field studies, potential source areas have tried to determine. During the field study, samples were taken from ophiolithic units (Koçali complex, Ophiolitic Nappes etc.) as the possible source rocks for Stone vessels and petrographic analyzes were performed on these samples. In this way, it is tried to make a qualitative comparison of the archaeological samples with samples collected from the field.

2.1.3.1. Field Rock Samples

During the field studies, samples were taken from ophiolithic units (Koçali complex, Ophiolitic Nappes etc.) in order to locate the possible raw material sources for stone vessels. Field studies were carried out in four stages considering the results of analytic studies (Figure 2.10). In the first stage (first field study

2011), mineral composition of stone vessel samples were detected with the help of thin sections and XRD analysis. According to petrographic analysis, it was determined that the rock type is a kind of meta-serpentinite (Petrographic and mineralogical findings are described in the relevant Section (see Section 3.2.1.) In light of this information, the geology of the region were examined and were identified areas for sampling. For this examination, some research about ophiolite in region has been taken into account (Bağcı, 2004, 2013; Parlak et al., 2009). First field study shown as black circle on map at Figure 2.11 Each field study has been planned according to results of the analysis of a previous field study.

Second field (2013) study were planned to visit the ophiolitic units containing of serpentinite, nearest to Domuztepe settlement. Three large ophiolite blocks were identified on the north and south side of river in the Narlı Plain and sampling taken from this exposures. These exposures belong to the ophiolite Naps which are Late Cretaceous aged alloctonous geologic units. Because of their closeness to the Domuztepe settlement vicinity (within 2 km away from the settlement), these areas had been selected primarily for the study.

Also from the Aksu River bed, pebbles, believed to had been derived from ophiolitic units were collected. This is because, stone findings have a rounded shape and surfaces are burnished. River pebbles take a rounded form through sedimantary processes due to stream transportation . Therefore, some of the river pebbles might had been preferred deliberately in the production of stones vessels (its shown as yellow circle on map at Figure 2.11).

In addition to these, in the second field study has also focused on also three possible source areas, located further away from Domuztepe. These areas are located on west (south of Andırın, 60 km from the setlement), north-east (north of the Araban, 50 km from the settlement) and south-east (Yaylacık, west of Gaziantep, 30 km from the settlement)of settlement. Different from previous field studies, geological units on the Koçali Complex were preferred for the sampling (its shown as yellow circle on map at Figure 2.11).

South-west of the Türkoğlu, Undifferentiated harzburgite, dunite, serpantinite etc./ Mesozoıc (37299773E, 4136378N).

South of the Sakçagöz, Undifferentiated harzburgite, dunite, serpantinite etc./ Mesozoıc (37295785E, 4132439N).

North-west of the Narlı, Undifferentiated harzburgite, dunite, serpantinite etc./ Mesozoıc (37302210E, 4135139N).

Front of the Kartalkaya Dam barrier (37343661E, 4148457N).

Figure 2.10. Some locations where rock samples were collected during field work.

During the third field study (2014), four different locations were determined for the sampling (its shown as red circle on map at Figure 2.11). Two of these areas (ophiolitic units north and south of the Aksu River) were re-visited to perform a more detailed sampling using the remote sensing method, although they were also used in previous field studies. Exposures belonging to the Late Cretaceous age Ophiolite Nappe were investigated and field rock samples were collected for further analytical studies in the vicinity of Kartalkaya Dam and Narlıca village.

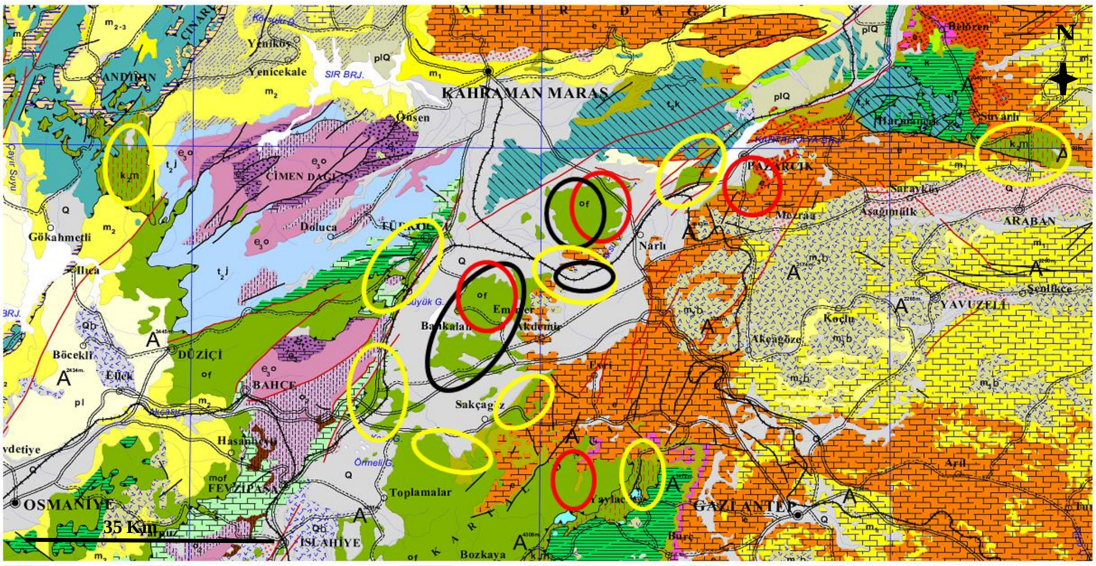


Figure 2.11. The distribution of the geological units which are thought to be used as raw materials in the production of stone vessels, and the areas in the vicinity of Domuztepe where rock and soil samples are collected during the field studies (The black circles represent the locations where the first field work was carried out, the locations where the yellow circles second field work was carried out, and the red circles represent areas where the third field work was concentrated.). See Figure 1.4 for lithology information (MTA, 2002, Hatay-1/500.000).

Prior to the last field work the study area was investigated by means of Remote Sensing technique using the facilities available in the Remote sensing Laboratory at the Geological Engineering Department at METU.

Firstly spectro-radiometric analysis of stone vessel samples were made (summer 2015). As a result of these analyzes, some key minerals (Tanyaş & Dirican et al., 2017) and rocks compositions were determined for use in the provenance analyzes. Based on the data obtained the locations of potential raw material sources in the field was determined by the spectral satellite imagery. Details of this study are given under the relevant heading (Remote Sensing and Sampling). According to the results of this remote sensing study, 4 different areas and approximately 40 locations has been determined in the vicinity of the Domuztepe (Figure 3.1).

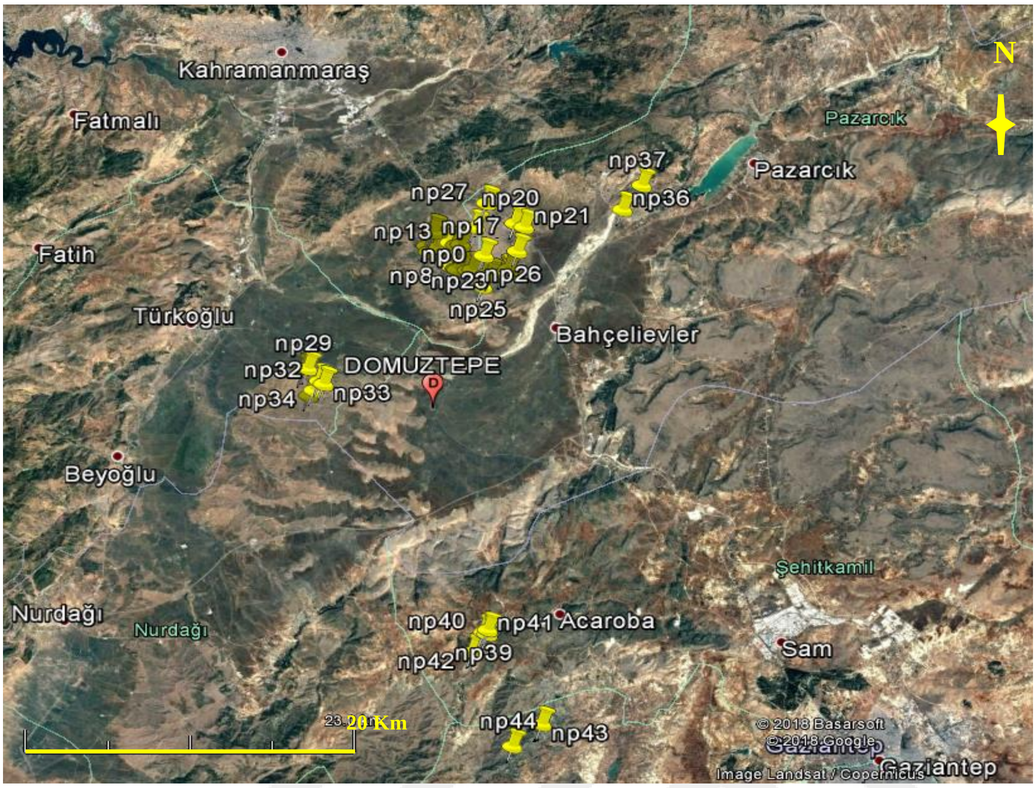


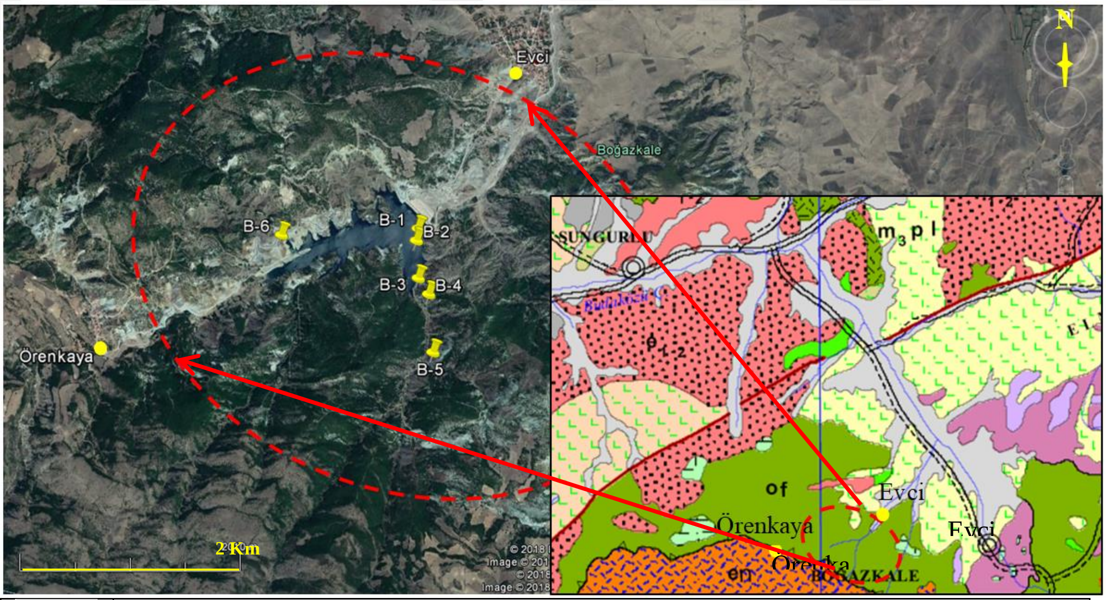
Figure 2.12. Sampling points targeted in the third field study. These target points were determined by remote sensing method

In the last period of field study, an observation field-trip was organised around Boğazkale-Hattuşa where the remains of Hittite period in Sungurlu-Çorum were found. In this region, there are some workshops, producing small stone sculptures or figurines as souvenirs for tourists. Rock type used in the production of small sculptures, show great similarities with the raw materials of stone vessels found in excavations of Domuztepe (Figure 2.13) at the macroscopic level.

Figure 2.13. Souvenir benches at the ancient Hittite city Hattuşsa (Boğazkale). All of the figurines and reliefs on these benches are produced from ultramafic (probably serpentine etc.) type rocks in the ophiolitic units commonly found in the area.

The raw material used in production of figurines at these workshops, was provided from a location in the west of the Evci village near Boğazkale where ophiolitic units are exposed around the Evci village. In order to compare petrographic properties of potential raw materials for he Stone vessels, about 10 samples from 6 different locations were collected during this field study (Figure 2.14).

Aim of this field trip was defined petrographic properties of the raw material used in figurines and to compare with petrographic properties of the geological units in the potential source areas.



	Evaporite sedimentay rocks / Upper Miocene-Pliocene
	Evaporite sedimentay rocks / Oligocene-Lower Miocene
	Clastic rocks / Lower-Middle Eocene
	Undifferentiated volcanic rocks / Eocene
	Clastic and Carbonate rocks / Paleocene
	Clastic and Carbonate rocks / Upper Cretaceous
	Pillow lava and sedimentary rocks / Upper Cretaceous
	Neritic Limestone / Upper Jurasic-Lower Cretaceous
	Clastic and Carbonate rocks / Permo-Triassic
	Undifferentiated basic and ultrabasic rock / Mesozoic
	Active fault
	Reverse fault

Figure 2.14. The locations of the samples taken during the observation trip around Çorum-Boğazkale on the geological map (MTA, 2002, Sinop-1/500.000).

2.2. Analytical Studies

In the scope of this study, the process of analytical studies carried out are summarized in the following diagram (Figure 2.15). More than one analysis was performed on each sample in order to compare the produced data. In this analysis process, the thin section analysis was used as a pilot analysis. In this context, thin section analysis was performed on all samples in the first stage (except for field soil samples) and regarding each sample, subsequent analysis was decided by the result of thin section analysis. In order to compare the data, multiple analysis on each of samples had to be implemented. Therefore, during the selection of the samples, size of each sample should be sufficient to perform multiple analysis.

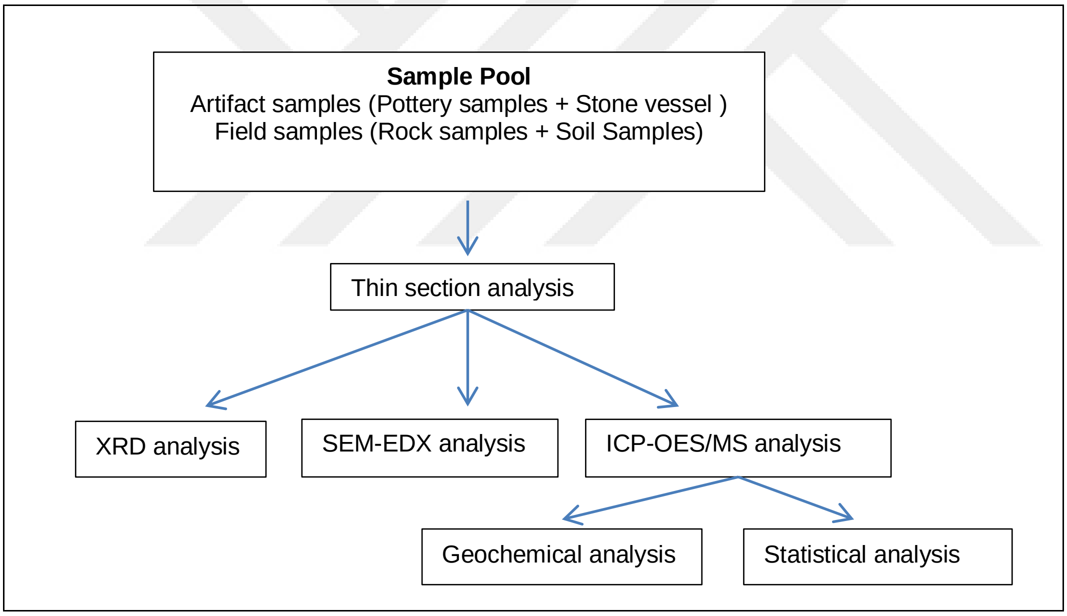


Figure 2.15. The flowchart showing the steps followed for the analytical studies.

2.2.1. Thin Section Analysis

Thin-section petrography is a technique conventionally used for the analysis of rocks, pottery and other materials because it provides a detailed understanding of the texture and the nature of the various mineralogical components and constitutive phases of the materials (rock composition, pottery paste etc.). Moreover, one can discover other important characteristics about the clay fabric through petrography (like the size of the inclusions and their distribution within the clay, existence of organic inclusions) leading to a better understanding of not only the possible clay source, but also post-collection procedures, like intentional tempering of and purification levels applied to the clay. Thin-section analysis allows the establishment of pottery-making techniques on the basis of the nature of the tempers, the roundness, or angularity, of the inclusions, and the grain-size and distribution within the pottery groundmass, firing temperature, firing atmosphere (Echallier, 1984; Quinn, 2009). The thin-section component volume proportions were measured by visual estimation (Folk, 1965). Additionally, some technological aspects related to the raw material treatments and paste preparations had been recognized.

Prepared slides of pottery thin-sections can be examined using a polarized light microscope with transmitted light, and the optical properties of the grains can be determined for the identification and characterization of the pottery paste and inclusions. Properties such as porosity and the preparation of the clay can also be studied. Thin sections were prepared by slicing the sherd and fixing the freshly cut surface to a glass slide with epoxy resin, followed by grinding and thinning down to a thickness of approximately to 30 microns, a standard thickness for petrographic analysis (Kerr, 1977).

For petrographic analysis thin sections were made at the Thin Section Laboratory - Department of Geology Engineering / METU. The petrographic analysis was done and digital pictures of the thin sections under cross-polarized and plane-polarized light were taken at the at the Mineralogy-Petrography Laboratory - Department of Geology Engineering / METU. The petrographic characterization was carried out using a petrographic polarizing Olympus BH2 microscope, equipped with an Olympus DP-10 digital camera. A total of 204 samples (66 pottery, 47 stone vessels and 91 field rock samples) were examined during the thin section analysis (Table 2.5).

2.2.2. X-Ray Powder Diffraction Analysis (XRD)

XRD, on the other hand, requires the samples to be in powder form for the instrument to measure the minerals within the clay fabric. This method is more of a black-box system compared to petrography. Therefore, in this dissertation the results of the petrographic analysis were taken as principal data and the results from XRD analysis were used to fine-tune the data obtained through petrographic analysis (Tsolakidou, et al., 2002).

The mineralogical composition of the samples was measured by XRD. In order to measure the mineralogy of the bulk material, about 1 g of the powdered sample (grain size <170 mesh) was placed in a sample holder and compressed with a glass slide. The samples were measured using with a Cu–Kα source. The glass slide used for compressing the sample was roughened, in order to suppress a preferred orientation of the platy clay particles.

The clay fractions of the samples (grain size <2 micrometer) were also examined. In order to prepare oriented specimens, a small amount of the clay–water suspension was pipetted on to a glass slide and left to dry. For better adhesion of the sample, slides with a slightly ground surface were used. Afterwards, one of the air-dried samples was saturated in an ethylene glycol atmosphere and another heated for 1 h at 300 and 550° C. From each clay sample, one air-dried specimen, one ethylene glycolated and two heated specimen were measured, in order to distinguish between particular phyllosilicate minerals (Brindley & Brown, 1980).

X-Ray Diffraction facilities at the XRD Laboratory - Department of Geology Engineering / METU and XRD Laboratory - MTA (Mineral Research & Exploration General Directorate-Ankara) were used to acquire mineralogical information about the samples. The XRD analysis was done on Bruker D8 Advance, Panalytical X'Pert Powder and Philips PW 1830 Difractometers. The wavelength used was Cu K-a radiation at 45kV and 40 mA. Diffraction patterns were recorded from 5-75° 2 6 with the sample spinning at one revolution per 16 seconds. Mineral identification was performed using the software program HighScore Plus. The results of the XRD analysis were combined with the results of petrographic analysis to fine-tune the fabric types defined as a result of the petrographic analysis and to enrich the characteristics of these fabric types.

2.2.3. Inductively Coupled Plasma–Optical Emission Spektrometry / Mass Spectrometry (ICP-OES/MS)

ICP–OES/MS is an analytical technique that is becoming increasingly popular for determining the provenance of materials found in archaeological contexts (Tykot & Young 1996; Mallory-Greenough et al., 1998; Speakman & Neff 2002; Neff, 2003). ICP-OES/MS analysis were performed by ACME Laboratories-Canada. ICP-OES/MS instruments to provide a fully extracted quantitative analysis for all elements. Detection limits are comparable to industry leading mixed acid trace element ICP-OES/MS packages. Multi-acid digestion packages are capable of dissolving most minerals. ICP-OES/MS and Ultra Trace ICP-OES/MS analysis to give near total values for all elements. A 0.25 g split is heated in HNO3 , HClO4 , HF to fuming and taken to dryness. The residue is dissolved in HCl.

The potential advantages of ICP– OES/MS compared to other techniques include: (1) the ability to analyse small samples, thus making it a less destructive technique (particularly when coupled with laser ablation); (2) more target substance (~70); (3) lower detection limits (parts per billion) on more elements relative to other techniques; (4) the possibility of measuring the isotopic ratios of some elements; and (5) a lower cost per sample, particularly compared to INAA (Tykot & Young, 1996). The application of this technique to archaeological materials is in its infancy, and a great deal of methodological development is needed to effectively contend with contamination problems associated with measuring small samples and the difficulties in characterizing heterogeneous materials. Dissolution techniques must also be improved to effectively measure certain elements (Tsolakidou et al., 2002). However, used cautiously, ICP– OES/MS can be employed to discriminate source-related compositional groups and ultimately help reconstruct prehistoric interaction and trade. The capabilities of ICP– OES/MS are also expanding as sample preparation techniques improve and more sensitive magnetic sector instruments equipped with multicollectors become widely available (Neff, 2003).

2.2.4. Scanning Electron Microscopy coupled with Energy Dispersive X-Ray Analysis (SEM-EDX)

Morphological characteristics of the samples were determined using SEM in order to investigate the vitrification levels the samples have reached. This study is based on the standards created by Tite and Maniatis in early 1980s where the scholars determined firing temperatures of ancient pottery based on the vitrification levels of the pottery discernable through high magnification levels the SEM imagery can provide. On some samples quantitative chemical analysis was done using EDAX to determine if chemical compositions of the clays conform to the distinctions established through mineralogical analyses. For this purpose, QUANTA 400F Field Emission SEM system at Central Laboratories / METU was used.

SEM was used as a high-resolution imaging technique as well as a semi-quantitative compositional analysis tool. In compositional analysis, SEM works by sending an electron beam at the surface of matter and measuring the quantity of electrons refracted at various angles. SEM images are generated by means of X-ray microscopy at resolutions as high as a few microns. Crystal structure can usually be determined to some extent by means of this high-resolution microscopy, especially when considered along with compositional data. Because SEM involves refraction of X-rays off a surface of variable topography—as opposed to XRD, which requires a perfectly smooth surface—count rates are less accurate. Compositional analysis is therefore semi-quantitative rather than fully quantitative. SEM was used as an indication of composition, as a supplement to the fully-quantitative technique of TD, and as a crystal structure imaging tool. Temper types were discerned using compositional analysis, and firing states were inferred from X-ray images (Tite, 1982).

2.2.5. Cluster Analysis

Cluster analysis techniques allow the investigation of the relationships between the objects or the variables of a dataset, in order to recognise the existence of groups. In this study, agglomerative hierarchical methods and the *K*-means method are applied: the theoretical aspects of these techniques are not taken into consideration here since they have already been described elsewhere. In the hierarchical method objects are grouped on the base of inter-object distances.

Cluster analysis is the most common multivariate statistical method used in the chemical study of pottery (Baxter, 1994, 2009; Everitt et al., 2011, Kettenring 2006; Papageorgiou et al. 2001; Bourriau et al., 2004; Mallory-Greenough et al., 1998; Barone et. all. 2005; O'Driscoll, 2003) because it allows all of the elemental concentrations in each sample to be considered, representing the chemical similarities and differences as a visual tree diagram. SPSS software was used for cluster analysis (SPSS 15.0). In the SPSS clustering analysis, the hierarchical cluster method was preferred. In addition, z-score standardization was performed on the data because all of the chemical data were not in same scale (main elements%, trace elements ppm).

CHAPTER 3

RESULTS OF THE STUDY

3.1. Pottery Samples

3.1.1. Thin Section Analysis of Domuztepe Pottery Samples

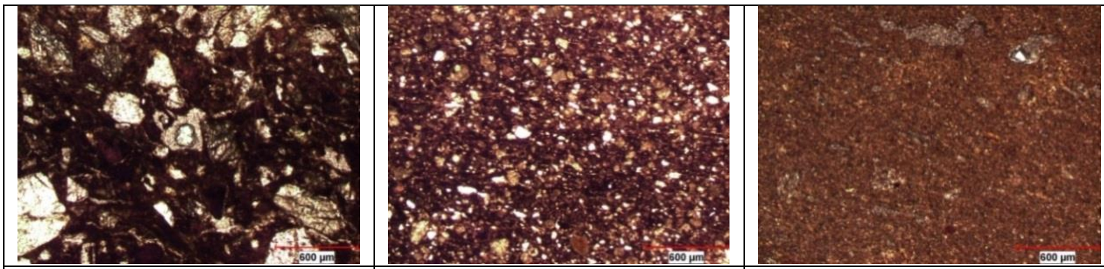
In the first stage of analytical work; analysis has been launched on 66 pottery samples which are thought to represent the entire collection. Thin sections of these samples were prepared and some of petrographic properties were determined.

For the first investigations on thin sections of the pottery samples, seven main petrographic variable was determined. These variables were selected for comparison of the samples from petrographic direction. These variables are listed below.

1.Texture (microstructure of rock or ceramic im thin section), 2. Hematitization (a kind of rock alteration), 3.Existence of organic matter (as a temper), 4. Existence of fossil (from rocks), 5. Zoning (the layers resulting from firing or cooling conditions), 6.Existence of rock fragment (as a temper) and 7.Main mineral composition (as a temper).

Considering these qualitative variables, observations were made on each sample. These qualitative observations were converted to quantitative data. In other words, each variable related to observational data has been shown in the form of some oppositions like that presence-absence or fewness-abundance.

Texture: According to grain size of aggregate, some classes like coarse (C > 200 μm), medium (M >50 μm) and fine (F < 50 μm) were defined (Figure 3.1)



4916U2-x4-PP **Coarse** (C)	4928bwb1-x4-PP **Medium** (M)	4927in-x4-PP **Fine** (F)

Figure 3.1. Classification of the grain size of aggregattes

Hematitization: Presence-absence of hematitization were defined and it was classified according to more or less (Figure 3.2).

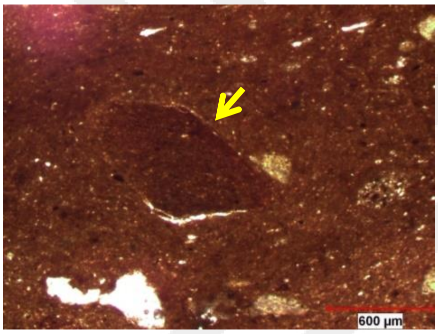
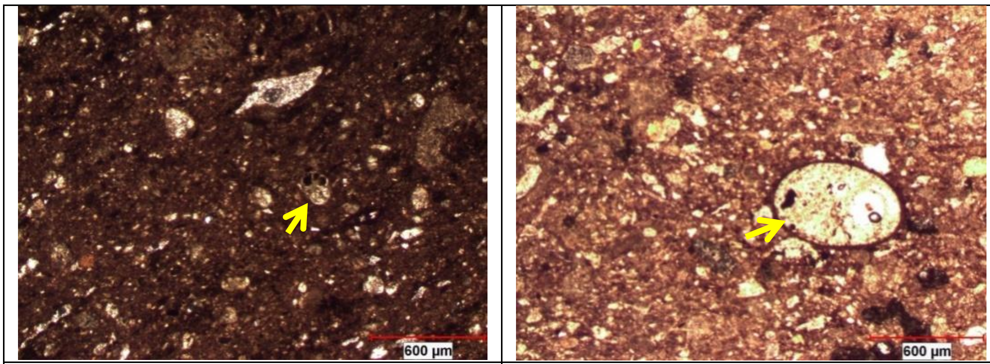


Figure 3.2. Distinctive hematitization 4927PO-x4-PP

Existence of organic matter: Presence-absence of organic matter were defined and it was classified according to more or less(Figure 3.3).

Figure 3.3. Rich in organic matter. 4916vt-x4-PP

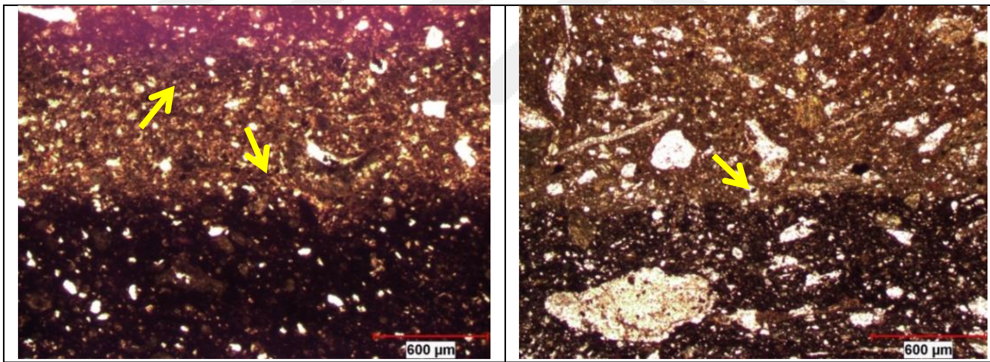
Existence of fossil: if whether there are fossils, it was classified according to more or less.The type of the fosil is identified when possible (Figure 3.4).



4916pb-x4-PP	4915in1-x4-PP

Figure 3.4. Two samples containing fossil

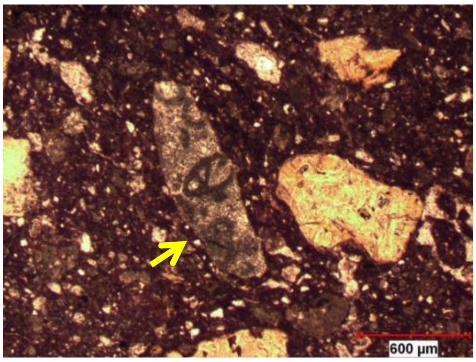
Zoning: Zoning may be observed due to laminations or may be resulted from the effects firing (Figure 3.5).



4928bwb3-x4-PP	4927cv-x4-PP

Figure 3.5. Two of the samples showing zoning

Existence of rock fragment: Such as micritic calcite or quartzite, presence-absence of rock fragment were defined and it was classified according to more or less (Figure 3.6).

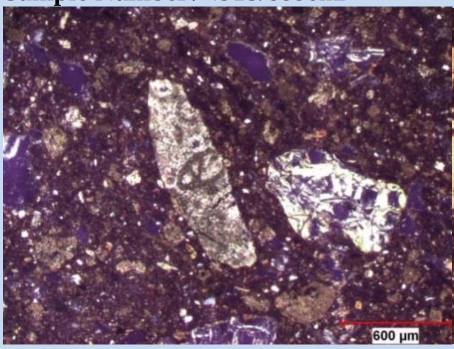


4915bbbon2-x4-PP

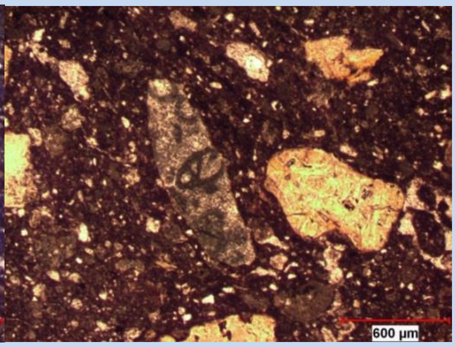
Figure 3.6. A sample containing a large amount of rock fragments

Main mineral composition: Main mineral species found in the samples were determined (e.g. serpentine, quartz, K-feldspar, mica etc.) and it was classified according to more or less. Observation data-sheet has formed as follows for each sample (Figure 3.7).

Sample Number: 4915/bbbon2



4915bbbon2-x4-XP



4915bbbon2-x4-PP

Texture: Matrix of rock is dominated by organic matter and iron staining. Coarse-grained minerals and rock fragments are observed predominantly in the thin section. All types of grains are observed in a soft-edged and relatively rounded shape. Coarse grains are mictitic calcite, quartzite (less), serpentinite and K-Feldspar. It contains a large amount of fossil fragments.

Medium size grains: Mictitic calcite, quartzite, serpentinite and K- Feldspar.

Hematitization: Observed

Organic matter: Observed abundantly.

Fossil fragment: Observed abundantly.

Existence of Zoning: Not observed

Existence of rock fragment: Abundance of micritic calcite. Quartzite and serpentinite are observed.

Main mineral composition: Quartz (fine grains), K- Feldspar, serpentine, mica.

Figure 3.7. Sample of observation data-sheet.

These variables, which were determined for each sample, were combined in one table (Appendix C).

Some simple inferences were made, using digitized observational data in the (Appendix C). These inferences were made considering certain conditions like that presence-absence or fewness-abundance. However, these conditions are not limited to petrographic criterias. In this cluster of circumstances, there are also some of archaeological features of pottery. For example: Some decorative elements, such as painting or scraping, the stuation of being coarse or fine pottery...etc. As a result of these inferences, some emerging assumptions are as follows.

Condition 1: General situation in the table (Appendix C)

Possible inferences:

- It is observed that in most of the samples, different additives, like minerals, rock fragments, organic matter are used.
- It is observed that serpentine additives were preferred during earlier periods.
- The fossils observed in some samples, can provide information about the source of the additive.
- The number of samples for which the zoning is observed are less in amount. Zoning may provide data about the firing conditions.

Condition 2: Texture=F
(Distrubution of fine texture samples- **F**ine, **M**edium, **C**oarse- Table 3.1)

Table 3.1. Correlation of variables in the fine texture samples

	Pottery samples	**SC**	**OM**	**H**	**F**	**Z**	**T**	**RF**	**S**	**C**	**Q**	**AF**	**M**
Lot4915 Owen Before Red Terace	Lot 4915 - 1E Black Burnished	B	2	2	1	1z	F	0	0	1	?	?	?
Lot 4928 Transition of Halaf (Later than 4915-4916):	Lot 4928 - 5 Brown Burnished	B	2	0	1	1	F	0	0	0	1	1	1f
	Lot 4928 - 3 Black Burnished	B	1	2	1	1z	F	1	0	1	1	1	1
	Lot 4928 Unpainted	UH	1	2	2	0	F	1	0	1	1f	1f	1f
Lot 4927 Later Halaf	Lot 4927 Red Burnished	B	2	1	2	0	F	0	0	1c	1	1	1
	Lot 4927 Painted Orange	PH	0	2	1	0	F	1	0	1c	1f	1	0
	Lot 4927 Bichrome		?	1	1	1	F	1					
	Lot 4927 - 1 Incised	I	0	1	1	0	F	1	0	1c	1	1	1
	Lot 4927 Brown Burnished	B	1	1	1	0	F	1	0	1	1f	1f	1f
A group of samples that look similar but different from DT Painted Orange and Bichrome.	DT09 Lot 4842) Plaster Coated		0	1	1	1	F	1	0	1	1	1	1

SC: Stylistic class, **OM:** Organic matter, **H:** Hematitization, **F:** Fossil, **Z:** Zonning, **T:** Texture, **RF:** Rock fragment, **S:**Serpentinite, **C:** Calcite, **Q:** Quartz, **AF:** A. Feldspar, **M:** Mica

Possible inferences:

- Organic matter was observed in early period samples. In later period samples, minerals additives are more in amount compared to the other type of additives.
- In the production of fine-textured pottery, serpentine may not be preferred as additive matter.
- Calcite and magmatic origin additive were preferred as additive matter in the production of fine-textured pottery.
- According to Table 2.5, the fine-textured pottery were encountered in all periods. This may mean that, such fine-textured pottery vessel were produced for special purposes (storage of liquids etc ..) at all periods.

Condition 3: Stylistic Group=I, the samples distribution of incised decorated (Table 3.2)

Table 3.2. Correlation of incised decorated pottery

	Pottery samples	**SC**	**OM**	**H**	**F**	**Z**	**T**	**RF**	**S**	**C**	**Q**	**AF**	**M**
1. 4915 Owen Before Red Terace	Lot 4915 -1 Incised	I	2	1	2	0	C	1	0	1c	1c	1c	1f
	Lot 4915 - 2 Incised	I	0	2	1	0	M	1	0	1c	1	1	1
Lot 4928 Transition of Halaf (Later than 4915-4916):	Lot 4928 Incised	I											
	Lot 4928 - 2 Incised	I	2	1	2	1	C	0	0	1c	1	0	0
	Lot 4928 - 3 Incised	I	2	1	2	1	C	1	1	1	1	1	1
Lot 4927 Later Halaf	Lot 4927 - 1 Incised	I	0	1	1	0	F	1	0	1c	1	1	1
	Lot 4927 - 2 Incised	I	1	1	1	0	C	1	0	1	1c	1c	1

SC: Stylistic class, **OM:** Organic matter, **H:** Hematitization, **F:** Fossil, **Z:** Zonning, **T:** Texture, **RF:** Rock fragment, **S:**Serpentinite, **C:** Calcite, **Q:** Quartz, **AF:** A. Feldspar, **M:** Mica

Possible inferences:

- For the most of the samples with incised decoration , the organic additives are more than mineral additives.
- Serpentine may not be preferred as mineral additives.
- Mineral additives may be used in different amounts.

Condition 4: Stylistic Group: PH, the samples distribution of decorated by paint (Table 3.3)

Table 3.3. Correlation of painted pottery

	Pottery samples	**SC**	**OM**	**H**	**F**	**Z**	**T**	**RF**	**S**	**C**	**Q**	**AF**	**M**
Lot 4915 Owen Before Red Terace	Lot 4915 Painted Pottery	PH	1	2	1	0	C	1	1?	1	2	1	1
Lot 4928 Transition of Halaf (Later than 4915-4916):	Lot 4928 Painted	PH	1	2	1	0	C	1	0	1c	1f	1f	0
Lot 4916 Owen After Red Terrace	Lot 4916 Painted	PH	?	1	1	0	C	1	0	1c	1	0	1
Lot 4927 Later Halaf	Lot 4927 Painted Orange	PH	0	2	1	0	F	1	0	1c	1f	1	0
	Lot 4927 Mature (painted) Halaf	PH	1	2	1	0	C	1	0	1c	1c	1c	1c
A group of samples that look similar but different from DT Painted Orange and Bichrome.	(DT 09 Lot 4924) DT Bichrome	PH	0	1	1	0	M	1	0	1c	1f	0	0

SC: Stylistic class, **OM:** Organic matter, **H:** Hematitization, **F:** Fossil, **Z:** Zonning, **T:** Texture, **RF:** Rock fragment, **S:**Serpentinite, **C:** Calcite, **Q:** Quartz, **AF:** A. Feldspar, **M:** Mica

Possible inferences:

- Serpentine may not be preferred as mineral additives.
- There is a clear decrease in the use of organic additives.

Condition 5: Stylistic Group:C, The distribution of the coarse pottery class as a style (Table 3.4).

Table 3.4. Correlation of variables in the coarse texture samples

	Pottery samples	**SC**	**OM**	**H**	**F**	**Z**	**T**	**RF**	**S**	**C**	**Q**	**AF**	**M**
1. 4915 Owen Before Red Terace	Lot 4915 Grid Coarse	C	2	1	1	0	M	1	1	1	2	1f	1c
Lot 4928 Transition of Halaf (Later than 4915-4916):	Lot 4928 Coarse Veg	C	1	1	1	0	C	1	0	1	1	1c	1c
	Lot 4928 Coarse Grit	C	2	1	2	1	C	1	0	1	1f	1c	1
Lot 4927 Later Halaf	Lot 4927 Coarse Vegetable	C	2	1	1	1	C	1	0	1	1c	1c	1c
	Lot 4927 Coarse Grit	C	1	2	1	0	C	2	0	0	1c	1c	0

SC: Stylistic class, **OM:** Organic matter, **H:** Hematitization, **F:** Fossil, **Z:** Zonning, **T:** Texture, **RF:** Rock fragment, **S:**Serpentinite, **C:** Calcite, **Q:** Quartz, **AF:** A. Feldspar, **M:** Mica

Possible inferences:

- Serpentine, in the early period may had been preferred as an additive in coarse pottery. In later period the use of serpentine might be abondened.
- Use of coarse grain minerals, rock fragment and organic matter may be a systematic preference in the production of the coarse pottery.

In the next phase of the petrographic study, thin sections had been re-examined and some petrographic clues for the detection of the pottery firing conditions (firing atmosphere, firing temperature and firing duration) had been investigated on the thin section of pottery samples.

Petrographic criteria are considered during this re-exemined are summarized below.

- Sintering starts at 600^0 C degrees and vitrification starts at 900-1100 ^{0}C degrees. During vitrification, some changes are observed in the calcite and clay minerals. Clay minerals are vitrified and calcite loose its crystalline structure. Clay particles become smaller and the pore structure is changed. The sintering and end eventual vitrification of the clay matrix of ceramics during firing leads to a change in the birefringence of its constituent clay minerals. As they fuse together and melt, the optical activity of the matrix, observed bay rotating the sample in XP at light pover, is reduced until it becomes anisotropic and glassy looking. Its thought that the clay matrix of much tridational earthenware pottery loss its birefringence between 800-850 ^{0}C during firing (Quinn, 2013).

- The color of the hornblende are green. At the 750 ^{0}C degrees, this green color turns to brown (Quinn, 2013).
- Similar changes (green color turns to brown) in the serpentin and glauconite minerals are seen at 600^{0} C (Quinn, 2013).
- Mica minerals lost its briefrigence beyond 900-1000^{0}C. It gets a dark brown color and, an expansion is observed between mineral cleavage surfaces (Quinn, 2013).
- When quartz is heated, at 573^{0}C, alpha quartz turns into beta quartz.When heating is stopped, this polymorphic transformation is reversed. In other words, quartz crystal expands when heated, and shrinks again when cooled. This phenomenon in thin sections, may show itself in the form of a thin pore space surrounding the quartz mineral in clay matrix (Quinn, 2013).
- Calcite is transformed into calcium oxide, between 650-750 ° C. Meanwhile, the mineral shows expansion and it may cause some cracks in the surrounding clay matrix(Quinn, 2013).
- At about 1000 ^{0}C temperature, apparent border with clay matrix of calcite minerals is lost due to vitrification and calcite minerals may show greenish color. The remains of the organic matter in clay matrix is carbonized at about 300 ^{0}C . At 600 ^{0}C degrees it completely disappears and leaves a space in its place (Quinn, 2013).
- If the color of the pottery is light (dark yellow, light orange and dark orange) it indicates that the amount of oxygen is enough in the medium (oxidizing medium=open air fire or sufficient air flow in furnace). If the color of the pottery is dark (black, gray and dark brown) it indicates that amount of oxygen is not enough in the medium (reductive medium= insufficient air flow in furnace) (Quinn, 2013).
- In the cross-section of pottery, if the color of pottery is lightened towards the edge of the cross-section (from dark brown to orange) , it means that pottery is

fired fast (short firing time). In the cross-section of pottery, if there is thin light-colored zone at pottery surface, this suggests that the pottery cooled rapidly. If there is thin dark-color zone at pottery surface, this suggests that the pottery was covered with organic matter during the firing (It can be wrapped in straw or straw) (Quinn, 2013).

According to the above criteria, re-evaluation of thin section characteristics was performed on 66 pottery samples. Results of this analysis presence in Table 3.5 and Table 3.6.

Table 3.5. Chronological comparison of burnished pottery according to production conditions and raw materials.

Sample name	**Firing atm.**	**Zonning (because of fast firing and fast cooling)**	**Birefringence of clay matrix**	**Thermal Minerals**	**Firing temp.**	**Type of clay**
Lot 4915-1E Black Burnished	Red	Fast firing + Covered organic substance	Exist	Absence	>600	
Lot 4915 - 2 Black Burnished	Red	Absence	Exist	Serpentine+Muscovit	600-900	Smectite
Lot 4915 - 1 Black Burnished	Ox	Absence	Not detected	Not detected	Not detected	
Lot 4915 Brown Burnished	Red	Absence	Exist	Serpentine +Calcite (not altered)	600-900	İllite
Lot 4915 -1 Incised	Red	Fast cooling	Exist	Biotite+ Calcite (not altered)	600-900	
Lot 4915 - 2 Incised	Ox	Covered organic substance	Exist	Calcite (not altered)	<900	
Lot 4915 Pattern Burnished	Ox>Red	Fast firing	Exist	Biotite+ Calcite (not altered)	<900	
Lot 4915 Leather Burnished 1-b	Ox>Red	Covered organic substance	Exist	Calcite (not altered)	800-900	
Lot 4915 - 2 Leather Burnished	Red	Fast firing	Exist	Calcite (not altered)	800-900	İllite+smectite
Lot 4928 Incised	Red	Fast cooling	Not detected	Serpentine+ Calcite (not altered)	600-900	
Lot 4928-2 Incised	Red	Fast cooling	Exist	Serpentine+Biotite	800-900	
Lot 4928-3 Incised	Red	Fast cooling	Exist	Biotite+ Calcite (not altered)	<900	
Lot 4928 - 1 Red Burnished	Ox>Red	Absence	Exist	Serpentine+ Calcite (not altered)	600-900	not detected

Table 3.5. (continue)

Lot 4928-2 Red Burnished	Ox>Red	Fast cooling + Covered organic substance	Exist	Serpentine+ Calcite (not altered)	600-900	
Lot 4928 - 1 Brown Burnished	Red	Fast cooling + Covered organic substance	Exist	Calcite (not altered)	<900	not detected
Lot 4928 - 2 Brown Burnished	Red	Fast cooling + Covered organic substance	Exist	Serpentine+ Biotite+Calcite (not altered)	600-900	not detected
Lot 4928 - 4 Brown Burnished	Red	Fast firing	Exist	Serpentine+ Biotite+Calcite (not altered)	600-900	smectite +chlorite +illite
Lot 4928 - 5 Brown Burnished	Red	Fast cooling	Exist	Biotite+Calcite (not altered)	<900	
Lot 4928 - 1 Black Burnished	Red	Covered organic substance (two surface)	Exist	Serpentine+ Biotite+Calcite (not altered)	600-900	not detected
Lot 4928 - 2 Black Burnished	Red	Fast firing + Covered organic substance	Exist	Serpentine+ Biotite	600-900	smectite +chlorite +illite
Lot 4928 - 3 Black Burnished	Ox>Red	Fast firing + Covered organic substance (two surface)	Absence	Calcite (altered)	>1000	
Lot 4916 - 1 Brown Burnished	Ox>Red	Covered organic substance (two surface)	Not detected	Biotite	800-900	not detected
Lot 4916 - 2 Brown Burnished	Ox>Red	Fast cooling	Exist	Serpentine+ Calcite (not altered)	600-900	
Lot 4916 Lether Burnished	Ox>Red	Fast firing	Exist	Serpentine+ Biotite+Calcite (not altered)	800-900	Smectite
Lot 4916 Lether Burnished (patterned and applied ???)	Red	Fast cooling	Exist	Serpentine+Cal cite (not altered)	600-900	İllite+sm ectite+ka olin?
Lot 4916 Pattern Burnished	Red	Fast cooling	Exist	Serpentine+ Calcite (not altered)	600-900	Smectite +illite
Lot 4916 Black Burnished	Red	Covered organic substance (two surface)	Exist	Biotite+Calcite (not altered)	<900	İllite+sm ektite
Lot 4927 Red Burnished	Red	Fast cooling	Not detected	Calcite (not altered)	<900	
Lot 4927 Lether Burnished	Ox>Red	Absence	Exist	Calcite (not altered)	<900	
Lot 4927 Black Burnished	Red	Fast cooling + Covered organic substance	Exist	Biotite+Calcite (not altered)	<900	Chlorite+ illite
Lot 4927 - 1 Incised	Ox>Red	Absence	Exist	Calcite (not altered)	800-900	
Lot 4927 - 2 Incised	Ox>Red	Covered organic substance	Exist	Biotite+Calcite (not altered)	<900	
Lot 4927 Brown Burnished	Red	Absence	Exist	Biotite	<900	İllite+sm ectite
(DT 09 Lot 4914) Lether Burnished?	Red	Fast cooling + Covered organic substance	Exist	Biotite+Calcite (not altered)	<900	
67 Neolithic	Red	Fast cooling	Not detected	Serpentine+ Calcite (not altered)	800-900	not detected

Table 3.6. Chronological comparison of Halaf pottery according to production conditions and raw materials.

Sample name	Firing atm.	Zonning (because of fast firing and fast cooling)	Birefringence of clay matrix	Thermal Minerals	Firing temp.	Type of clay
Lot 4915 Vegetable Temperd	Ox	Absence	Exist	Serpentine+ Calcite (not altered)	800-900	Smectite+ illite
Lot 4915 Unpainted	Red>Ox	Fast firing	Not detected	Biotite+ Calcite (not altered)	800-900	Smektite+ illite
Lot 4915 Grid Temperd Unburnished Coarse	Red>Ox	Absence	Exist	Serpentine+Biotite+ Calcite (not altered)	800-900	İllite+smectite
Lot 4915 Painted Pottery	Ox	Absence	Exist	Calcite (not altered)	800-900	
Lot 4928 Coarse Veg	Ox	Fast firing	Exist	Serpentine+ Calcite (not altered)	800-900	İllite
Lot 4928 Coarse Grit	Red>Ox	Fast cooling	Exist	Biotite+ Calcite (not altered)	<800-850	
Lot 4928 Painted (transitual and orange painted-check Olivier!)	Ox	Fast cooling	Not detected	Calcite (not altered)	<900	
Lot 4928 Unpainted (increases in transitual?)	Ox	Fast firing	Exist	Serpentine+ Biotite+Calcite (not altered)	800-900	İllite+smectite
Lot 4916 Organik Katkılı	Red>Ox	Absence	Exist	Biotite+Calcite (not altered)	<900	not detected
Lot 4916 Painted (similar to Halaf rather than transition)	Ox	Fast firing	Exist	Calcite (not altered)	600	
Lot 4916 Unpainted	Red>Ox	Fast firing	Exist	Biotite+Calcite (not altered)	<900	
Lot 4916 - 1 Unpainted	Ox	Fast firing	Exist	Serpentine+Calcite (not altered)	600-800	
Lot 4916 - 2 Unpainted	Ox	Fast firing	Exist	Serpentine+Calcite (not altered)	600-800	Smecktite +illite
Lot 4927 Coarse Vegetable	Red>Ox	Fast cooling	Exist	Calcite (not altered)	800-900	İllite+ chlorite
Lot 4927 Coarse Grit	Red>Ox	Fast firing	Exist	Serpentine+Calcite (not altered)	600-800	
Lot 4927 Unpainted Halaf	Ox	Fast firing	Exist	Serpentine+ Biotite+Calcite (not altered)	600-900	not detected
Lot 4927 Painted Orange	Ox	Fast cooling	Exist	Calcite (not altered)	<900	not detected
Lot 4927 Bichrome	Ox	Fast firing	Exist	Biotite	<900	Chlorite
Lot 4927 Mature (painted) Halaf	Ox	Absence	Not detected	Calcite (not altered)	<900	not detected
(DT 09 Lot 4924) DT Bichrome	Ox	Fast cooling	Not detected	Calcite (not altered)	<900	
(DT09 Lot 4842) Plaster Coated	Ox	Fast cooling	Exist	Biotite+Calcite (not altered)	<900	
67 Halaf?	Red>Ox	Fast cooling	Absence	Altered calcite	>1000	
67 Monochrome	Ox	Fast cooling	Not detected	Serpentine	>600	not detected
67 Bichrome	Ox	Fast cooling	Exist	Serpentine+ Biotite+Calcite (not altered)	<900	not detected

Table 3.6. (continue)

67 White Surface transition to Ubaid but not Ubaid??)	Ox	Fast cooling	Absence	Altered calcite	>1000	
96 White Surface	Ox	Fast cooling	Not detected	Serpentine+ Calcite (not altered)	<900	
96 Bichrome	Ox	Absence	Not detected	Serpentine+ Biotite	<900	not detected
96 Monochrome	Ox	Absence	Not detected	Altered calcite	>1000	not detected
96 Ubaid	Ox	Absence	Not detected	Altered calcite	>1000	not detected
70 Halaf	Red>Ox	Absence	Not detected	Biotite+Calcite (not altered)	<900	

Another investigation was also carried out on the pottery thin sections in order to determine the fossil species. In addition to calcite, limestone rock fragments and fossil fragments were observed in the majority of samples. The fossil species had been determined only in the 11 samples. They are identified as shown in Table 3.7.

However, the fossils species could not be determined with certainty. Although the fossil data may indicate some geological units in the region, it is not possible to use this information to suggest any source location for the raw material of the ceramic samples.

Table 3.7. Observed fossil species in pottery samples

Species of fossil	**The amount of sample**	**Sample name**
Planktonic foraminifera	9	4916PB, 4916BWB2 (Globotruncania), 4915LB 1b, 4915U, 4915PB, 4915PP, 4928BB2, 4915BBBON2, 4928BWB5
Benthic foraminifera	3	4916LBPA, 4915PB, 4915BBBON2
Ostracod shell fragment	2	4915 IN1, 4928 BWB4
Macro fossil shell fragment	1	4928 CV (bentic foraminifera?, briyazoa?)
Undefined fossil fragment	3	4928 BB3, 4916 P, 4928 RB2
Straw fragment?	1	4928 IN2

3.1.2. XRD Analysis of Domuztepe Pottery Samples and Field Soil Samples

Pottery Samples

The data obtained from the analysis of thin sections, were used in the selection of samples for XRD analysis. For the XRD analysis, the samples were selected from pottery fired at low temperatures since at the high temperatures, clay minerals are loose their crystalline structures, vitrified and and they become amorphous. On the contrary to this situation, glassification does not occur at low temperatures, so it is possible to determine the clay type of ceramics.

Pottery had been divided into 5 groups according to the chronological classification by archaeologists (Lot 4915, Lot 4916, Lot 4927, Lot 4928, chronologically undefined grup). the XRD analysis was carried out using 34 samples which are selected from five different groups. Analysis were applied on the unoriented bulk samples and oriented samples to determine the clay minerals.The clay minerals were determined in 20 of the samples. Since the amount of sample is less than the others, the clay fraction could not be separated (amount of samples are very limited in archaeological samples). The results of the XRD analysis are presented in Table 3.8.

Table 3.8. Clay mineralogy of the pottery samples.

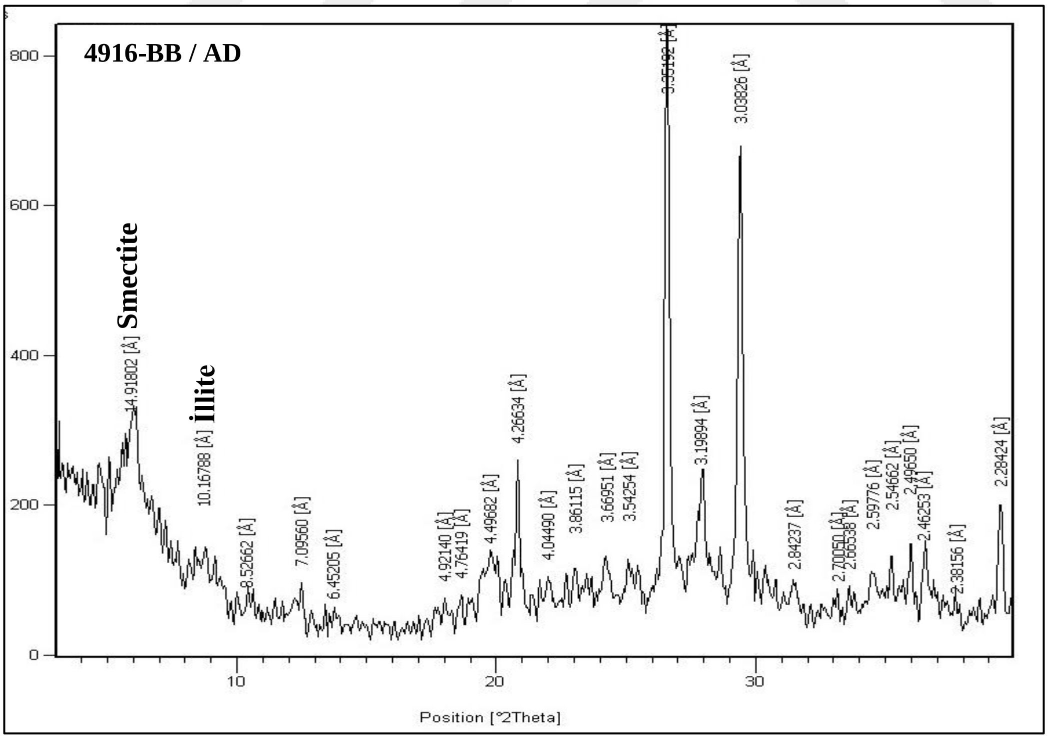
Pottery Samples	**Type of clay**
Lot 4915 Vegetable Temperd	Smectite+illite
Lot 4915 - 2 Black Burnished	Smectite
Lot 4915 Brown Burnished	İllite
Lot 4915 Unpainted	Smectite+illite
Lot 4915 Grid Temperd Unburnished Coarse	İllite+smectite
Lot 4915 - 2 Leather Burnished	İllite+smectite
Lot 4928 Coarse Veg	illite
Lot 4928 - 1 Red Burnished	not detected
Lot 4928 - 1 Brown Burnished	not detected
Lot 4928 - 2 Brown Burnished	not detected
Lot 4928 - 4 Brown Burnished	Smectite+chlorite+illite
Lot 4928 - 1 Black Burnished	not detected
Lot 4928 - 2 Black Burnished	smectite+chlorite+illite
Lot 4928 Unpainted (increases in transitual?)	İllite+smectite
Lot 4916 - 1 Brown Burnished	not detected
Lot 4916 Lether Burnished	Smectite
Lot 4916 Lether Burnished (patterned and applied ???)	İllite+smectite+kaolin?
Lot 4916 Vegetable Temperd	not detected
Lot 4916 Pattern Burnished	Smectite+illite
Lot 4916 Black Burnished	İllite+smectite
Lot 4916 - 2 Unpainted	Smectite+illite
Lot 4927 Coarse Vegetable	İllite+chlorite
Lot 4927 Unpainted Halaf	not detected
Lot 4927 Painted Orange	not detected
Lot 4927 Bichrome	Chlorite
Lot 4927 Black Burnished	Chlorite+illite
Lot 4927 Black Burnished	İllite+smectite
Lot 4927 Mature (painted) Halaf	not detected
67 Neolithic	not detected
67 Monochrome	not detected
67 Bichrome	not detected
96 Bichrome	not detected
96 Monochrome	not detected
96 Ubaid	not detected

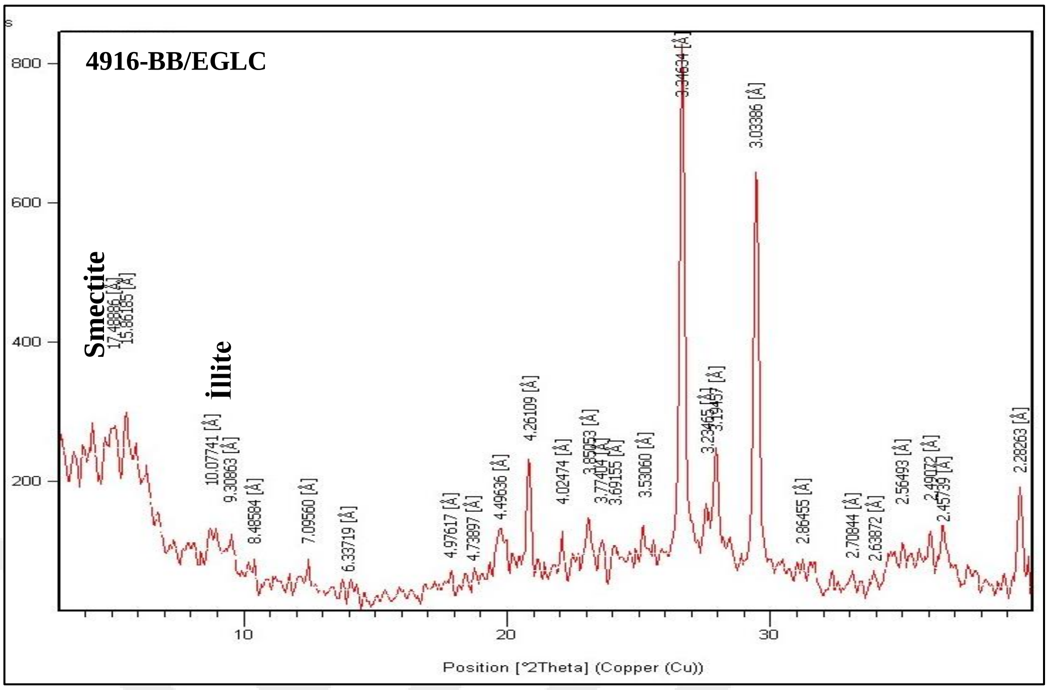
The analysis showed that almost all of potery samples consist of illite, smectite or chlorite.

- The type of clay used in pottery could be detectedby the XRD analysis. This shows that the firing temperature is below 900-1100 ° C. This information is important because it is helpful to obtain information on the pottery production technology, The analyzed samples represents time interval 700 or 800 years there is not any substantial change in relation to firing technology during this time.

- Clay mineralogical data indicates that, in a range of time about 700-800 years, illite and smectite-illite rich clay sources were used in pottery production in the region.

XRD patterns of some pottery samples are given below (Figure 3.8).





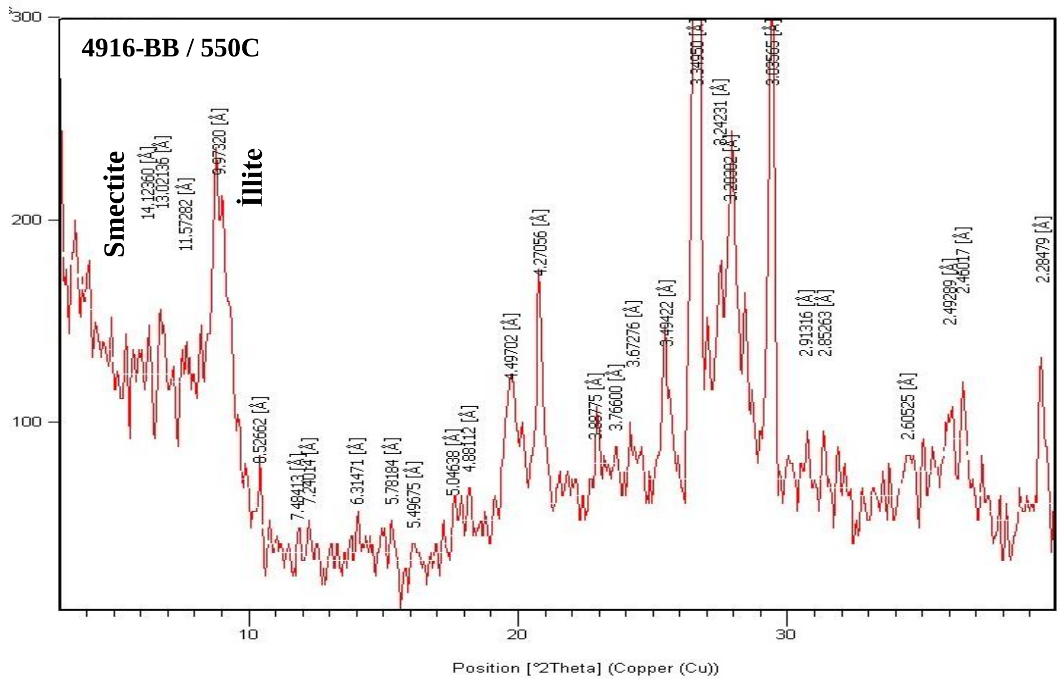
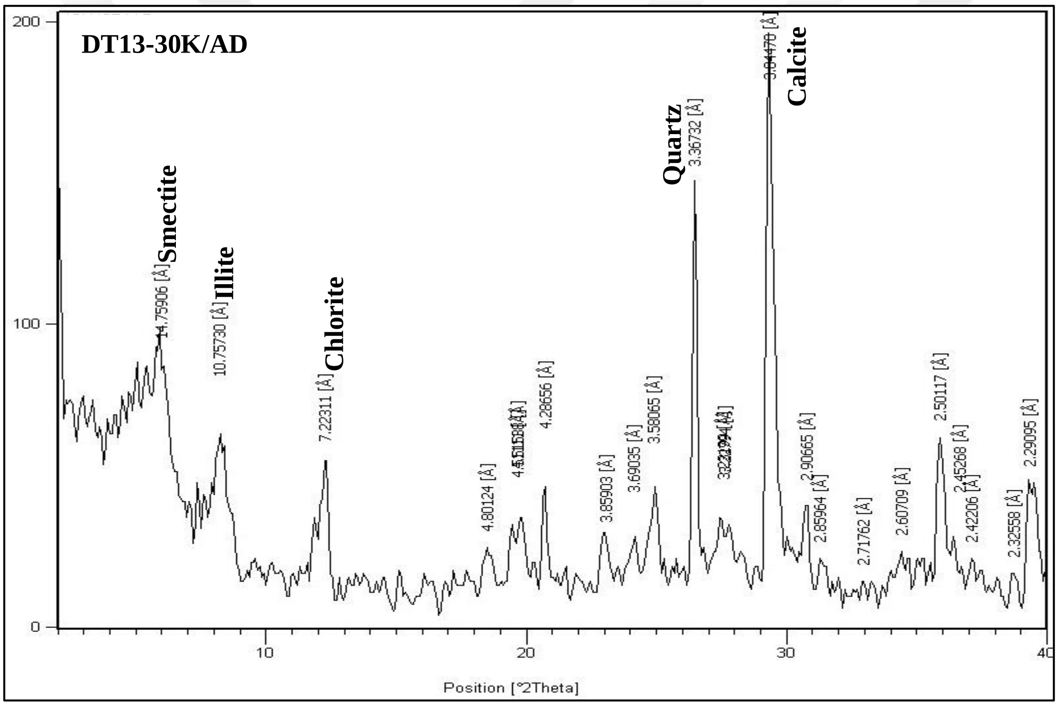


Figure 3.8. XRD results of one of the ceramic samples (4916-BB). Illite and Smectite group clay had been determined (AD: Air Dried, EGLC: Ethylene glycol, 550C degree).

Field Soil Samples

As for the understanding of the dominant clay mineral species in the alluvial deposits at the close vicinity of Domuztepe settlement, field soil samples were collected from seven different locationsduring the field studies. Analysis were applied on whole-rocks and oriented samples to determine the type of clay minerals. According to results of XRD analysis, in almost all of the field soil samples contains illite, smectite, illite-smectite (mixed leyer), chlorite and to a lesser extent kaolinite are detected (Figure 3.9).



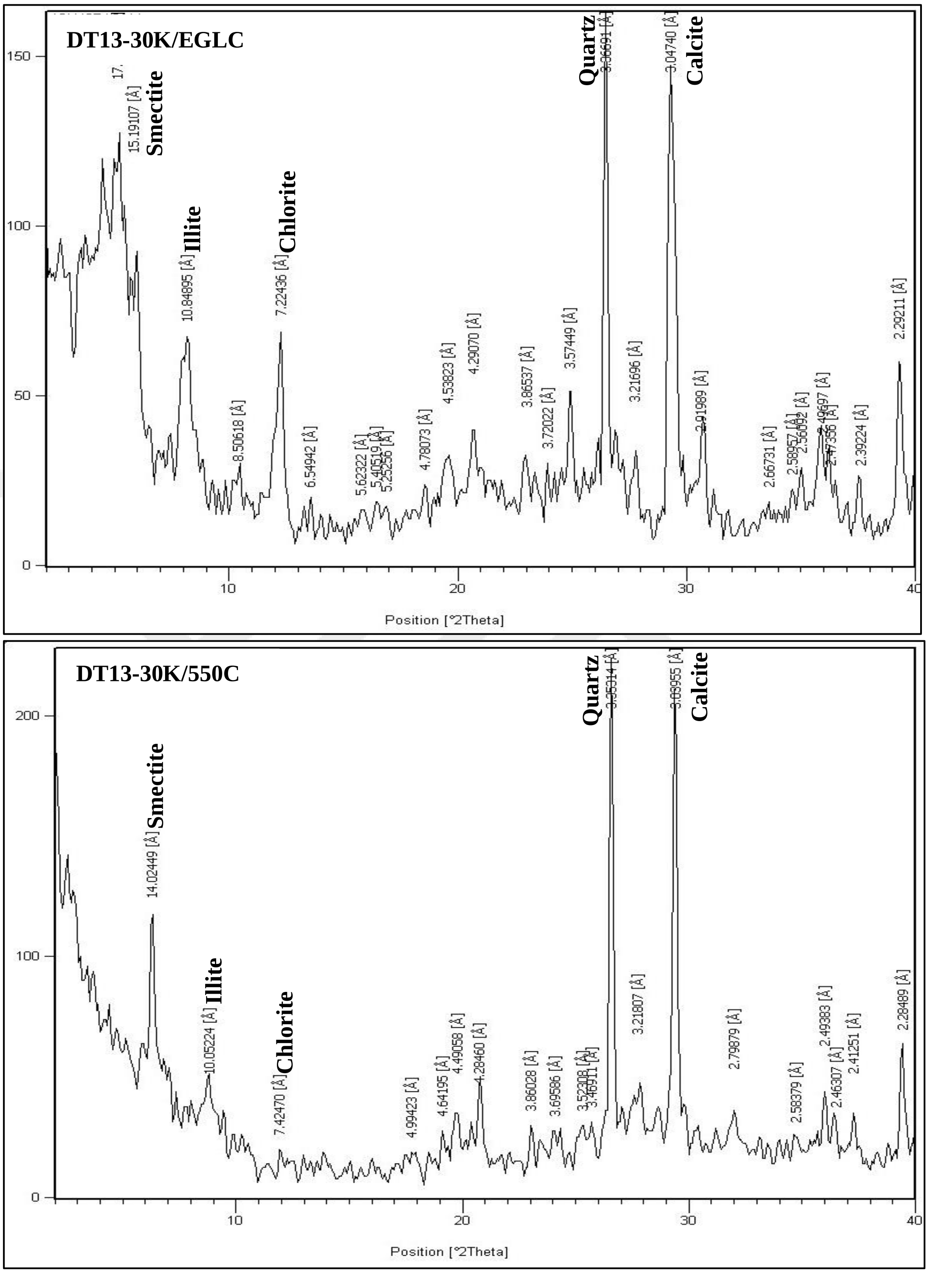


Figure 3.9. XRD result of one of the soil samples (DT13-30K) (AD: Air Dried, EGLC: Ethylene glycol, 550C degree)

XRD results were summarized in the following table (Table 3.9) for all of the samples. Clay mineral data summarized in the table below, shows similarities with the clay mineral types found in pottery samples. This suggests that the clay raw materials used in the pottery production were obtained from local sources.

Table 3.9. XRD data summary of the field soil samples.

Field Soil Samples	XRD Data: Minerals	XRD Data: Clay
DT13-30K	Calcite, Quartz, Plagioclase (less), Mica	Smectite, illite, Kaolinite
DT13-19BK	Calcite (abundant), quartz (less)	Smectite (abundant), smectite-illite mixed layer, kaolinite (less)
DT13-28K	Calcite, Quartz, Plagioclase, Pyroxene?	Illite-Smectite mixed layer
DT13-26K	Calcite, Quartz, Pyroxene	Illite-smectite mixed layer, kaolinite
DT13-27K	Calcite, Quartz, Pyroxene	Smectite, illtite, illite-smectite mixed layer, kaolinite
DT13-29K	Calcite, Quartz	Smectite, chlorite, illite, illite-smectite mixed layer, kaolinite
DT13-Dere	Calcite, Quartz, Plagioclase, Serpentine	Smectite, chlorite, illite

3.1.3. SEM-EDAX Analysis of Domuztepe Pottery Samples

For the SEM-EDAX analysis, pottery samples were selected from four different groups which are classified according to the archaeological chronology. Additionally, in order to compare the data, the samples were selected among the previously used in different analysis (Table 3.10).

Table 3.10. Summarized previous analysis table of SEM-EDAX samples

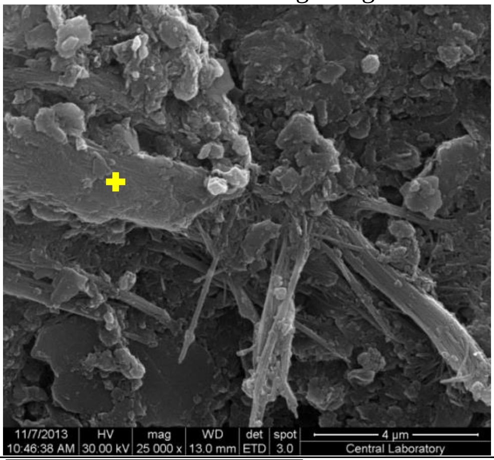
Chronologic Groups	Pottery Samples	Clay Type	Main Mineral Composition	SEM-EDX
Lot: 4915 6200 BC	Lot 4915 - 2 Lether Burnished	İllite+smectite	Quartz, Calcite, Serpentinite, amphibole, Plagioclase	x
Lot 4928 6100 BC	Lot 4928 Unpainted	Small amount İllite+smectite	Quartz, Calcite, Plagioclase, amphibole, hematite	x
Lot 4916 6000-5750 BC	Lot 4916 Lether Burnished	İllite+smectite +kaolin?	Quartz, Calcite, Plagioclase, K.feldspar, amphibole?, dolomite	x
Lot 4927 5750-5500 BC	Lot 4927 Model Painted Halaf	Vitrified	Quartz, Calcite, Plagioclase, dolomite, Opac: magnetite?	x

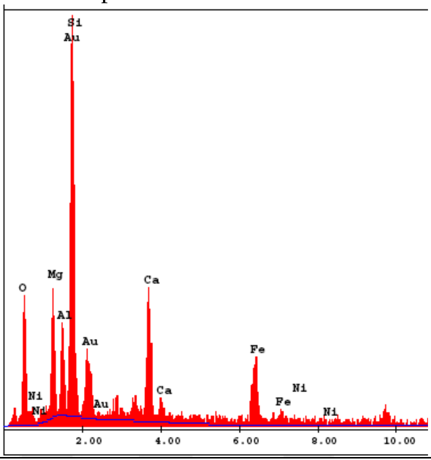
Datas of SEM-EDX samples are summarized below. The yellow marks indicate the points where the edx measurements are made (Table 3.11).

Table 3.11. Results of SEM-EDX analysis

Lot 4915-2 Lether Burnished (Lot 4915, 6200 BC)

* Vitrification is observed at low rates.
* Iron (Fe) content is high.
* Some micro pores are observed (probably belonging to organic materials).
*Fibrous minerals have high magnesium silicate compositions.

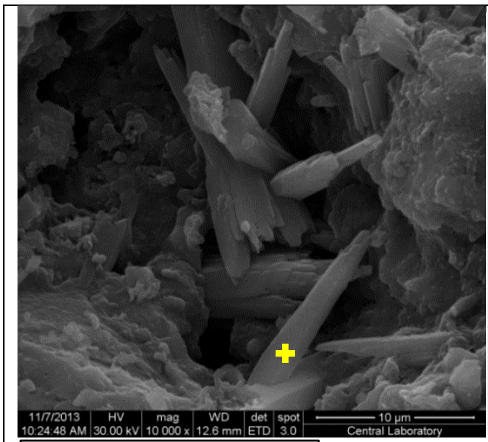


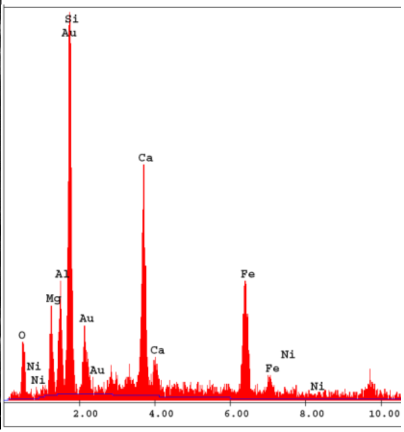


Element	Wt %	At %
O K	29.70	49.28
MgK	8.81	9.62
AlK	6.25	6.15
SiK	25.68	24.27
AuM	14.07	1.90
CaK	7.68	5.08
FeK	7.19	3.42
NiK	0.63	0.28
Total	100.00	100.00

Lot 4928 Unpainted (Lot 4928, 6100 BC)

* Calcium (Ca) content is high.
* Mica minerals are observed.
* Some micropores are observed (probably belonging to organic materials).
* Calcium carbonate is observed in crystal form. This shows that, calcium carbonate was not converted into calcium oxide and saved the its crystal form. Its known that, transformation of calcium carbonate ($CaCO3 \rightarrow CaO+CO2$) is a thermal process and this thermal process occur at 650-750C degrees. This shows that, firing temperature of this pottery sample might be low than 650-750C degrees (Lide 2005).

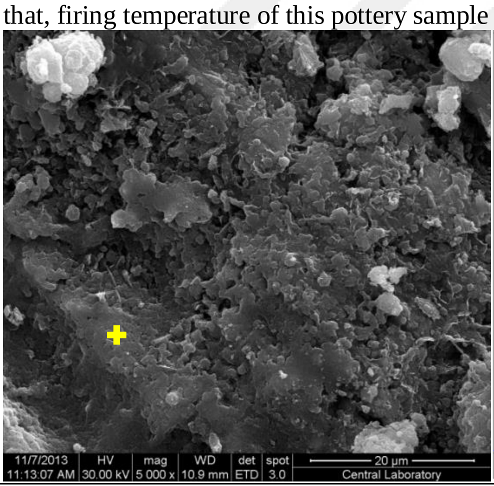


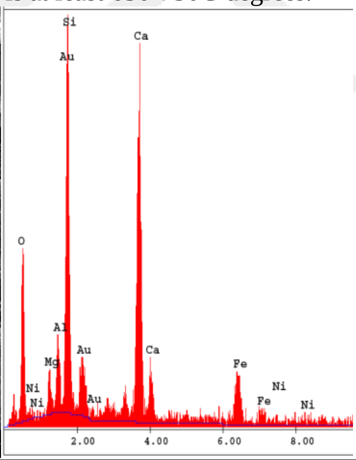


Element	Wt %	At %
O K	16.75	32.74
MgK	6.37	8.19
AlK	7.59	8.79
SiK	26.37	29.35
AuM	14.70	2.33
CaK	12.89	10.05
FeK	14.37	8.04
NiK	0.97	0.52
Total	100.00	100.00

Lot 4916 Lether Burnished (Lot 4916, 6000-5750 BC)

* Calcium (Ca) content is high.
* Calcium carbonate is not observed in crystal form. This means that the calcium was transformed to calcium oxide. This conversion takes place at 650-750 ° C. This shows that, firing temperature of this pottery sample is at least 650-750C degrees.

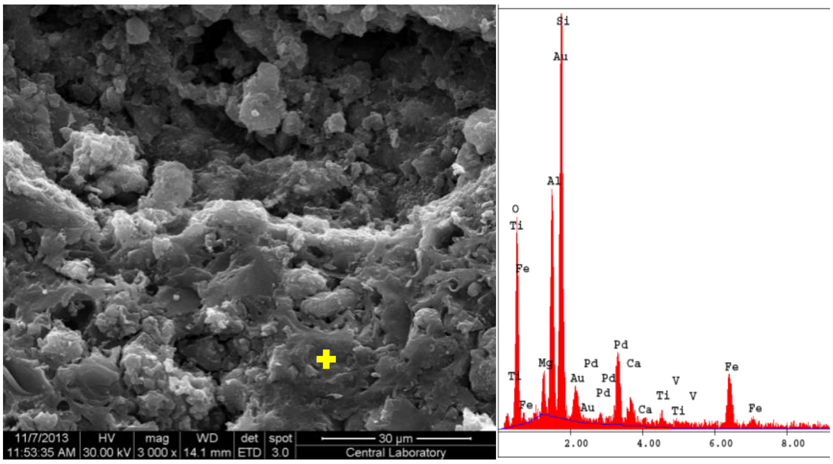




Element	Wt %	At %
O K	40.21	61.60
MgK	2.98	3.00
AlK	4.51	4.09
SiK	19.49	17.01
AuM	9.67	1.20
CaK	17.09	10.45
FeK	5.48	2.41
NiK	0.57	0.24
Total	100.00	100.00

Lot 4927 Painted Halaf (Lot 4927, 5750-5500 BC)

* A high amounts of silicon (Si) and aluminum (Al) and a lower amounts of calcium (Ca), magnesium (Mg) and iron (Fe) were detected.
* Vitrification is very evident and firing temperature is high (more than 900-1100C degree)



Element	Wt %	At %
O K	38.70	57.28
MgK	2.90	2.82
AlK	13.99	12.28
SiK	26.61	22.44
AuM	7.87	0.95
PdL	1.60	0.36
CaK	1.55	0.92
TiK	0.82	0.40
V K	0.48	0.22
FeK	5.49	2.33
Total	100.00	100.00

3.1.4. ICP-OES/MS and Statistical Analysis of Domuztepe Pottery Samples

33 ceramic samples were analyzed by the ACME laboratory in Canada with ICP-OES/MS method. Analysis results are presented in Appendix D. Samples were selected from five different stylistic groups constituting the repertoire of pottery samples. In order to reach meaningful conclusions, Cluster Analysis were carried out using the results of the ICP-OES/MS analysis.

ICP-OES/MS analysis data, includes information on concentration of 48 elements at percent or ppm levels. In addition to the major elements (Si, Al, Ca, Mg, Na, K, Ti, Fe, Mn, P), trace elements (Cr, Ni, Ba, Co, Cs, Ga, Hf, Nb, Rb, Sr, Ta, Th, U, V, Zr, Mo, Cu, Pb, Zn, Ni, As, Cd) and rare earth elements (Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Sc, Tb, Tm, Yb, Y) concentrations in the samples were identified. In the first stage, Clustering Analysis were performed for the whole 33 samples.

Types and criteria of cluster analysis were determined by literature survey. The most obvious choice as, in order to standardize the measured relative value of the element, "z standardization / z scores" has been made on the measured values (because, concentration of elements was measured in some of elements rate as % and some others as PPM) (VanPool et. al., 2011; Sinopoli, 1991; Barone et. al., 2014).

There are also "chronologically unidentified group" samples in statistical sample pool (Table 2.1: table of pottery chronology). These samples were collected from different settlements which located in Domuztepe vicinity during field survey. These settlements are thought to be associated with Domuztepe (Höyük number 67, 70, 96). It is believed that, these settlements were inhabited at about the same time chronologically with the Domuztepe . And relationship of this settlements with the Domuztepe will be tried to understand through pottery chemical analysis.

Cluster analysis was performed on chemical data of 33 samples in total and the results are shown in the following two dendrogram. 21 of these samples are Domuztepe findings and also 12 of these samples are from the other settlements findings (settlemen numbers 67, 70 and 96). First dendrogram is the result of the cluster analysis performed on all samples (Figure 3.10). In the second dendrogram just are seen their relations with each other of the pottery samples from Domuztepe (Figure 3.11). According to kinship status, appearing groups were marked in the dendrogram.

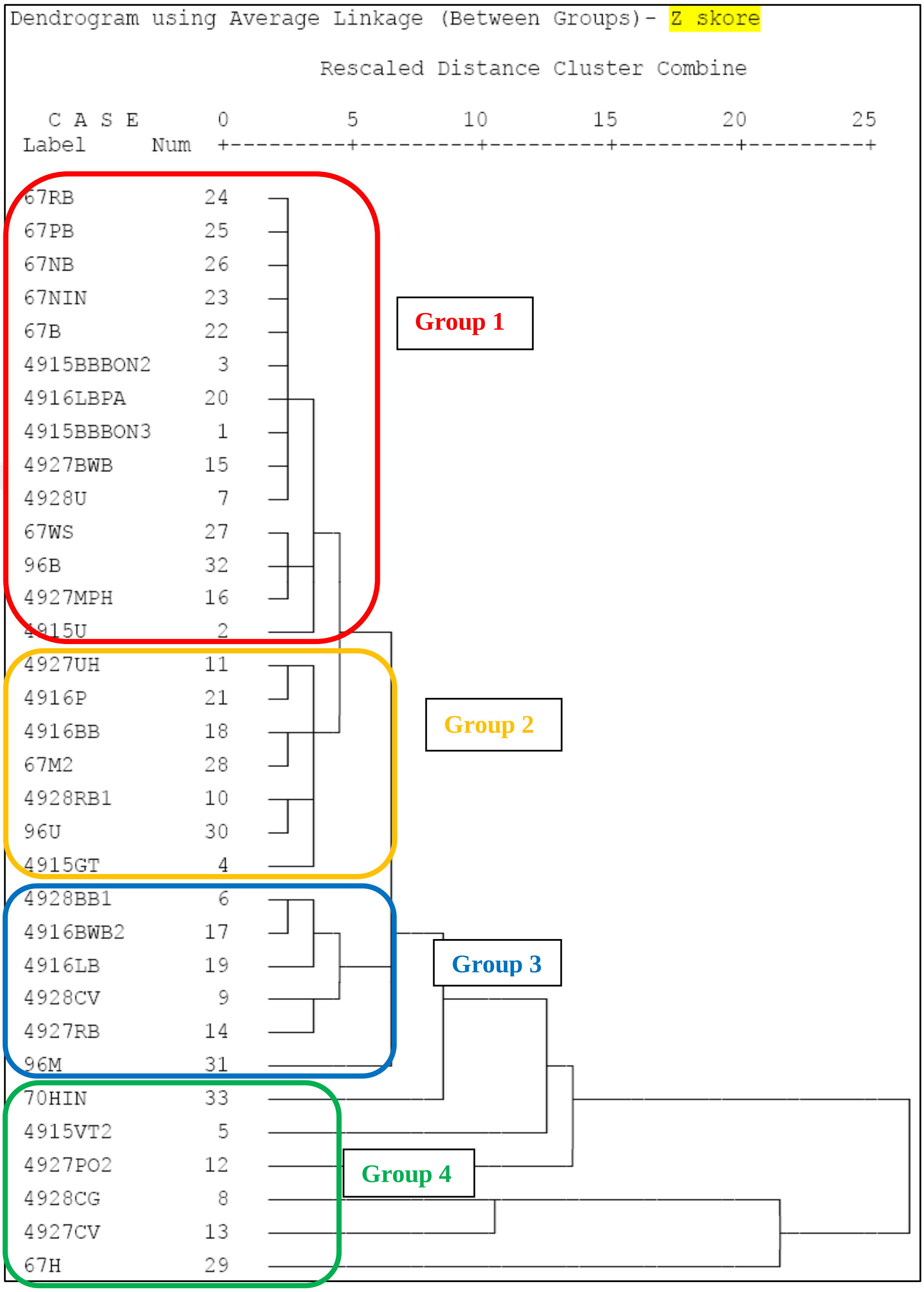


Figure 3.10. The cluster analysis performed on all of the pottery. In this dendogram, besides Domuztepe, there are also pottery samples of Number 67, Number 70 and Number 96 höyüks in the vicinity of Domuztepe.

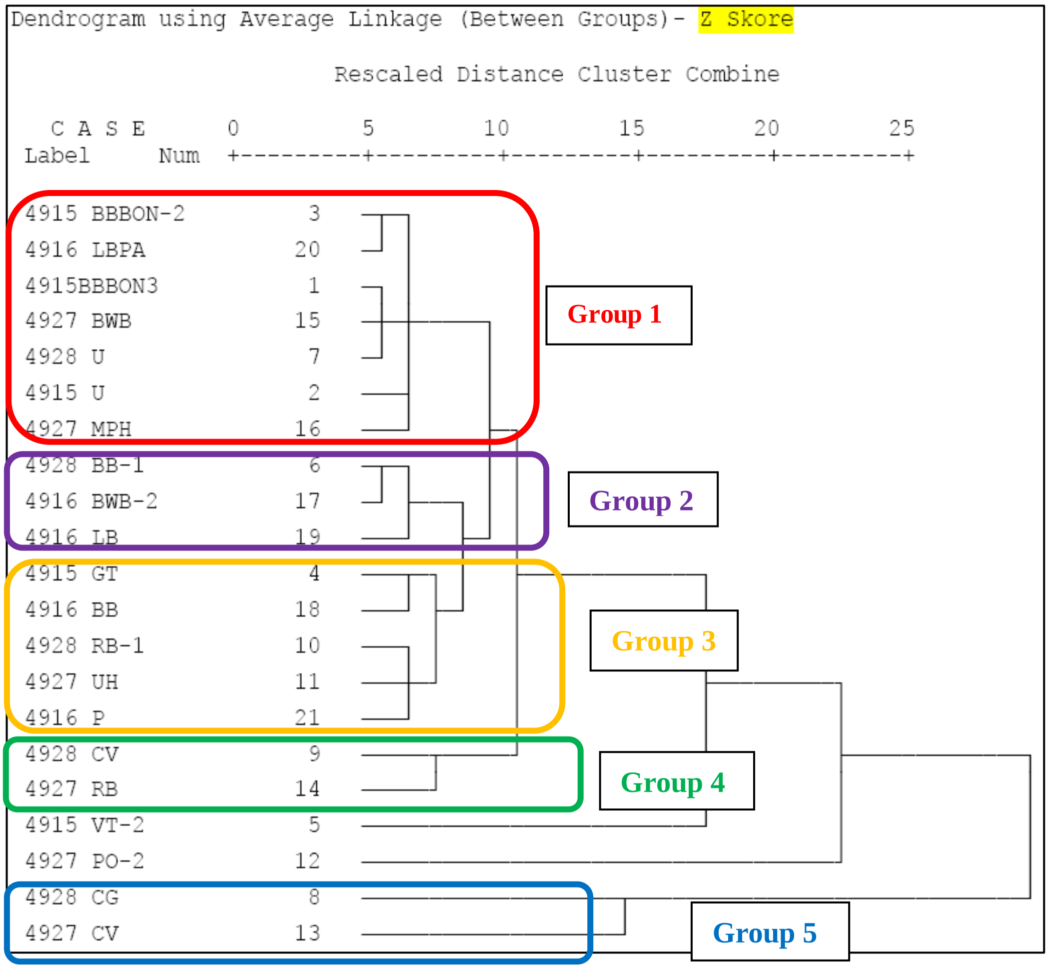
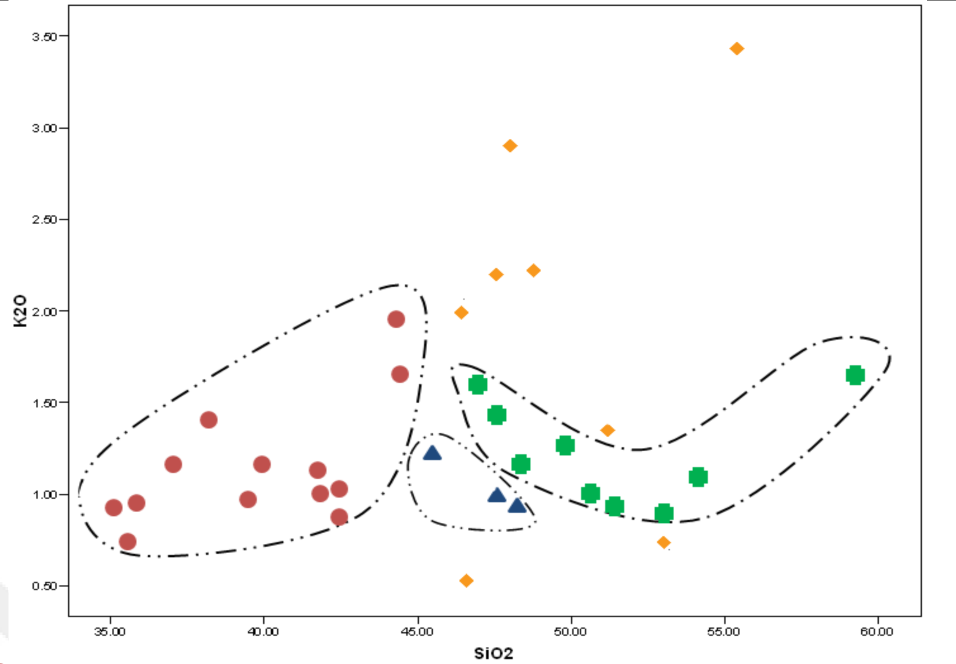
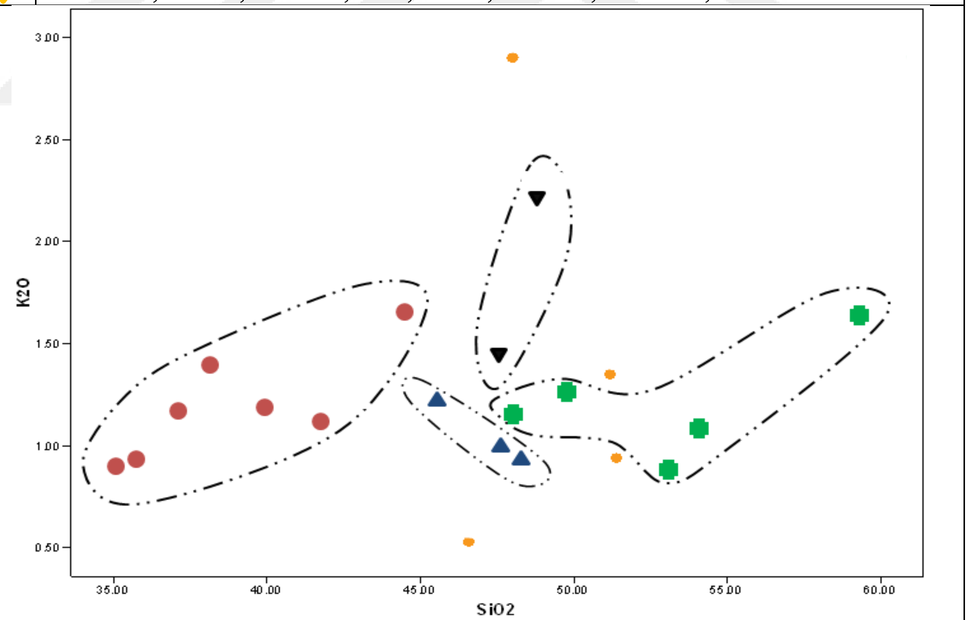


Figure 3.11. The cluster analysis just performed on Domuztepe pottery.

Results of Analysis show that pottery paste had been clustered at least at 5 different group. Cluster analysis listed above were carried out according to the chemical composition of the samples. In the some of these geochemical diagrams used the main elements (K2O, SiO2, Al2O3, CaO) (Barone, 2005; Martineau, 2007) while some used trace and rare earth elements (Cs, U, La, Cr, Th) (Tschegg et all., 2008; Hein et all., 2004). In certain preferred geochemical diagrams in a similar studies had been applied to the same chemical data and results are as follows (Figure 3.12, Figure 3.13, Figure 3.14, Figure 3.15 and Figure 3.16). In the diagrams, groups emerging from cluster analysis are shown as approximately in the circles.

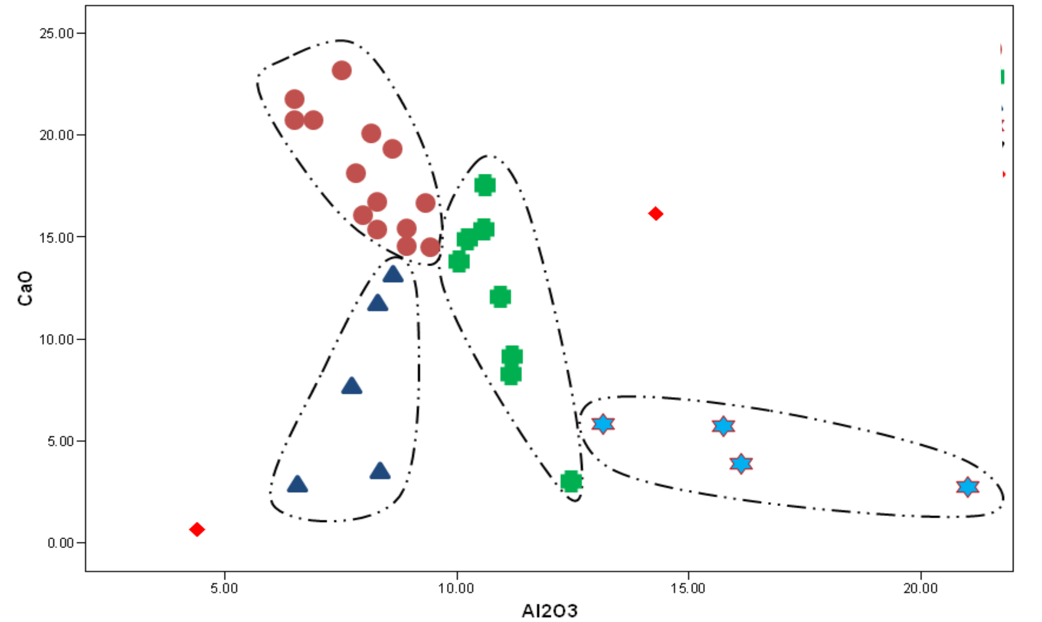


●	96B, 4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 67B, 67NB, 67PB, 67NIN, 67RB, 4916LBPA
■	96U, 4927CV, 4928RB1, 4927UH, 67M2, 4927RB, 4916BB, 4916P, 4915GT
▲	4928BB1, 4916LB, 4916BWB2
◆	4915VT2, 70HIN, 4928CV, 96M, 67WS, 4928CG, 4927PO2, 67H

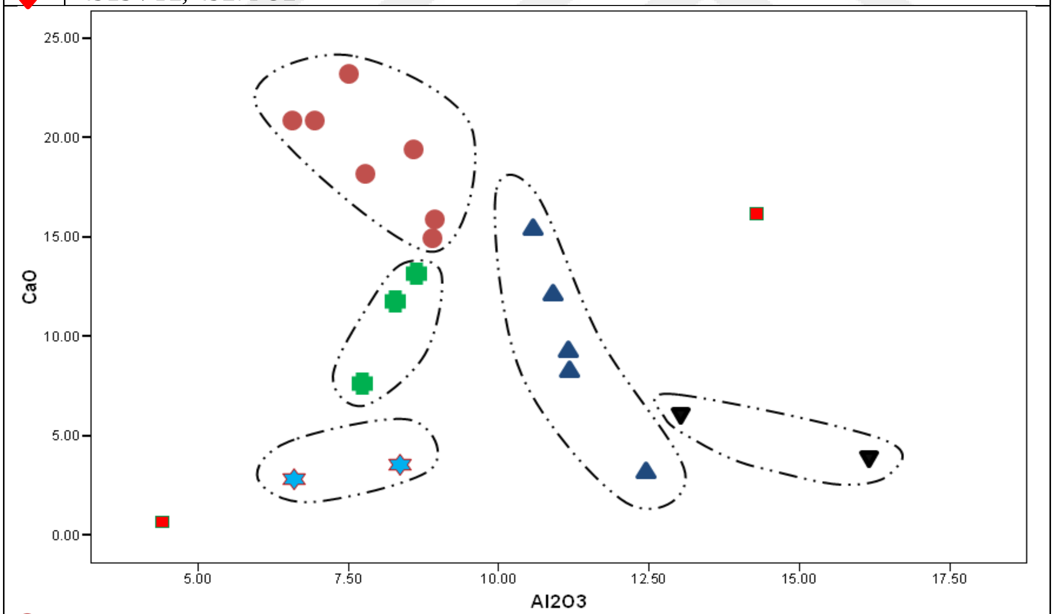


●	4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 4916LBPA
■	4928RB1, 4927UH, 4916BB, 4916P, 4915GT
▲	4928BB1, 4916LB, 4916BWB2
▼	4927CV, 4928CG
●	4927RB, 4915VT-2, 4928CV, 4927PO2

Figure 3.12. Distribution of samples according to some geochemical analysis (Barone, 2005) In the graph (SiO2/K2O), groups emerging from cluster analysis are shown as approximately in the circles. The upper graph includes all of the examples. Samples of Domuztepe are also shown In the chart below.

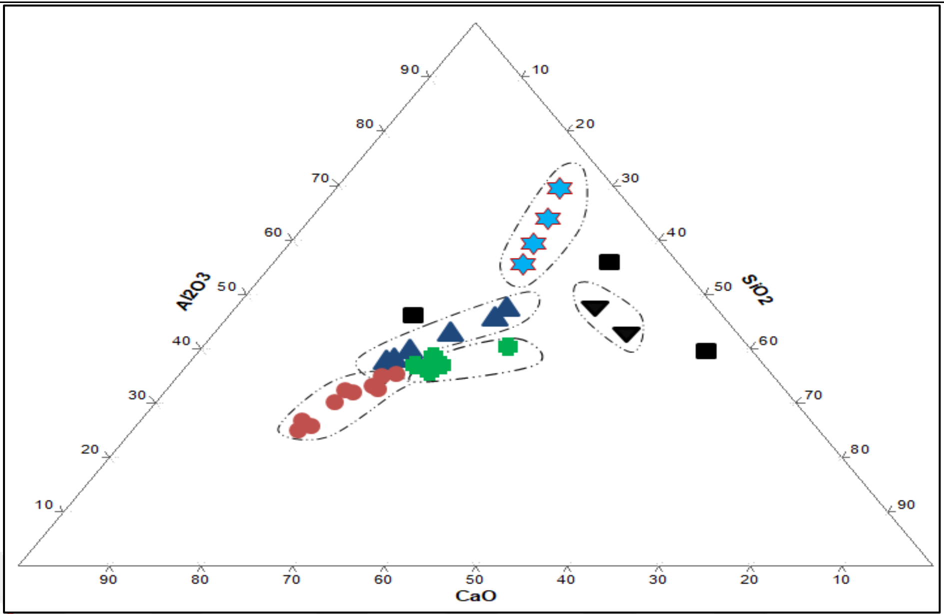


●	96B, 4927MPH, 67WS, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 67B, 67NB, 67PB, 67NIN, 67RB, 4916LBPA
✚	96U, 4928RB1, 96M, 67M2, 4927UH, 4916BB, 4916P, 4915GT
▲	4928BB1, 4916LB, 4916BWB2, 4927RB, 4928CV
✡	4927CV, 4928CG, 70HIN, 67H
◆	4915VT2, 4927PO2

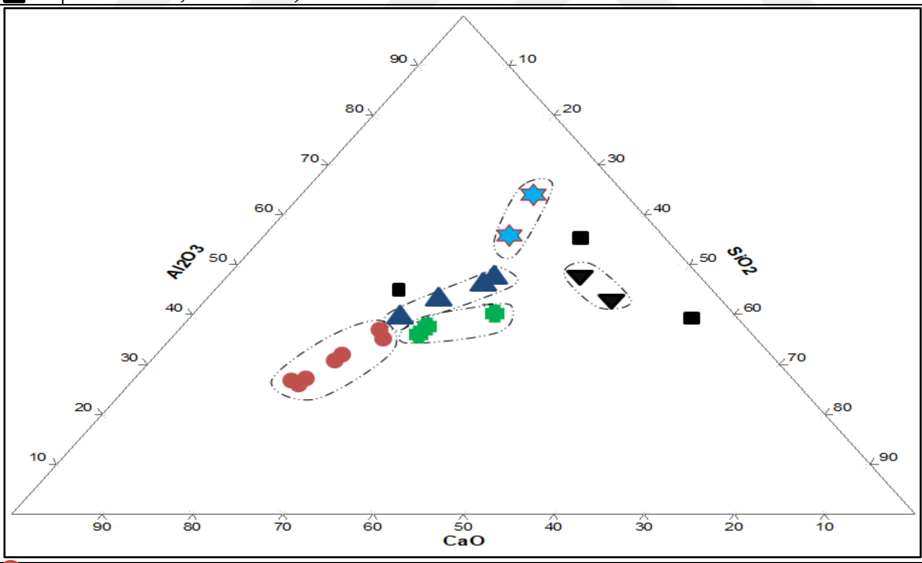


●	4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 4916LBPA
▲	4928RB1, 4927UH, 4916BB, 4916P, 4915GT
✚	4928BB1, 4916LB, 4916BWB2,
✡	4927RB, 4928CV
▼	4927CV, 4928CG
■	4915VT2, 4927PO2

Figure 3.13. Distribution of samples according to some geochemical analysis (Barone G., 2005). Circles on the Al2O3/CaO graphs shows the results of cluster analysis as approximately. The upper graph includes all of the examples. Samples of Domuztepe are also shown In the chart below.

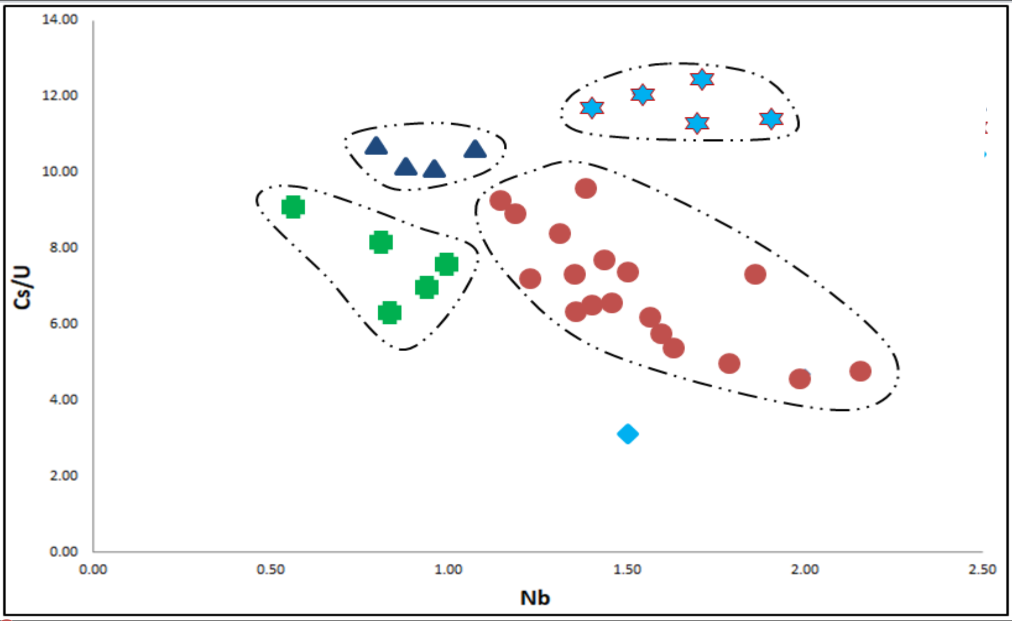


●	96B, 4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 67B, 67NB, 67PB, 67NIN
▲	4928RB1, 4927UH, 4916BB, 4916P, 4915GT, 4916LBPA, 67RB
✚	4928BB1, 4916LB, 4916BWB2, 96M, 67M2, 4916P
✡	4927RB, 4928CV, 70HIN, 67H
▼	4927CV, 4928CG
■	4915VT2, 4927PO2, 67WS

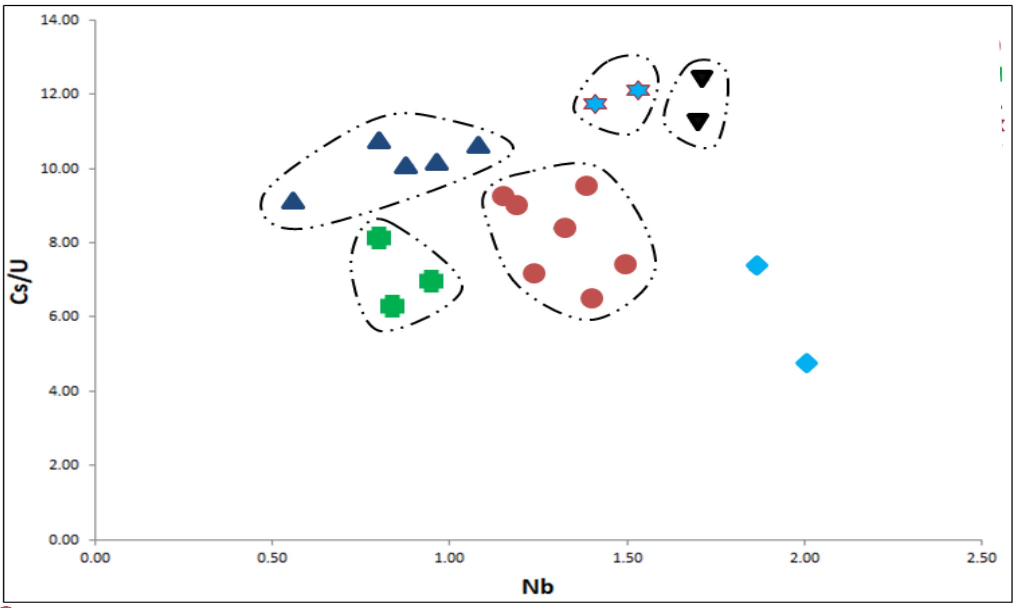


●	4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 4916LBPA
▲	4928RB1, 4927UH, 4916BB, 4916P
✚	4928BB1, 4916LB, 4916BWB2
✡	4927RB, 4928CV
▼	4927CV, 4928CG
■	4915VT2, 4927PO2, 4915GT

Figure 3.14. Distribution of samples according to some geochemical analysis (Martineau, 2007). Circles on the Al2O3/CaO/SiO2 tri-plot graphs shows the results of cluster analysis as approximately. The upper graph includes all of the examples. Samples of Domuztepe are also shown In the chart below.

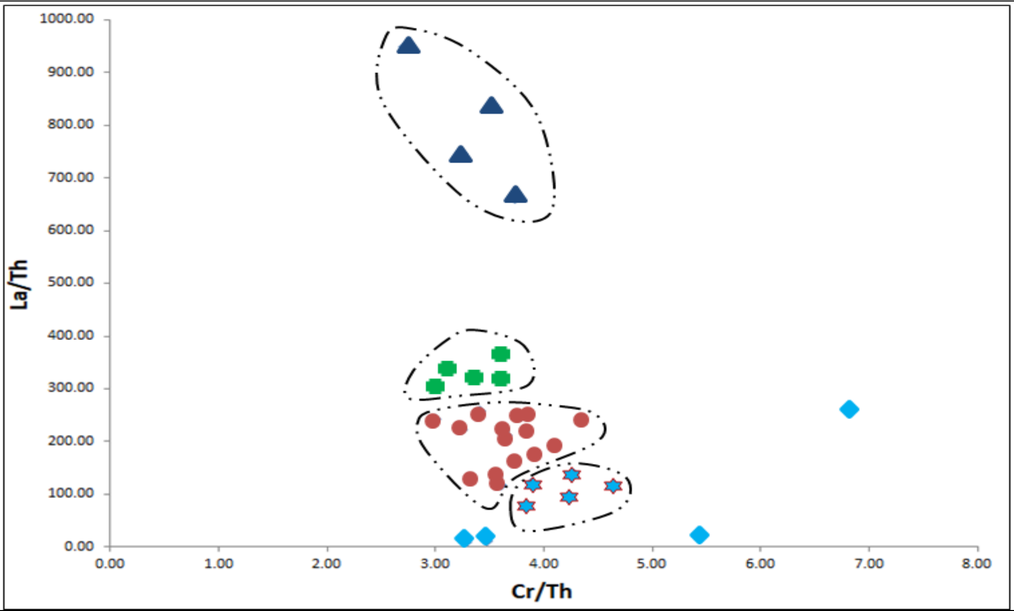


●	96B, 4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 67B, 67NB, 67PB, 67NIN 4927PO2, 67WS, 4916P,4915GT, 4916LBPA, 67RB, 4928CG
▲	4928RB1, 4927UH, 4916BB, 4916P
■	4928BB1, 4916LB, 4916BWB2, 96M, 67M2
✡	4927RB, 4928CV, 70HIN, 67H, 4927CV
◆	4915VT2

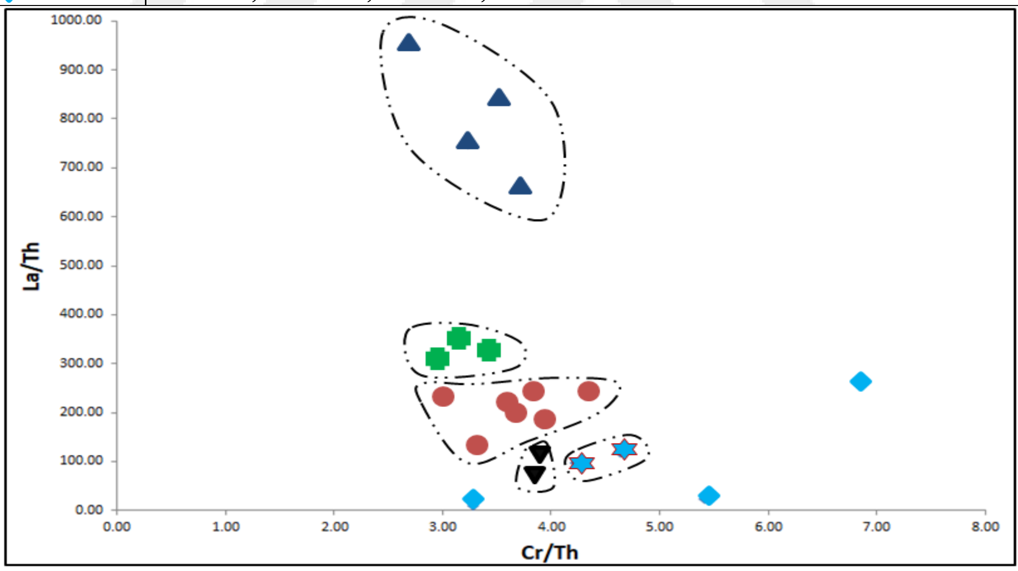


●	4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 4916LBPA
▲	4928RB1, 4927UH, 4916BB, 4916P
■	4928BB1, 4916LB, 4916BWB2
✡	4927RB, 4928CV
▼	4927CV, 4928CG
◆	4915VT2, 4927PO2, 4915GT

Figure 3.15. Distribution of samples according to some geochemical analysis (Tschegg et al., 2008). Circles on the Cs/U - Nb plot graphs shows the results of cluster analysis as approximately. The upper graph includes all of the examples. Samples of Domuztepe are also shown In the chart below.



●	96B, 4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 67B, 67NB, 67PB, 67NIN, 4915GT, 4916LBPA, 67RB, 4916P
▲	4928RB1, 4927UH, 4916BB, 4916P
✚	4928BB1, 4916LB, 4916BWB2, 96M, 67M2
✡	4927RB, 4928CV, 70HIN, 67H, 4927CV
◆	4928CG, 4915VT2, 4927PO2, 4915GT



●	4927MPH, 4927BWB, 4915BBON3, 4915U, 4928U, 4915BBON2, 4916LBPA
▲	4928RB1, 4927UH, 4916BB, 4916P
✚	4928BB1, 4916LB, 4916BWB2
✡	4927RB, 4928CV
▼	4927CV, 4928CG
◆	4915VT2, 4927PO2, 4915GT

Figure 3.16. Distribution of samples according to some geochemical analysis (Hein et all., 2004). Circles on the La/Th - Cr/Th graphs shows the results of cluster analysis as approximately. The upper graph includes all of the examples. Samples of Domuztepe are also shown In the chart below.

Results of the cluster analysis of geochemical data seems to be consistent of with each other as overall. It is thought that, the geochemical plots show a relationship between samples as further detail. Furthermore, when looking at the details of geochemical plots, the trend of some samples are different than appearing in the cluster analysis. Considering this case, the main pottery groups with the chronologic information of the pottery are presented in the table below comperatively (Table 3.12). Arrangement of table is based on K2O/Al2O3/CaO/SiO2/Cs/U/La/Cr/Th) plot diagrams. In other words, this diagrams are used as guide to the determination of the raw material group.

Table 3.12. The table of main pottery paste groups with the chronologic information of the pottery.

Raw material #: 1 Cermic paste		**Raw material #: 2 Cermic paste**		**Raw material #: 3 Cermic paste**		**Raw material#: 4 Cermic paste**		**Raw material #: 5 Cermic paste**	
5500-5300 BC	67 M2	5200 BC	96 U	5500-5300 BC	67 B	6000-5750 BC	Dt4916 LBPA	6000-5750 BC	Dt 4916 P
6100 BC	Dt 4928 BB1	6200 BC	D4915 BBON3	5750-5500 BC	Dt 4927 BWB	6200 BC	Dt4915 BBON2	6000-5750 BC	Dt 4916 BB
6000-5750 BC	Dt4916 BWB2	5200 BC	96 B	6100 BC	Dt 4928 U	6200 BC	Dt4915 U	6000-5750 BC	Dt4916 LB
5500-5300 BC	67 WS	5750-5500 BC	Dt4927 MPH			5500-5300 BC	67 NIN	5750-5500 BC	Dt4927 UH ?
6100 BC	Dt4928 RB1	5500-5300 BC	67 PB					5750-5500 BC	Dt4927 PO2 ?
		5500-5300 BC	67 NB						
		5500-5300 BC	67 RB						

Possible paste of pottery used for pottery making at Domuztepe and two höyüks (67 and 96) near the Domuztepe were summarized in the following table with chronologic information about these pottery materials (Table 3.13).

Table 3.13. Pottery chronology and possible raw materials.

Settlement	Pottery chronology (B.C.)	Raw material # Cermic paste
Domuztepe Settlement	6200	2, 4
	6100	1, 3
	6000-5750	1, 4, 5
	5750-5500	2, 3
Settlement # 67	5500-5300	1, 2, 3, 4
Settlement # 96	5300-5200	2

The most important findings of the statistical analysis are listed below:

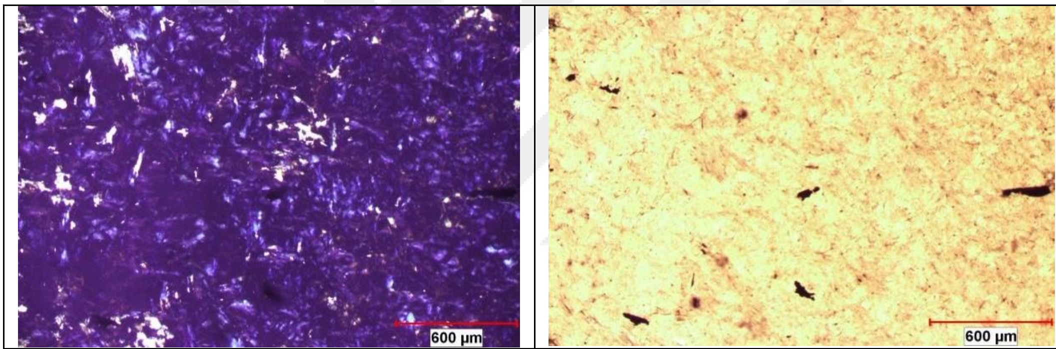
- According to the statistical and geochemical analysis results, five different ceramic paste were determined.
- The same raw materials are thought to be used in the production of stylistically different pottery.
- Raw materials number two, may be the only raw material used in all of the settlements (Domuztepe, settlement 96, settlement 67).
- The all raw materials used at Domuztepe except for "raw material no. 5", may also considered to were prefered in settement 67. This settlement is considered to had a central importance like that Domuztepe by some archaeologists whic studying on this issue. This settlement is known to had been used as well in the period of after Halaf. Because of this reason, these raw materials are considered to could be a preferred later for these settlements.
- Settlement 96 appears to associated to with single source and analysis which will perform on more samples, may give more satisfactory results.

3.2. Analysis of Stone Vessels and Field Rock Samples

3.2.1. Thin Section Analysis of Stone Vessels and Field Rock Samples

Stone Vessels

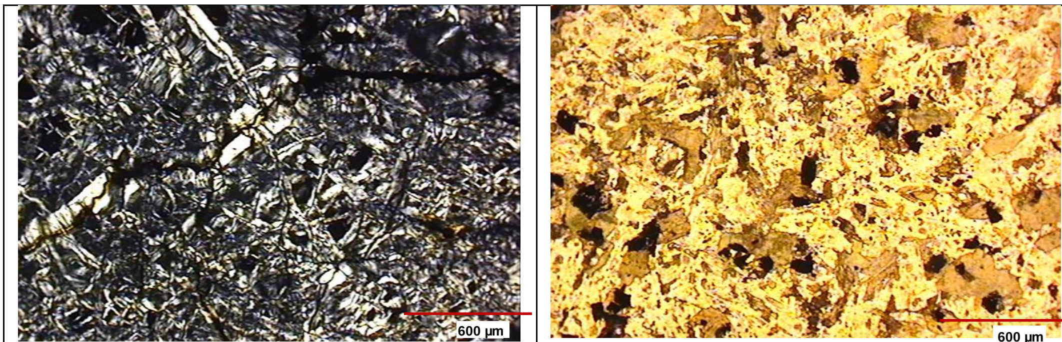
When thin sections of (47) stone vessels were examined, chlorite minerals was determined as a main mineral component. And also as optically two main groups were observed. One of these groups has a significant purple interference color (optically negative).The samples in this group is 23 pieces. One sample of this group are presented below (Figure 3.17).



DT6435 x4, XP | DT6435 x4, PP

Figure 3.17. A thin section image: One of the samples giving distinctive interference color.

The other group consists of 24 samples. In the second group of these samples, purple interference color was not observed (Figure 3.18).



DT6608 x4, XP | DT6608 x4, PP

Figure 3.18. A thin section image of one of the samples without purple interference color.

Within the scope of analysis, stone vessel samples were subjected to detailed petrographic analysis. In this way, samples that demonstrate similar petrographic characteristics have tried to be determined. In other words, petrological characteristics of the vessels raw materials were tried to determine. Eight different groups were identified in the results of this study (Table 3.14).

Table 3.14. Groups determined according to petrographic characteristics in stone vessel samples.

	Group Description	Sample number
1. Group	Interference color of chlorite: Purple	dt6535, dt6524, dt6618, dt6435, dt592, dt2200, dt2125, dt1315
2. Group	Interference color of chlorite: Purple Crystal form of chlorite: radial	dt6425, dt6538, dt6611, dt6600, dt6436, dt6607, dt1480, dt602, dt2444, dt2106, dt627
3. Group	Crystal form of chlorite: radial	dt6567, dt6446, dt634, dt1308, dt962, dt636, dt338, dt3511
4. Group	Texture: Reticulated Opaque minerals: Cromite	dt3867, dt2093, dt261, dt3616, dt330, dt1475, dt501
5. Group	Fine grained chlotire + setpentinite	dt6605, dt6608, dt6522, dt637, dt1457, dt379, dt1313, dt374, dt2098
6. Group	Silicified serpentinite + x mineral	dt6487, dt1479
7. Group	Serpentinite + chlorite + pyroxene +sphene	dt629
8. Group	Non-chlorite/non-serpentinite sample: Olivine basalt	dt960

In this case, It suggests that at least two different raw material may had been used in the production of stone vessels (chlorite minerals with violet purple interference color and without violet purple interference color). In order to give new evidence this idea, XRD analysis was performed on a total of 16 samples of the two groups mentioned. Results are presented in the relevant section (analysis of XRD).

In addition to this classification, the raw materials used in the stone vessels were tried to describe as a petrogenetic variety. The purpose of this analysis can be summarized in the following way: The raw material of stone vessels had been identified as a type of metamorphic rocks containing high chlorite. In other words, as a result of metamorphic processes a rock type (protolith) have become another rock type containing high chlorite. Evidence for the perrogenesis (parent rock – protholith) of this type had been also sought by petrografic (thin section) petrogenetic analysis. One of the environment of chlorite mineral formation is in oceanic crust descending into subduction zones. Here, amphiboles, olivines, pyroxenes, and micas are altered into chlorite. Such a tectonic structure can be see also in the our study area. And also under low grade regional metamorphism, the anhydrous pyroxene and olivine are replaced by the hydrous minerals chlorite, epidote and actinolite (an amphibole). The faulty structure in the region can create conditions under which such low grade regional metamorphism can occur. Another result of the faulty structure in the region is hydrothermal occurances. Chlorite is a one of the common minerals associated with hydrothermal ore deposits (Wilson 2007).

Petrogenetic analysis of stone vessel samples suggest that a large portion of these samples can be basaltic-gabbroic (15 samples), a smaller portion can be of ultramafic origin (8 samples), and the remainder can be of tracy-andesitic (3samples) and Rhyolite-Dacitic (1samples) origin.

The data associated with this analysis are summarized in the following Table 3.15 Also, geochemical evidence about this issue were presented in the related section (ICP-OES/MS analysis).

Table 3.15. Summarized petrogenetic analysis by means of petrografic analysis (thin section).

Sample #	Possible source rock
Dt6535, Dt338, Dt2098, Dt6524, Dt2200, Dt2125, Dt6522, Dt1480, Dt6618, Dt1457, Dt6425, Dt2444, Dt592, Dt960?, Dt629?	Basalt-Gabbro
Dt636, Dt6487, Dt374, Dt637, Dt261, Dt501, Dt3616, Dt330	Ultramafic
Dt634	Rhyolite-Dacite
Dt1313, Dt379, Dt3511	Trachy-Andesite

Field Rock Samples

Field studies were carried out in four periods, approximately 90 rock samples were collected from 12 different locations. Thin section analysis were carried out on these rock samples and mineral composition of the samples were determined to be serpentine (generally antigorite), weathered serpentine minerals as predominantly.

Talc and chromite are found a part of the thin sections. Field samples show different structural and textural features in itself. However, these data are compared with thin section data of stone vessels, have not been observed a similarity between them.

At this stage of analysis, the overall situation regarding the stone materials (vessel fragments and field samples) has been summarized below.

- According to the results of the analysis carried out on stone vessels, two main groups had been observed as optically. One of these groups has a significant violet purple interference color (optically negative). The samples in this group is 23 pieces. The other group consists of 24 samples. In the second group of these samples, violet purple interference color was not observed. Petrological characteristics of the vessels raw materials were tried to determine. Eight different groups were identified in the results of this study.
- In the four field studies performed, samples taken from sources of potential raw materials (ophiolitic geological units) demonstrate similarity in general in terms of some mineralogical properties (structure and texture). Despite this situation, a similarity was not observed in between field samples with stone samples in thin section analysis.

3.2.2. XRD Analysis of Stone Vessels and Field Rock Samples

Stone Vessels

In light of thin section analysis, two main groups of stone vessels were identified (violet purple interference color observed / or not observed). In XRD analysis, from the these two groups, total 16 samples were selected and exemined (total samples of 16/47). The result of analysis, Fe- rich chlorite minerals have determined in all samples (Figure 3.19) (Moore & Reynolds, 1997).

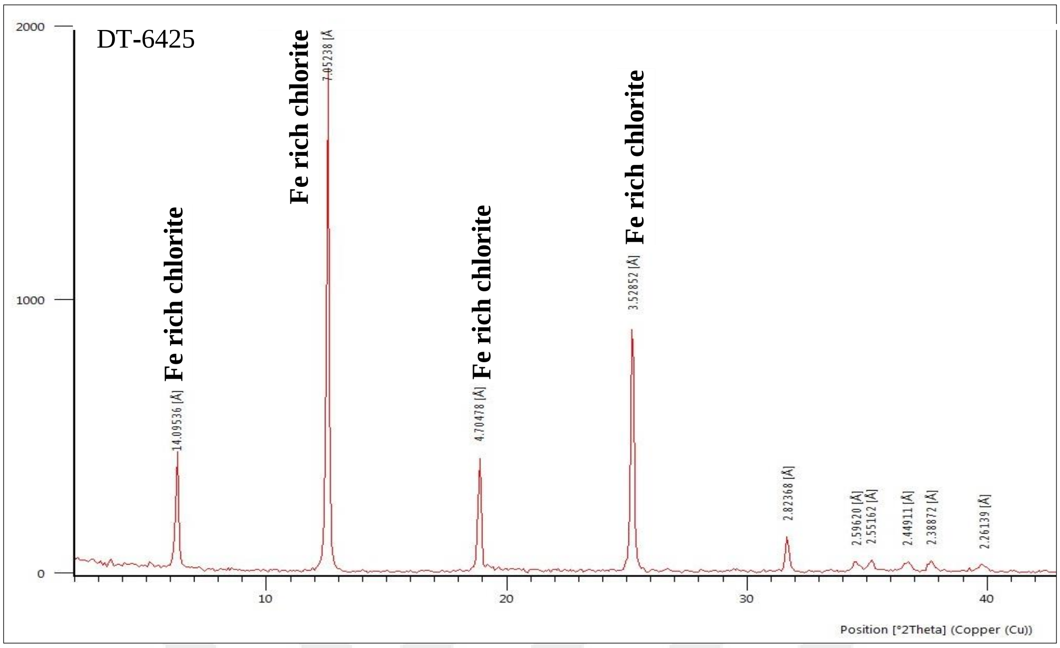


Figure 3.19. XRD chart of the DT-6425 stone vessel sample (bulk sample)

In analysis of thin sections had been detected the presence of two different groups as petrographic (in one of them, chlorite minerals shown the violet purple interference color and in the other groups did not show). According to the XRD results it was observed only Fe rich chlorite minerals as main mineral component. Therefore, it was understood that it was not possible to speak of two different raw group.

Chlorite mineral, which shows purple interference color, is known as repidolite. Ripidolite has been historically used as a name for intermediate and undetermined members of the chamosite-clinochlore series. According to Albee (1962), most common low-grade metamorphic chlorite is ripidolite; this species may be optically positive or negative, with the change in optic sign occurring where β : 1.630 and F/FM (the ratio Fel(Fe+Mg)) = 0.52 (Albee, 1962). At this changeover point, chlorite is effectively isotropic for the whole spectrum of white light, although very commonly some parts of the spectrum are not extinguished, resulting in purple interferencecolors (Craw & Jamieson, 1984).

If F/FM is between about 0.52 and 0.7 the chlorite is optically negative, with β > 1.630, and is isotropic for longer wavelengths of light, giving rise to abnormal blue interference-colors. If F/FM is beween about 0.3 and 0.52, the chlorite is optically positive, with β < 1.630, andisisotropicfor shorter wavelengths, giving rise to abnormal red-brown interference-colors. However, observed in several low-grade metamorphic situations that chlorite flakes commonly are made up of interlayered or intermixed abnormal blue (-) and abnormal brown (+) chlorite (Craw & Jamieson, 1984).

Field Rock Samples

During the field studies, approximately 90 samples were collected from 12 different locations which were estimated as the potential source area of stone vessels from ophiolitic units. Thin section analysis was performed on these samples and 37 samples were selected can be petrogenetic resources and XRD analyzes were performed on them. According to the results of these analysis, antigorite (one of the serpentine group minerals, ((Mg,Fe++)3Si2O5(OH)4) has been found as main mineral components (Figure 3.20).

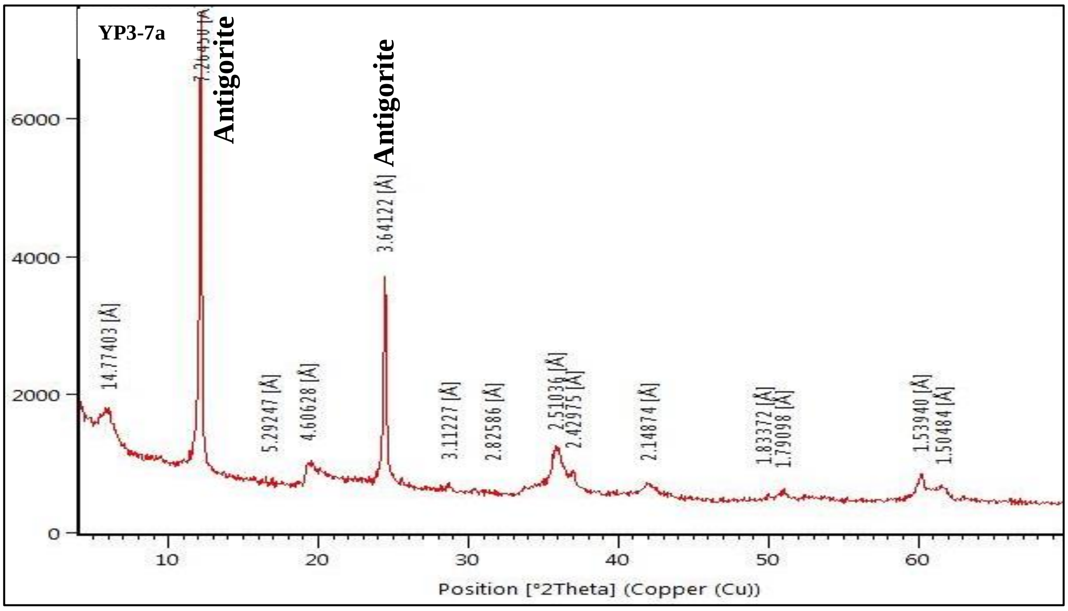


Figure 3.20. XRD chart of the YP3-7 field (rock) sample**.**

3.2.3. ICP-OES/MS Analysis of Stone Vessels and Field Rock Samples

Stone Vessels

ICP-OES/MS analysis was performed on 27 stone vessel samples to determine the chemical composition. Analysis results are presented in Appendix E. In order to reach meaningful conclusions, Cluster Analysis were carried out using the results of the ICP-OES/MS analysis. Moreover, in order to investigate the some petrogenic aspects of the stone vessels material, geochemical analysis has been applied.

This geochemical analysis of the raw materials, used in the manufacture of stone vessels reveals the petrogenetic characteristics of the samples. The geochemical discrimination diagrams using mobile and immobile elements as suggested by Pearce (1983) and reviewed by Sun & McDonough (1989) were used. Accordingly, the trends shown by the immobile elements of stone vessels sample were compared each other and a petrogenetic differences between the samples were studied.

Firstly, the high Ni and Mg ratios in some samples suggest that these samples are most possibly likely to be ultramafic origin (Wilson, 2007) (Table 3.16). The Spider diagram below, shows the distribution of some immobile element concentrations of stone vessels (Figure 3.19). In this diagram, it can be seen that some of the elements (Th, Ta, Nb, Ce, P, Zr, Hf, Sm, Ti, Y, Yb – this element series modified from Sun and McDonough (1989)) of some samples (Dt6487, Dt637, Dt261, Dt374, Dt3616, Dt330, Dt636, Dt501) were not measured or found. These are ultramafic samples with high Ni and Mg ratio also mentioned above.

Table 3.16. Ni and Mg ratios of stone vessel samples. The proportions of these elements seems to be higher in the samples thought to be of ultramafic origin. These samples are marked in the table.

Samle #	MgO (%)	Mg (%)	Ni (ppm)
dt6425	14.73	8.88	271
dt6535	16.18	9.76	255
dt6524	15.47	9.33	191
dt6618	15.31	9.23	120
dt6487	24.30	16.24	730
dt6522	22.47	13.55	217
dt637	23.93	14.43	659
dt592	16.13	9.73	153
dt2200	18.59	11.21	421
dt1480	16.85	10.16	207
dt634	16.94	10.22	275
dt960	5.18	3.12	133
dt2125	16.51	9.96	190
dt1457	23.86	14.39	1020
dt629	11.35	6.85	189
dt2444	15.54	9.37	165
dt379	15.84	9.55	196
dt261	33.21	20.03	2645
dt1313	20.86	12.58	372
dt374	24.85	14.99	601
dt3616	33.31	20.09	2800
dt2098	21.89	13.20	376
dt330	36.01	21.72	2411
dt636	26.12	15.75	683
dt338	20.84	12.57	408
dt3511	21.93	13.23	259
dt501	34.46	20.79	2534

According to these diagram, sample set is divided into two large groups (Figure 3.21). The emergence of these two groups, it is observed that the concentration of Zr (zircon) and Hf (hafnium) is a significant influence. One of them, the group with high zirconium and hafnium concentrations (blue zone in diagram), the other is the group with low same element concentrations (yellow zone in diagram). Samples in blue zones are usually acidic and also samples in yellow zones are usually basic. The border between the groups is not very obvious and overlaps somewhere.

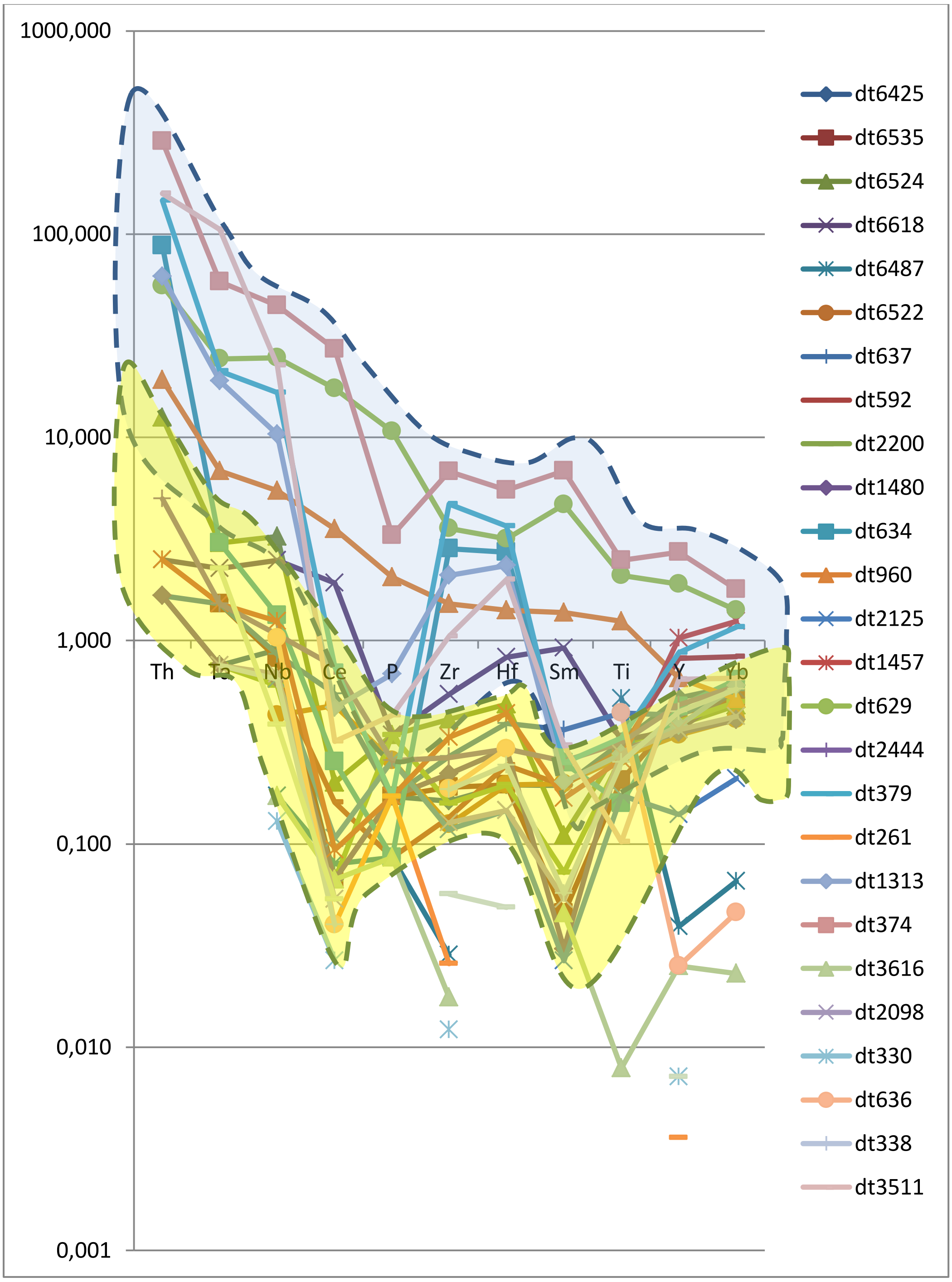


Figure 3.21. The distribution of immobile elements concantration of stone vessels. Normal-MORB normalized (Sun & McDonough, 1989) trace element concentration patterns. The sample groups are differ according to the Zr and Hf element ratios.

In the chart below (Figure 3.22), data of the samples without ultramafic origin as genetic has been transfered. Some diagrams had been used to determine the non-ultramafic origin rocks of stone vessels. One of them is a diagram which has been taken Ti-Y-Zr-Nb elements concentrations as reference. This diagram is used in basaltic rock clasification and were produced by Winchester & Floyd (1977) and reviewed by Pearce (1996). According to this clasification, it is seen that the samples were divided into at least five groups in itself (Figure 3.22).

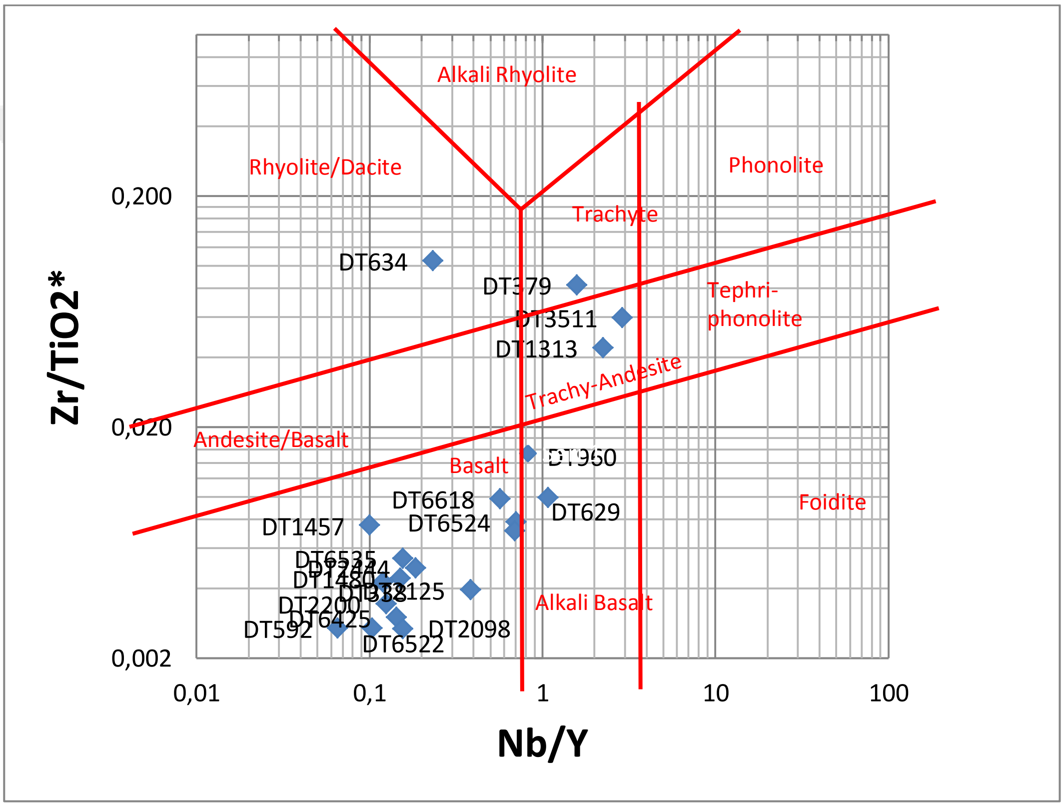


Figure 3.22. Zr/Ti vs. Nb/Y discrimination diagram (Pearce, 1996 after Winchester and Floyd, 1977). Some trace element distribution of stone vessels have non-ultramafic origin.

When the above diagram (figure 3.22), is taken into account, it is seen that the origin rock non-basaltic specimens are located in the blue zone in the immobilization diagram (figure 3.21). The samples in the yellow zone on the same diagram (Figure 3.21) also point to the basaltic samples. This data summarized in the table (Table 3.19) below is showed also similarity to the results of thin section analysis (Table 3.17).

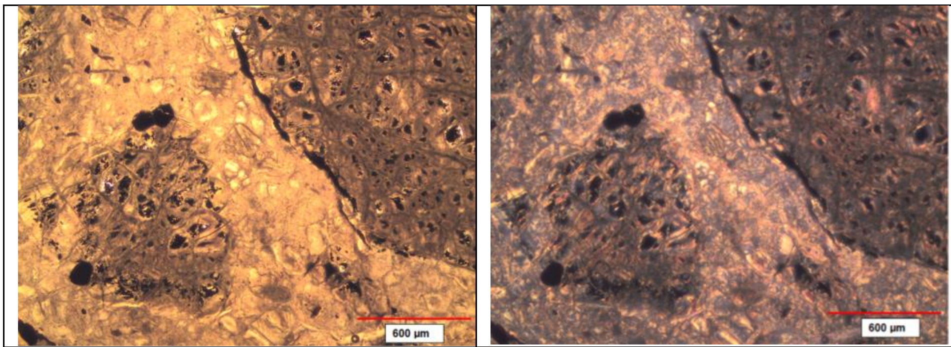
Table 3.17. Summary table of geochemical analysis results.

Sample #	Possible source rock
Dt6535 Dt338 Dt2098 Dt6524 Dt2200 Dt2125 Dt6522 Dt1480 Dt6618 Dt1457 Dt6425 Dt2444 Dt592 Dt960	Basalt
Dt636 Dt6487 Dt374 Dt637 Dt261 Dt501 Dt3616 Dt330	Ultramafic
Dt634	Rhyolite-Dacite
Dt629	Alkali Basalt
Dt1313 Dt3511	Trachy-Andesite
Dt379	Trachyte

Reached findings were evaluated in detail in the discussion and conclusions section.

Field Rock Samples

During the field work, approximately 98 samples were collected from 15 different locations which are possible sources areas of stone vessels raw materials. As a result of analysis (thin section and XRD) performed on these samples, any petrographic similaritie between stone vessels and field samples were not observed. Nevertheless, ICP-OES/MS analyzes were performed on 37 field samples, for use in petrogenetic analiysis. ICP-OES/MS analysis results are presented in the Appendix F. The petrographic studies revealed that approximately one third of the collected field samples have protolithes of ultramafic rock (Figure 3.23), while the rest of the samples are the greenish colored alteration products of mafic (gabbroic- basaltic) igneous rock.



NP19-1 (4x-PP)	NP19-1 (4x-XP)

Figure 3.23. Protolith of ultramafic rock from field rock samples. The opaque minerals in the thin section are chromite indicating that the rock is ultramafic.

The data obtained from petrographic and mineralogic examination of stone vessel and collected field samples is further checked with ICP-OES/MS analysis carried out by ACME Laboratories, Canada. Na, La, Cr, P, Zr, Y are selected to discriminate between protolith rock types of the field samples and also the stone vessel samples. The geochemical data is plotted on the diagram proposed by Pearce (1983) and reviewed by Sun and McDonough (1989) as shown in Figures 3.24 and 25.

Figure 3.24 indicates clearly that one group of stone vessel samples have similar geochemical signatures as the field samples having ultramafic origins. On the other hand, there is another group of stone vessel samples which are geochemically dissimilar to the previously mentioned group of field and vessel samples (Figure 3.25). These findings point out that, there is a genetically significant relationship between the sampled rock speciments and stone vessel samples oroginated from ultramafic rocks. It means that based on these findings, it can be claimed that the source rock location for ultramafic stone vessel sampels are succesfully detected.

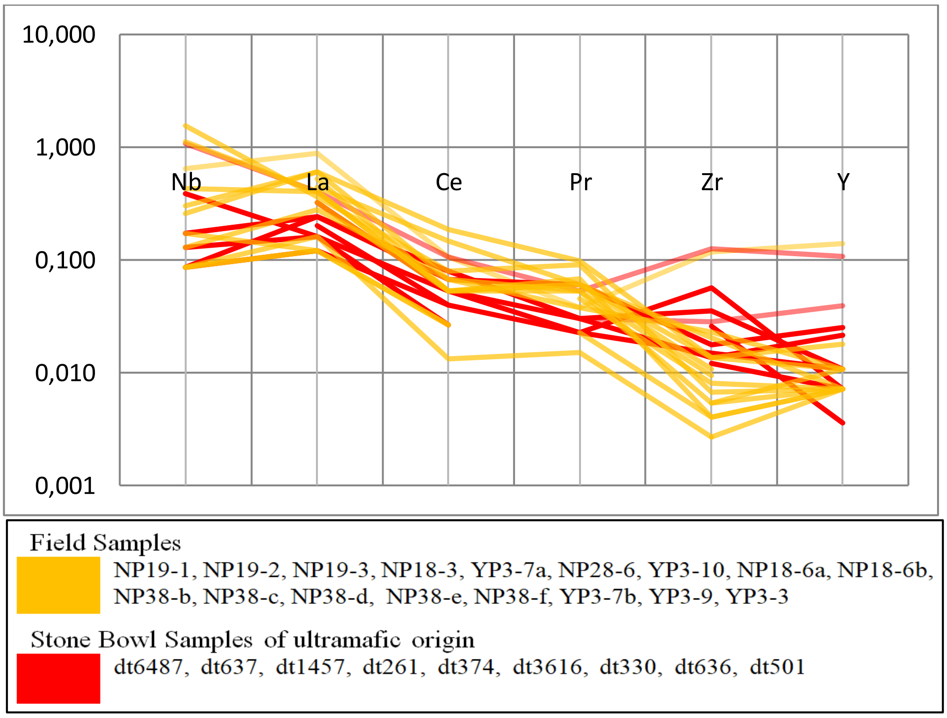


Figure 3.24. Group of stone vessels samples have similar geochemical signatures as the field samples having ultramafic origins.

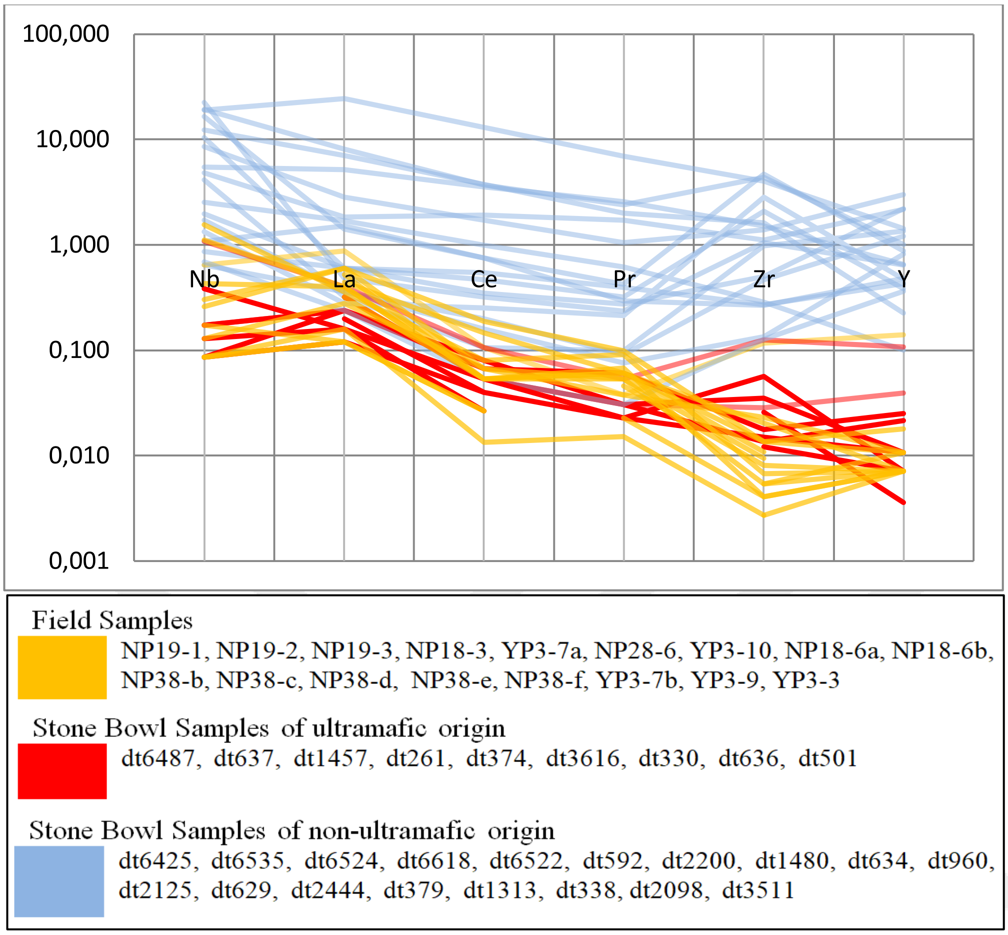


Figure 3.25. Group of stone vessel samples have similar geochemical signatures as the field samples having ultramafic origins and stone vessel samples of non-ultramafic origin.

Petrographic-mineralogic and geochemical analysis indicated that for the manufacture of stone vessel samples at least two different raw material sources, were utilized: first group of raw materials are composed of chloritized ultramafic rocks exposed as a part of the ophiolitic units. The second raw material source comprises a non-ultramafic rock outcrop. Whereas the first group of raw materials are sampled in the vicinity of Domuztepe, the second group of raw materials have not been found in the field surveys. The data regarding the geochemical signatures of these two groups indicate a genetic relation. Therefore it is concluded that the source rock of a major portion of the stone vessels unearthed at Domuztepe most probably originated from the near vicinity of the site.

3.2.4. SEM-EDX Analysis of Stone Vessels and Field Rock Samples

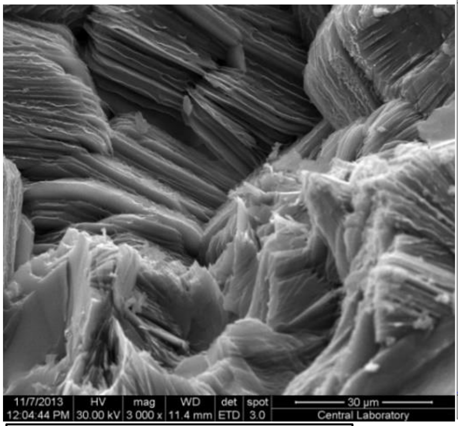
Samples of SEM-EDX analysis (totaly 11 samples) were selected from different groups as Petrographical, geochemical and field samples. The following data are presented to three of these samples.

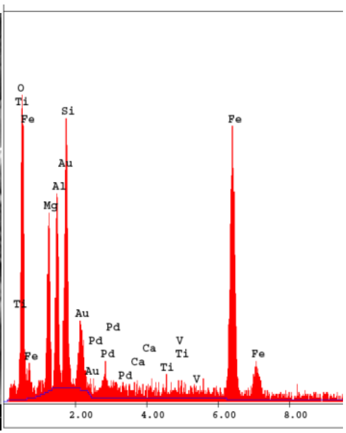
Stone Vessels

Table 3.18. Results of SEM-EDX analysis

DT 2524 (stone vessel)

* Iron (Fe) content is very high.
* It is observed a specific crystalline form (crystallized in the monoclinic crystal system typically chlorite).

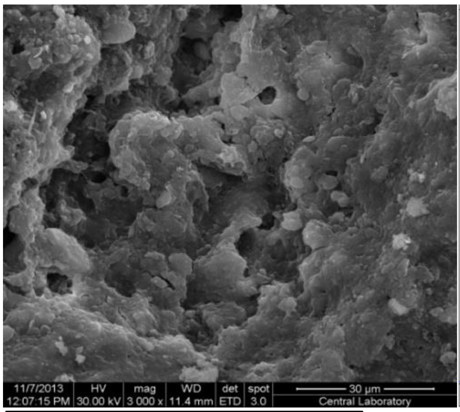


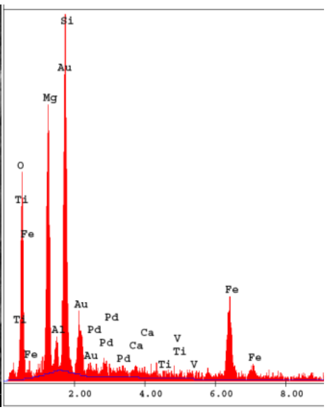


Element	Wt %	At %
O K	35.75	56.97
MgK	10.15	10.65
AlK	10.51	9.93
SiK	13.21	11.99
AuM	8.98	1.16
PdL	2.70	0.65
CaK	0.33	0.21
TiK	0.45	0.24
V K	0.43	0.22
FeK	17.49	7.98
Total	100.00	100.00

DT 330 (stone vessel)

* Despite the high Iron (Fe) ratio, this ratio is lower than the previous sample (DT 2524).
* It shows the an amorphous structure (monoclinic chlorite crystals are not observed, probably altered).





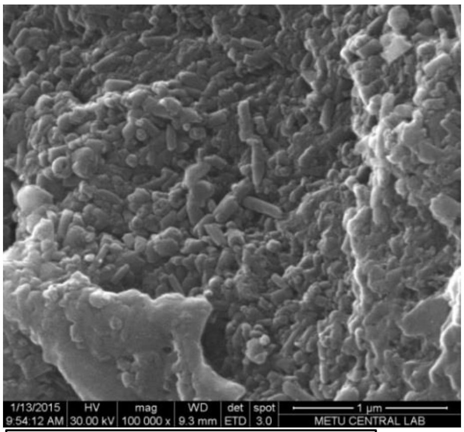
Element	Wt %	At %
O K	34.79	53.44
MgK	18.71	18.91
AlK	2.21	2.02
SiK	22.68	19.85
AuM	10.78	1.35
PdL	2.13	0.49
CaK	0.46	0.28
TiK	0.34	0.18
V K	0.31	0.15
FeK	7.59	3.34
Total	100.00	100.00

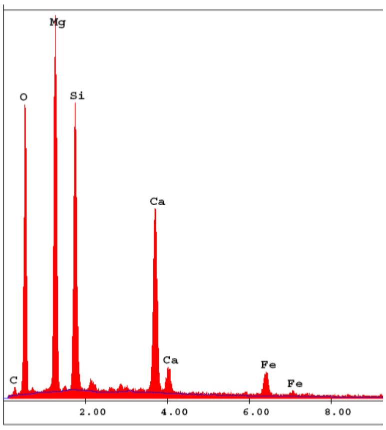
Field Rock Samples

Table 3.19. Results of SEM-EDX analysis

YP3-7a (field sample)

It shows the general wiev of structure.





Element	Wt %	At %
C K	4.98	8.27
O K	45.67	56.93
MgK	22.27	18.27
SiK	15.92	11.30
CaK	8.90	4.43
FeK	2.26	0.81
Total	100.00	100.00

Samples of SEM-EDX analysis were chosen from the samples which carried out other analyzes for making comparisons. When the samples are selected, petrogenic and geochemical differences were taken into account. Three samples taken from the field has also been included in the study (Table 3.18 and 3.19). Analysis which was performed on these samples and data from this analysis had been summarized in the following table (Table 3.20) with comparing.

Table 3.20. SEM-EDX data sheet for stone vessels (SV: Stone vessel, FRS: Field Rock Sample).

Samples	**Thin section** (Violet purple interference color- Chlorite)	**XRD**	**Petrogenetic and Geochemical data(ppm)**	**SEM-EDX**
DT 6425 (SV)	+	Fe rich Chlorite	Ultramafic	Crystalline
DT 330 (SV)	_	Fe rich Chlorite	____	Amorphous
DT1479 (SV)	+	Fe rich Chlorite	Gabbroic Zr-Hf <1000	Crystalline
DT 3511 (SV)	+	Fe rich Chlorite	Zr-Hf >1000	Crystalline
DT629 (SV)	_	Fe rich Chlorite	Alkali Basalt Zr-Hf >1000	Crystalline
DT3616 (SV)	_	Fe rich Chlorite	Ultramafic Zr-Hf <1000	Amorphous
DT2093 (SV)	_	Fe rich Chlorite	Ultramafic Zr-Hf <1000	Amorphous
DT374 (SV)	_	Fe rich Chlorite	Ultramafic Chromite with Zr-Hf >1000	Crystalline
DT627 (SV)	+	Fe rich Chlorite	Zr-Hf >1000	Crystalline
DT6522 (SV)	_	Fe rich Chlorite	Ultramafic Zr-Hf <1000	Amorphous
DT6535 (SV)	+	Fe rich Chlorite	Ultramafic Zr-Hf <1000	Crystalline
NP38-b (FRS)	Antigorite, Chromite	Antigorite (distinctive)	Ultramafik	Crystalline
YP3-7a (FRS)	Antigorite	Antigorite (distinctive)	Ultramafik	Crystalline
NP18-6a (FRS)	Antigorite	Antigorite (distinctive)	Ultramafik	Crystalline

3.2.5. Statistical Analysis of Stone Vessels

According to the results of thin sections and XRD analysis performed on stone vessels, the raw material used in the production of stone vessels was determined to be iron (Fe) rich chlorite mineral. In the mineralogy, Chlorite represents a group of minerals known by its name. Chlorite group minerals, according to Nickel-Strunz mineral classification system in mineralogy literature is one of the mineral group in the phyllosilicates class and $(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \bullet (Mg,Fe)_3(OH)_6$ is described by the general formula. In this group generally four elements (Mg, Fe, Ni, Mn) constitute the members of the chlorite groups at the silica lattice. Because of zinc within the crystal lattice, different types chlorite may also occur.

Some statistical methods were applied on chemicals data of stone vessel. These data, includes information on concentration of 58 elements as percent or ppm. There are also trace elements and rare earth elements in this element series. In the first stage, according to amount of the elements (persent scale or PPM scale) in the chemical composition of samples, Clustering Analysis was decided to perform without considering the nature of samples (regardless of samples to be pottery). Types and criterias of cluster analysis were determined by literature survey. The most obvious choice as, in order to standardize the measured relative value of the element, "z standardization / z scores" has been made on the measured values (because, concentration of elements was measured in some of elements rate as % and some others as PPM). Cluster analysis was performed on chemical data of 27 samples in total and the results are shown in the following dendrogram (Figure 3.26). According to kinship status, appearing groups were marked in the dendrogram.

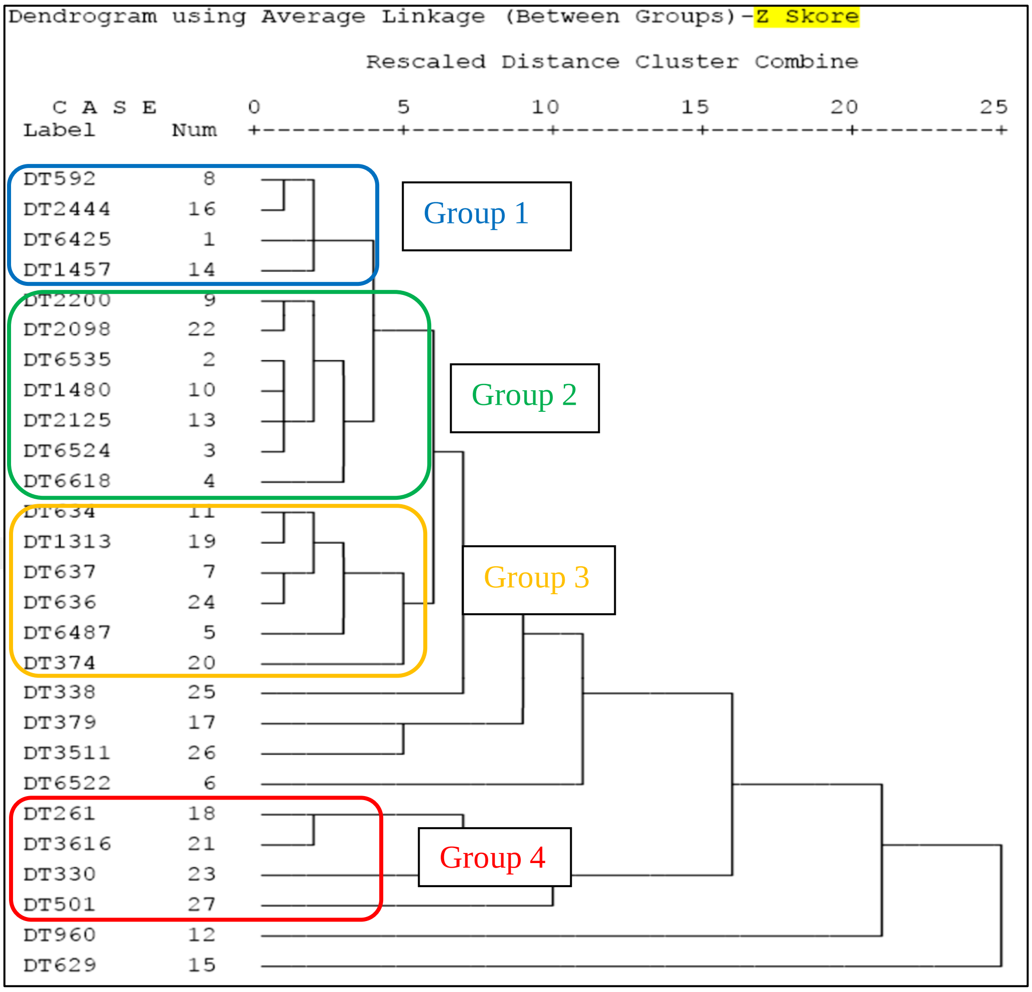


Figure 3.26. Sample clusters based on closest kinship relationships in cluster analysis.

Cluster analysis listed above were carried out according to the chemical composition of the samples. According to the results of cluster analysis, four distinct groups were observed. The raw material of stone vessels is known as soapstone (steatite) in the archaeological literature (Jones, 2007; O'Driscoll, 2003). Some statistical methods used in geochemical studies of this type of rocks was applied on stone vessel samples. Analysis results are shown in Figure 3.27, Figure 3.28 and Figure 3.29 Results of the cluster analysis and the results of geochemical analysis seems to be consistent of with each other as overall.

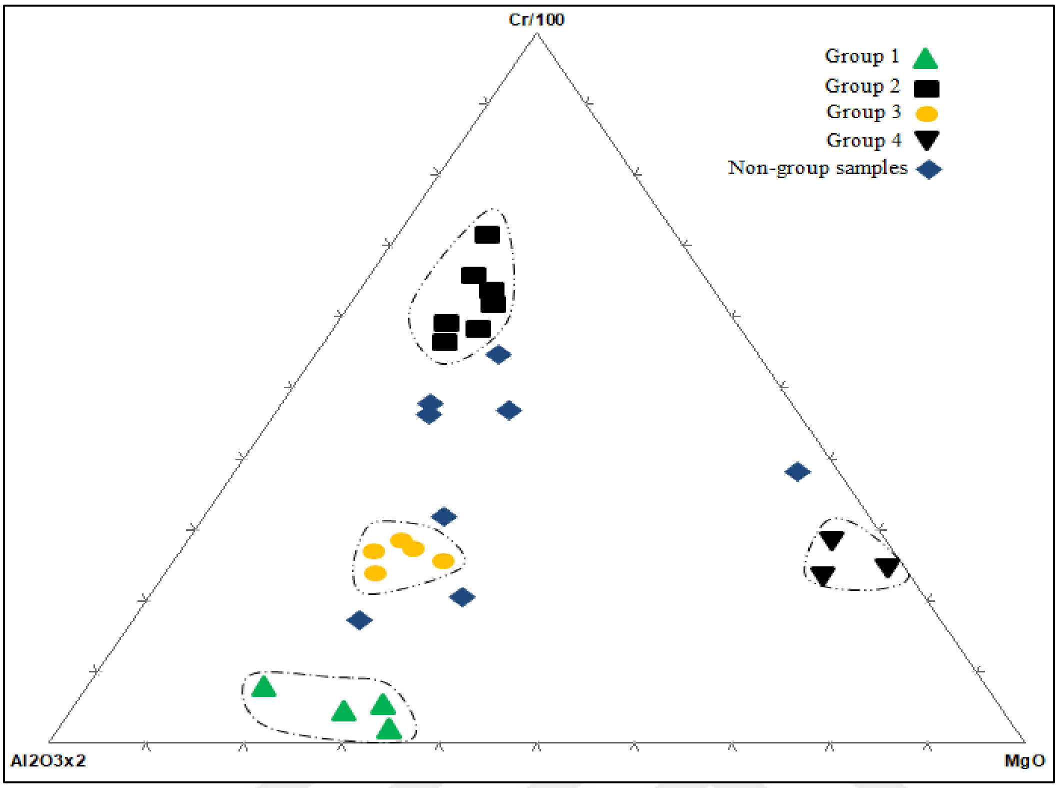


Figure 3.27. Stone vessels CrO/Al2O3/MgO tri-plot diagramı (O'Driscoll, 2003). Marked samples show groups emerging in the cluster analysis.

Groups of samples are shown in triplot diagram within the red circle. A total of four groups, including two big and two smaller have emerged. It is thought that, these groups show the results of cluster analysis as little more detail. In other words, some relationships that were not observed in cluster analysis is observed in the geochemical diagrams. Groups observed in triplot diagram are also shown in Figure 3.28 and Figure 3.29 as generally. In this graphics, some of the relationships between the clusters and intracluster are thought to emerge more clearly.

Some samples in the above diagram has never been included in any cluster in the following Co/Cr diagram, only a group consisting of these samples (has never been included in any cluster) was observed (dt 636, dt 637, dt 374, dt 6487). In this case, the distribution depends on Co/Cr concentration, suggesting that an important criterion relating about stone vessel. The common feature of the clustered samples in this diagram, Chromium (Cr) concentration of these samples can be said to be relatively low compared to others samples (Figure 3.30).

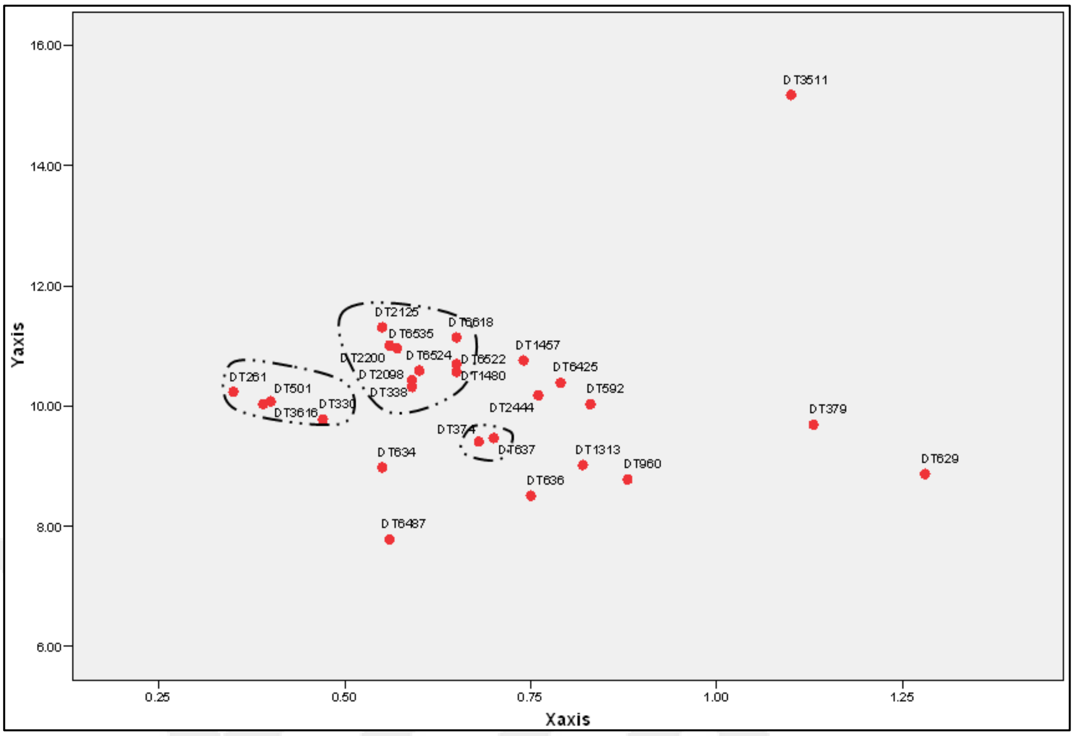


Figure 3.28. In the graph, according to x (log(sum of REE)/log Cr) and y (sum of log Cr+log Zn+log Fe+log Co/log Sc) axis data, the distribution of the samples are seen (Jones, 2007).

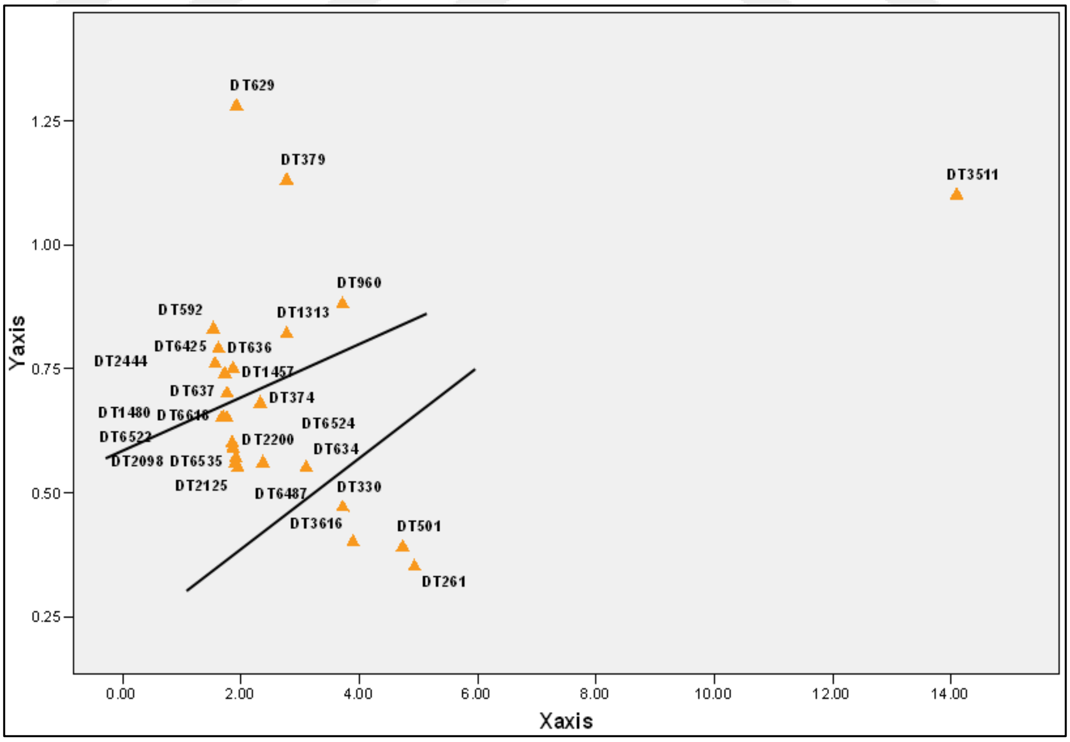


Figure 3.29. In the graph, according to X (sum of log REE/log Cr) and Y (sum of log transition metals/log Sc) axis data, the distribution of the samples are seen (Jones, 2007).

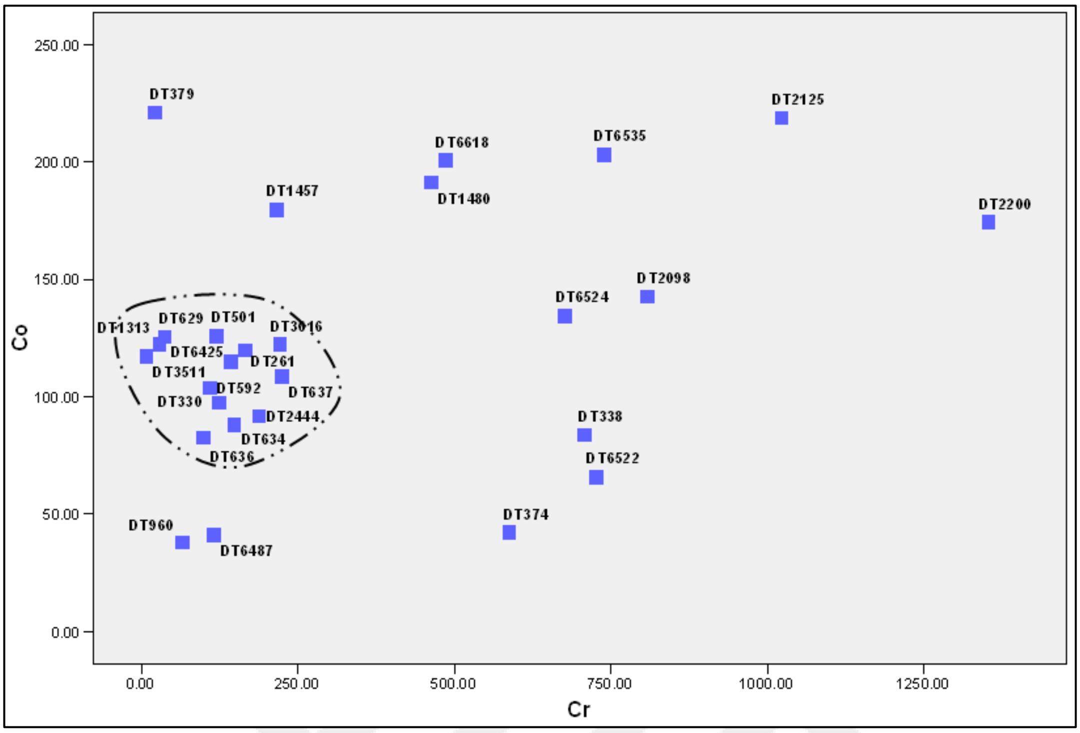


Figure 3.30. Distribution of stone vessel samples, according to Co/Cr concentrations (Jones, 2007).

The cases observed at the above charts (Figure 3.27, 3.28, 3.29 and 3.30) were interpreted as comparative in the following table (Table 3.21).

Table 3.21. Groups of stone bowls clustered by chemical and geochemical data.

Group 1	Group2	Group3	Problematic cluster	Weakly associated clusters
DT 6535 DT 2125 DT 2200 DT 6524 DT 2098 DT 338	DT 6522 DT 1480 DT 6618	DT 1457 DT 6425 DT 2444 DT 529	DT 636 DT 637 DT 374 DT 6487	DT 261, DT 501, DT 3616, DT 330, DT 634, DT 960, DT 1313, DT 379, DT 629, DT 3511

The relationships between some examples are seen clearly in the diagrams. These clusters generated by these sample are formed group1, group 2 and group3. In this case, the possible raw materials used in production of the vessels suggest that were been available from at least 3 different sources. Samples located in Problematic Clusters are taking part in the some groups but these samples are not demonstrate consistency.

- DT 636, DT 637 and DT 6487 seems to be associated with Group 2 in the triplot graphics. And also , DT374 seems to be associated with Group 2.
- DT 636 and DT 637 appear to have associated with Group 2 in figure 3.1 The DT 374 and DT 6487 seem to be associated with each other as independent from clusters.

Nevertheless, the DT 637, DT 374 and DT 636 seems to be associated with each other.

- Group of consisting from DT 3511, DT 379, DT 629 and group of consisting from DT 261, DT 501, DT 3616, DT 330 in weak associated group appears to be related itself.

CHAPTER 4

DISCUSSION

4.1. Pottery of Domuztepe

In order to make the results easier to understand, it is useful to make a small reminder at this stage. Halaf ceramics; It is a ceramics type that is hand-shaped and often painted or decorated in a very attentive manner, which was preferred by many communities spread over North Mesopotamia from the 6th millennium BC (Oppenheim, 1933). In this period, Halaf type ceramics spreading in a wide geographical area were encountered abundantly also in Domuztepe.

Burnished pottery are distinguished from Halaf type pottery especially with their color and decor choices. Dark colored simple pot type forms; black, brown, dark red, and the surfaces are burnished. In addition, these types of pottery on which printing-nail-scratches were applied with a hard object are visible, whereas painting is not present. In our work, we tried to understand the effect of firing atmosphere and temperature on the pottery for which these stylistic choices were applied. In addition, these choices had been tried to compare with the choices observed in Halaf type painted ceramics (produced in Halaf stylistic style).

Halaf type ceramics constitute 60% of the ceramics found in Domuztepe excavations. The remaining ceramic finds are; it is observed that composed of the ceramics produced in the local style (Burnished type) known to have developed in the region from the beginning of the Ceramic Neolithic Period (Campbell,1992).

The results of the thin section analysis made to determine the firing conditions of the ceramics are presented in relevant chapter (Chapter 3.1.1.). According to these results, it is seen that burnished ceramics are produced mostly in the reducitive firing atmosphere. It is observed that this situation continued for in all chronological periods, in other words in one thousand two hundred years. For this reason, it can be said that in the production of burnished ceramics, the low temperature (less than 900 C)and reducing firing atmosphere are consistently preferred over a long period of time.

Zoning were seen in the thin sections of in most of the burnished ceramics. This fact can be explained either by covering or wrapping the ceramics with some sort of organic materials (wicker, straw, etc.) during firing or fast firing and or fast cooling.

Burnished type ceramics are usually has a dark surface color. In some samples, organic matter residues were seen on the ceramic surface. This suggests that organic matter is wrapped around the ceramic surface in order to darken the surface color during the firing (Quinn, 2013). This application occures a very thin dark zone on the ceramic surface. In burnished ceramics, this application, which darkens the surface color, was commonly encountered.

Fast firing of the ceramics or rapid (instantaneous) cooling after the firing process causes the surface color of the ceramics to be lighter (Quinn, 2013). In some of the burnished ceramics, such applications were seen (e.g. Lot 4916 - 2 Brown Burnished, Lot 4915 - 2 Leather Burnished etc.). Such applications are thought to be preferred in order to give desired color tone to the ceramics. In some burnished ceramic samples, it is seen that the firing process is applied by fast firing or fast cooling as well as by wrapping organic matter. These two processes have an opposite effect on the ceramic surface color (Rapid firing or rapid cooling causes the ceramic surface color to be light, whereas if the surface of the ceramic is covered with organic material and fired, the ceramic surface color becomes dark.). When this process is applied locally to the ceramic surface, it is possible to obtain a patchy (light-dark) color on the ceramic surface.

Another commonly observed phenomenon in thin section analysis of burnished ceramics is birefringence in the clay matrix (the optical activity of the matrix). This indicates that the clay minerals were not vitrified and the firing temperature was generally below 900 °C (Quinn, 2013).

The firing temperatures used ranges from 800-900°C. This is typical for early period pottery (Moorey, 1994). In addition, it was identified that, illite, smectite, chlorite and illite-smectite mixed layer clay mineral types were used in burnished ceramics, except for one sample. In just one sample (Lot 4916 Lether Burnished), the kaolin type clay was also determined.

It has been determined that organic and inorganic tempers were used as additives in clay paste of such ceramics. As an inorganic additive, it is understood that mostly quartz, feldspar, calcite, mica and much less serpentine were used. Rock fragments were also found (limestone, basalt, serpentinite etc.). It has been observed that these additives have sharp edges. This indicate that the additives do not already present to the clay raw materials naturally, but they were crushed or grinded and then mixed into the clay paste. The presence of large and angular mineral grains in the clay matrix is another indication of this situation. However only for the two incised decorated ceramics samples (4927-1 incised, 4915-2 incised), inorganic (mineral) tempers and an oxidizing atmosphere in both early and late stages were used. Organic temper were not observed.

Halaf type ceramics which were generally light buff colored, consisted of both painted decorated and unpainted decorated varieties. The studied ceramics cups had various forms such as plates, neck vases, curved casings, etc. They show superior features in terms of hand craft. It is known that the Halaf type ceramics become widespread after the burnished ceramics (6th millennium BC and after) in the region and they were used together with the burnished ceramics for one thousand years in Domuztepe, approximately in the ratio of 60% Halaf type, 40% burnished type.

During the study its was aimed to understand whether if there were significant differences between Halaf ceramics and burnished ceramics in terms of production technologies including firing conditions and raw material preparations (Table 3.5 and 3.6 – Chapter 3.1.1.). For Halaf ceramics, according to results of thin section analysis made to determine the firing conditions of the ceramics (Chapter 3.1.1.), it was identified that oxidizing atmosphere (causing light colored) was dominant in all chronological stages from Red Terrace Late Halaf c. 5.750-5,500 cal. BC to Pre-Red Terrace Ceramic Neolithic c.6.200 cal. BC. Like in a burnished ceramics, it is observed that this situation continued in all chronological periods, in other words in one thousand two hundred years. For this reason, it can be said that in the production of Halaf ceramics, the low temperature and oxidizin firing atmosphere are consistently preferred over a long period of time.

However, since oxidizing atmosphere probably might not fully achieved, it was believed that some interventions such as fast firing and fast cooling were done to keep the ceramics surface light color. Fast firing and fast cooling caused the color of ceramic paste to light color on the ceramic surface (Quinn, 2013). Therefore, it is generally estimated that the interventions were made in this direction. It was determined the fast firing method in unpainted Halaf ceramics samples was prefered as a method for achieving light surface coloring. In cases where this is not possible, it is suggested that the light colored surface of the ceramics was obtained by fast cooling. Coating or wrapping the ceramic surface with organic material during firing causes the ceramic surface color to darken. This application was widely observed in burnished ceramics. Contrary to burnished ceramics, no trace of organic matter was found on the ceramics surface in any of the studied Halaf type ceramics.

As a seen in burnished ceramics, in thin section analysis of Halaf type ceramics also exhibit birefringence in the clay matrix (the optical activity of the matrix). This indicates that the clay minerals were not vitrified and the firing temperature was generally below 900 °C. For this reason, clay types were used in the production of

Halaf ceramics could be determined by XRD analyzes. Using this method, illite, smectite, chlorite, illite-smectite mixed layer clay minerals were determined to be present in the raw material of the Halaf type ceramics. Organic and inorganic tempers were observed in clay paste of Halaf ceramics same as burnished ceramics. As an inorganic temper, it is seen that mostly quartz, feldspar, calcite, mica. Unlike burnished ceramics, serpentine additive material was observed in very few Halaf samples (Lot 4915 Vegetable Temperd, Lot 4915 Unpainted, Lot 4915 Grid Temperd Unburnished Coarse, Lot 4915 Painted Pottery, Lot 4916 - 1 Unpainted).

Geochemical and statistical analysis results of ceramics based on chemical data were presented in the related section (section 3.1.4). The groups formed by the chemical data actually point to the composition of the ceramic paste. In other words, it gives information about a mixture made by human rather than a raw material formed by natural processes. These results are summarized below (Table 4.1). According to this results, five different ceramic paste were determined. It had been determined that the same ceramic paste is used in the production of stylistically different pottery. Ceramic paste material #2, may be the only raw material used in all of the settlements (Domuztepe, settlement 96, settlement 67). All of the raw materials used at Domuztepe except for "Ceramic paste material #5", were also prefered in settement 67. This settlement is had a central importance like Domuztepe by some archaeologists whic studied on this issue (Atakuman, 2004). This settlement is known to be used as well during the period after Halaf period. Because of this reason, this Ceramic paste material #5 could be preferred for these settlements. Settlement 96 appears to be associated with single source (ceramic paste material #2).

In the Table 4.1, statistical and geochemical analysis results are compared with petrographic analysis results which are thought to be related to these results. Petrographic data were chosen from petrographic variables (taken from Appendix C) which are thought to influence the chemical composition of the ceramic paste.

These variables were determined as organic matter, hematitization and mineral tempers (serpentine, quartz, A. feldspar, calcite, mica). In the Table, the numerical values in relation to the petrographical results indicate the quantity of the variable (0 = none, 1 = small amount exists, 2 = large amount exists).

Table 4.1. Analysis results comparison chart (67 and 96 are two other settlements near of the Domuztepe. 4915, 4916, 4927 and 4928 also show some chronological periods of Domuztepe.).

Statistical and geochemical analysis results		**Petrografic analysis results**						
Possible raw material groups	**Sample / Settlement**	**Organic material**	**Hematitization**	**Se**	**Cal**	**Q**	**AF**	**Mic**
Ceramic paste material #1								
5500-5300 BC	67 M2	2	0	0	1c	1m	1c	1
6100 BC	4928 BB1	1	0	1	1	1f	1c	1c
6000-5750 BC	4916 BWB2	2	0	1	1c	1c	1c	1
5500-5300 BC	67 WS	1	0	0	1c	1f	1c	1
6100 BC	4928 RB1	1	1	0	1	1	1	1
Ceramic paste material #2								
5200 BC	96 U	0	1	0	1	1f	1	1
6200 BC	4915 BBON3	2	2	0	1	1	1	1
5200 BC	96 B	0	2	0	1	1	1f	1f
5750-5500 BC	4927 MPH	1	2	0	1c	1c	1c	1c
5500-5300 BC	67 PB	0	2	0	1c	1c	1	1
5500-5300 BC	67 NB	0	2	0	1	1c	1	1
5500-5300 BC	67 RB	0	2	1c	1	1	1c	1
Ceramic paste material #3								
5500-5300 BC	67 B	1	2	0	0	1c	1	1
5750-5500 BC	4927 BWB	1	1	0	0	1f	1f	1f
6100 BC	4928 U	1	2	0	0	1f	1f	1f
Ceramic paste material #4								
6000-5750 BC	4916 LBPA	1	2	1	1	1	1	1f
6200 BC	4915 BBON2	2	1	1	1c	1	1c	1c
6200 BC	4915 U	1	1	1	1c	1	1	1
5500-5300 BC	67 NIN	0	1	2	1c	1	1	1f
Ceramic paste material #5								
6000-5750 BC	4916 P	1	1	0	1c	1	0	1
6000-5750 BC	4916 BB	2	2	0	1	1c	1c	1f
6000-5750 BC	4916 LB	2	1	1c	1c	1f	1c	1c
5750-5500 BC	4927 UH	1	2	0	1c	1	1	1
5750-5500 BC	4927 PO2	0	2	0	1c	1f	1	0

Here, some smilarities have been observed between the sample groups that are based on chemical data and the petrographic properties of the samples in these groups. These smilarities, listed Table 4.1, can be considered as the reasons for groupings in which emerges by chemical data.

Some of the results achieved according to this comparison table are summarized below:

- **Ceramic paste material #1:** It may be separated from other groups for the reason that the amount of organic matter is excessive.
- **Ceramic paste material #2:** It may be differentiated from other groups due to the excess of hematitization.
- **Ceramic paste material #3:** Due to the excess of hematidisation and organic material and absence of calcite mineral can be distinguished from other groups.
- **Ceramic paste material #4:** The excess of hematite, organic material and serpentine mineral may have caused this group to separate from the others.
- **Ceramic paste material #5:** It may be differentiated from other groups due to the excess of hematitization and organic material.

However, chemical composition of the at least some of the pastes do not corelate with their mineral compositio. For example, it is thought that the raw material of Ceramic paste material # 2 is separated from the others due to high hematitization rate. However, when the Fe contents of the samples in this group are taken into consideration, it seen that these samples do not have the highest Fe (6.81%, 5.87%, 5.96%, 7.13%, 8.30%, 8.27%, 8.01%) concentration when comparet with the other samples. Similarly, in the samples group of ceramic paste material # 3, no calcite mineral was observed in thin sections. However, this samples have high CaO (20.14 %, 18.15%, 19.31%) content as reveald by chemical analysis. This maybe explain by the fact that Ca content is sourced from the clay matrix composition. Or it may have occured secondary during the period when the ceramics were buried.

The Comperasion of mineral assemblages of ceramic and field soil samples showed that they have similar non-clay and clay mineral associations although in the clay (smectite, illite, chlorite, smectite-illite mixed leyer) fraction of soil field samples kaolin minerals are more abundant. Based on this observation it is shown that the raw materials used for the production of ceramic had local sources. At Domuztepe, over 20 tonnes of pottery have been excavated in the 10 excavation seasons (Campbell 2013). The utilization of the local sources at domuz tepe ceramic production is also suported by the unearthed firing klins and abundance of ceramics during the excavations of Domuztepe (Campbell et al. 1999).

4.2. Stone Vessels of Domuztepe

As a result of petrographic analysis chlorite minerals was determined as a single and main mineral component all of the stone vessels samples. Optically two main groups were observed and in the one of these groups (23 samples) chlorite minerals have a significant purple interference color. In the second group (24 samples) of the vessel samples, chlorite minerals didn’t exibith purple interference color. According to Albee (1962), most common low-grade metamorphic chlorite is ripidolite; this species may be optically positive or negative, with the change in optic sign occurring where β : 1.630 and F/FM (the ratio Fel(Fe+Mg)) = 0.52 (Albee, 1962). At this changeover point, chlorite is effectively isotropic for the whole spectrum of white light, although very commonly some parts of the spectrum are not extinguished, resulting in purple interferencecolors (Craw & Jamieson, 1984).

A total 16 samples were selected and examined by XRD analysis which prowe that an Fe-rich chlorite mineral is present in all of this samples. The result of analysis, Fe- rich chlorite minerals were determined in all samples. In other words, XRD analysis results couldnt distinguished between the opticaly Fe rich chlorite.

Thin section analysis of the field rock samples showed that these samples have generally antigorite as a serpentine group minerals. Talc and chromite were determined in thin sections. Field samples show different structural and textural features in itself. It is shown that based on the major mineralogical differences stone vessels samples and field rock samples do not have similarity indicate the raw material sources are present with in the study area.

Based on the statistical analysis of the ICP-OES/MS results, three main clusters emerged(group 1, group2 and group3). Apart from these, two clusters were called "problematic cluster" (group 4) and "weakly associated cluster" (group 5).

Samples located in Problematic Clusters are taking part in the some groups but these samples are not demonstrate consistency when their chemical data were plotted on different geochemical discimination diagrams. In other words, samples in this statistical cluster can be seen in different clusters in different geochemical diagrams or can not be seen in the same cluster in each geochemical diagram (according to x (log(sum of REE)/log Cr) and y (sum of log Cr+log Zn+log Fe+log Co/log Sc) axis data, the distribution of the samples are seen and according to X (sum of log REE/log Cr) and Y (sum of log transition metals/log Sc) axis data, the distribution of the samples are seen (Jones, 2007).

Samples of weakly associated clusters were samples that do not come together in each geochemical diagram (CrO/Al2O3/MgO tri-plot diagramı (O'Driscoll, 2003), the graph according to x log(sum of REE)/log Cr) and y (sum of log Cr+log Zn+log Fe+log Co/log Sc) axis data, the distribution of the samples are seen (Jones at al, 2007), the graph, according to X (sum of log REE/log Cr) and Y (sum of log transition metals/log Sc) axis data (Jones, 2007) and Co/Cr concentrations diagram (Jones, 2007)). In addition, the samples in this group are divided into two groups in itself (DT 3511, DT 379, DT 629 and DT 261, DT 501, DT 3616, DT 330).

Petrogenetic analysis of the stone vessel samples based on the chemical analysis were done using discrimination diagrams such as the one (Zr/Ti vs. Nb/Y classification diagram) propose by Pearce 1996, in order to identify protolith (type of the origin of sources rock) of the rock samples used to make stone vessels.

These five groups that emerged as a result of these analysis, although parallel to the groups in the cluster analysis, were observed to give the clusters a little more detail (Table 3.17). Petrogenetic analyzes have produced additional findings about the "problematic cluster" and " weakly associated cluster" samples that could not be decomposed in the previous clusters. As a matter of fact, in the statistical analysis, the clusters we grouped as Group1, Group2, and Group3 match petrogenetically with the basaltic group. It is shown that samples of problematic cluster and weakly associated cluster were derived petrogenetically from a magmatism which has a ultramafic and non-basaltic (Rhyolite/Dacite, Alkali-Basalt, Trachy-Andesite, Trachyte) rock types.

In Spider diagram Figure 2.34, shows the distribution of some immobile element concentrations of stone vessels. In this diagram, it can be seen that some of the elements (Th, Ta, Nb, Ce, P, Zr, Hf, Sm, Ti, Y, Yb – this element series modified from Sun and McDonough (1989)) of some samples (Dt6487, Dt637, Dt261, Dt374, Dt3616, Dt330, Dt636, Dt501) were not detected or not found. This situation indicates that these samples mentioned above had an ultramafic origin (Wilson, 2007). In the table below (Table 4.2), samples in this clusters were shown with names of "missing element" under the petrogenetic groups.

Another evidence of the possibility that a partion of stone vessels may be of ultramafic origin is the following: Na, La, Cr, P, Zr and Y are selected to discriminate between protolith rock types (origin of the rock) of the field samples and also the stone vessel samples. The geochemical data is plotted on the diagram proposed by Pearce (1983) and reviewed by Sun & McDonough (1989). This diagram indicates clearly that one group of stone vessel samples (dt6487, dt637, dt261, dt374, dt3616, dt330, dt636, dt501) have similar geochemical signatures as the field samples (NP19-1, NP19-2, NP19-3, NP18-3, NP28-6, NP18-6a, NP18-6b, NP38-b, NP38-c, NP38-d, NP38-e, NP38-f, YP3-10, YP3-7a, YP3-7b, YP3-9, YP3-3) having ultramafic origins. These findings point out that, there is a genetically significant relationship between the sampled rock speciments and stone vessel samples oroginated from ultramafic rocks. It means that based on these findings, it can be claimed that the source rock location for ultramafic stone vessel sampels are succesfully detected.

Table 4.2. Petrogenic clustering of stone vessel samples.

Statistical Group	Sample	Petrogenetik Group	Possible source rocks
Group1	Dt6535	Low rate Hf-Zr	Basalt-Gabbro
	Dt2125	Low rate Hf-Zr	Basalt-Gabbro
	Dt2200	Low rate Hf-Zr	Basalt-Gabbro
	Dt6524	Low rate Hf-Zr	Basalt-Gabbro
	Dt2098	Low rate Hf-Zr	Basalt-Gabbro
	Dt338	Low rate Hf-Zr	Basalt-Gabbro
Group2	Dt6522	Low rate Hf-Zr	Basalt-Gabbro
	Dt1480	Low rate Hf-Zr	Basalt-Gabbro
	Dt6618	Low rate Hf-Zr	Basalt-Gabbro
Group3	Dt1457	Low rate Hf-Zr	Basalt-Gabbro
	Dt6425	Low rate Hf-Zr	Basalt-Gabbro
	Dt2444	Low rate Hf-Zr	Basalt-Gabbro
	Dt592	Low rate Hf-Zr	Basalt-Gabbro
Problematic cluster	Dt636	Missing element	Ultramafic
	Dt637	Missing element	Ultramafic
	Dt374	Missing element	Ultramafic
	Dt6487	Missing element	Ultramafic
Weakly associate cluster	Dt261	Missing element	Ultramafic
	Dt501	Missing element	Ultramafic
	Dt3616	Missing element	Ultramafic
	Dt330	Missing element	Ultramafic
	Dt634	High rate Hf-Zr	Rhyolite/Dacite
	Dt960	High rate Hf-Zr	Alkali-Basalt
	Dt1313	High rate Hf-Zr	Trachy-Andesite
	Dt379	High rate Hf-Zr	Trachyte
	Dt629	High rate Hf-Zr	Alkali-Basalt
	Dt3511	High rate Hf-Zr	Trach-Andesite

In the table below (Table 4.3), chronological data of stone vessels and also their petrogenetic clustering results were compared. It is shown that, for the stone vessels belonging to the earliest period (6100-5800 BC), the raw material with petrogenetically basaltic origin was preferred for almost three centuries. In the next two hundred years (5700 - 5500 BC) it is revealed that the rock sources of ultramafic, basaltic-gabbroic and rhyolitic-dacitic-andesitic-Trachytic origin had been used. The one hundred year period in the centuries between 5500 and 5400 BC, mainly ultramafic, basaltic-gabbroic souces were utilized. The samples in group "Finds without chronological data"are the samples recovered from the surface of the mound. Since these samples are not taken from an archaeological layer, there is no chronological data of these samples. Only two samples basaltic-gabbroic and trachytic sources.

Table 4.3. It shows the periodic change in the raw materials used in stone vessels. Here, the chronology of the stone vessels and the petrogenetic cluster data are compared.

Chronology of the stone bowls	Ultramafic	Basalt-Gabbro	Trachy-Andesit	Rhyolite-Dacite	Alkali-Basalt
6,100-5,800 BC		Dt6425, Dt6524			
5,700-5,500 BC	Dt636, Dt374 Dt637, Dt6487	Dt6522, Dt6535, Dt6618, Dt592, Dt2098, Dt2200	Dt3511, Dt1313, Dt1480,	Dt634,	Dt629
5,500-5400 BC	Dt330, Dt261, Dt501, Dt3616	Dt2444, Dt2125, Dt1457			Dt960
Finds without chronological data.		Dt338	Dt379		

CHAPTER 5

CONCLUSSION

As might be recalled, the basic research questions of this study were as follows:

- Which clay resources are used in the production of pottery in the region and what is the geographical relationship between the settlement of these areas of resources?
- How many different sources of raw materials, used by pottery and stone masters?
- Are the pottery and stone material resources used in the Domuztepe vary through time?
- What are similarities and differences between Halaf-type pottery and local pottery in terms of the use of source of raw material and technological production stages?

The results of the study were evaluated and discussed in the previous chapters in detail and the major conclusions arrived were stated as follows:

5.1. Pottery of Domuztepe

In this study, archaeometric studies were carried out on a group of ceramics recovered at Domuztepe Höyük. These ceramic groups, known as Burnished and Halaf, were studied petrographically (thin section analysis, XRD analysis and SEM-EDX analysis), the qualities of the raw materials (clay types and tempers) used in the production of these ceramics were determined and the production processes (firing atmosphere, firing temperature etc.) were tried to be determined. These informations about the ceramic groups have been compared. In addition, the presence of clay types used in the production of ceramics were attempted to identify by field studies in Domuztepe vicinity. Further more, the chemical composition of the ceramic paste prepared during the production of ceramics was determined (ICP-OES/MS analysis) and it was determined how many different kinds of paste were used in a time period of about a thousand years.

The following conclusions have been reached as a results these analysis:

1. Domuztepe ceramic finds were classified into 11 main (Early burnished , Leather burnished, Black burnished, Fine incised burnished, Red burnished, Other incised burnished, Brown burnished, Pattern burnished, Vegetable-grit coarse, Painted Halaf, Unpainted Halaf) and 65 sub-groups according to their different stylistic features (physical/visual properties that are noticed such as color, painting, decorating, burnishing, etc.). Among of these, there are also samples that do not belong to Domuztepe settlement. These samples were collected from different settlements which are located in Domuztepe vicinity during field survey. These settlements are thought to be associated with Domuztepe (Höyük number 67, 70, 96). It is believed that, these settlements were inhabited at about the same time chronologically with the Domuztepe and relationship of this settlements with Domuztepe are tried to understand through pottery chemical analysis.

2. It has been determined that organic and inorganic tempers were used as additives in clay paste of all of the ceramics (Burnished and Halaf type ceramics) As an inorganic additive, it is understood that mostly quartz, feldspar, calcite, mica and much less serpentine were used (in Halaf type ceramics, serpentine type tempers were seen to be much less than burnished type of ceramics).

   Despite the fact that so many different visual groups have been observed in the stylistic sense, it has been determined that at the end of the analytical work done, up to 5 different raw materials (ceramic paste material) were used for all of the investigated ceramics. Here, it is a ceramic paste consisting of clay and tempers (organic and inorganic) mixture expressed by ceramic raw materials. Chemical and combine statistical analysis results give information about the chemical composition of this ceramic pastes.

3. It is found that the different raw materials emerging at the end of chemical and combine statistical analysis were preferred at different times and different combinations for ceramic production. It also suggests that at least two different raw materials are used in each chronological period. In addition, it is estimated that some of the raw materials (Ceramic paste raw material #2 and #4) were periodically abandoned but later reused.

4. The raw material of ceramic paste material #2 is the only one which was used by Domuztepe settlement and höyük 96 and höyük 67 settlements. It is observed that höyük 67 settlement used almost the same raw material of ceramic paste material (except # 5) used by the Domuztepe settlement. It is thought by archaeologists working on this area that this settlement (höyük 67) could be a central settlement like Domuztepe. Because of the knowledge that this settlement is also being used in the post-Halaf period, it can be thought that the source of ceramic paste material #5 will be preferable source in later periods for this settlement.

   As a result of these studies, it was determined that raw materials (ceramic paste) were most probably used in the production of the Domuztepe site pottery and some other settlements in the immediate vicinity.

5. Another important goal of our research is to identify the production technologies of these two different types (Halaf type and Burnished type) of ceramics and to understand the similarities / differences and relationships between them. One of the most evident finding between the Halaf type ceramics and the local type burnished ceramics is that no significant difference is observed in terms of firing

temperature. This suggests that ceramic manufacturers focused on preferences for controlling other factors (firing atmosphere: reducing or oxidizing, firing duration, cooling duration), to produce ceramics with different colors. An other factors to be kept under control for having different colors was whether or not the ceramics wrapped with organic material during firing. Taking these factors into account, it is understood that in order to achieve the desired properties in Halaf ceramics (mainly ceramic color), organic material is not consciously contained in the firing environment and contact of the ceramics to each other is prevented in order to provide air circulation. It is also understood that an oxidizing atmosphere is being tried to provide as a firing atmosphere. However, when this is not achieved, technics of fast firing or fast cooling seems to be applied to obtain light colored surfaces.

6. This thesis study has shown that similar types of clay and probably similar clay sources, have been used in burnished ceramics and Halaf ceramics. For this reason, it is understood that the difference in ceramic color is not caused by clay types. The fact that the ceramics to be investigated were early period ceramics, in other words, they were fired at low temperatures (less than 900°C), caused the clay material used in ceramics production not to vitrify and allow the determination of the clay types in ceramics. XRD analysis were carried out in order to determine the clay mineral types used in ceramic production. According to the results of XRD analysis, it was understood that illite, smectite, less amount of chlorite and kaolinite, and mixed layer clays minerals are present in the all of the ceramic paste materials. Afterward, in order to determine the dominant clay types in Domuztepe and its vicinity, samples have been taken from the alluvial sedimentary units containing the clay of Narlı Plain. The results of their analysis showed that the clay mineral types of collected samples are the same as those found in the ceramic (illite, smectite, chlorite and kaolinite). This indicates that, clay raw material used in the ceramics were obtained from local clay sources in Domuztepe and its vicinity.

5.2. Stone Vessels of Domuztepe

The investigation of the stone vessels source of raw materials had an important place in this study. For this purpose, rocks used for the manufacturing of the stone vessels were analysed by different methods, petrographically and chemically. In addition to this, for three consecutive periods, field surveys were carried out in order to investigate the possible source of raw materials of these stone vessels. Rock samples collected during the field survey were analysed like stone vessels and the findings were compared.

The following conclusions have been reached as a results these analysis of stone vessels.

1. As a result of petrographic analysis of the stone vessels, chlorite minerals were found in the raw materials of these finds. The field studies have focused on ultramafic rocks that are observed more common in the study area. Antigorite-type serpentine minerals were encountered in samples collected from possible sources of raw materials during field work. As a result of this, petrographically well-suited parallelism was not observed between types of stone vessels and rock samples collected from the field.

   The findings show that the raw material from which the stone vessels are produced are obtained from at least five different petrogenetic types of possible sources rock. Using some geochemical analyzes and geochemical discrimination diagrams (Zr/Ti vs. Nb/Y classification diagram -Pearce, 1996 after Winchester and Floyd, 1977 and Normal-MORB normalized- The distribution of immobile elements concentration - Sun and McDonough, 1989), it was determined that possible rock sources could have 5 different petrogenetic types. These are ultramafic, basaltic-gabbroic, trachy-andesitic, rhyolite-dacitic and alkali-basaltic. It was also determined that the use of these resources varied periodically.

Petrogenetic analysis of stone vessels raw materials indicates that approximately 1/3 of the stone vessel samples were derived from ultramafic rocks, and the remaining 2/3 of the stone vessels were derived from others rocks.

The high ratio of ultramafic origin samples among the stone vessels, had led to focus on this type of rocks during the field study for sources rock identification. Another important cause of this selection is the wide spread occurrences of ultramafic units in the vicinity of Domuztepe and their closeness to the site.

2. The raw material source of the stone vessels produced from the ultramafic raw material recovered in the Domuztepe excavations can be related to nearby ophiolitic units of Domuztepe. Nb, La, Cr, P, Zr and Y are selected to discriminate between protolith rock types (origin of the rock) of the field samples and also the stone vessel samples. The geochemical data is plotted on the diagram proposed by Pearce (1983) and reviewed by Sun & McDonough (1989). This diagram indicates clearly that one group of stone vessel samples have similar geochemical signatures as the field samples having ultramafic origins. However the stone vessels samples ploted in this diagram have characteristic Fe rich chlorite formation which is not the case for the antigorite mineral formation in the ultramafic field samples ploted on the same diagram an exibiting same geochemical signiture with the stone vessel samples.

   There is no petrographically overlapping source rock (containing abundant amounts of iron chlorite) in the study area. This suggests that the source area sholud be outside the area investigated during the study.

3. The stone vessels samples of basaltic-gabbroic origin (11 samples) were seen in all chronological periods (6,100-5,800 BC., 5,700-5,500 BC., 5,500-5400 BC.) This suggests that also basaltic-gabbroic origin sources were used continuously for about 900 years. Ultramafic origin samples (8 samples) were collected in

two chronological phases (5,700-5,500 BC., 5,500-5400 BC.) and they had been used for about 300 years. Likewise, the samples (2 samples) which were determined to be of alkali-basaltic origin were seen in two phases (5,700-5,500 BC., 5,500-5400 BC.), whereas the trachy-andesitic origin (3 samples) and rhyolite-dacitic origin (1 sample) samples were encountered in one phase (5,700-5,500 BC). Apart from these, it was seen that one of the two samples (surface findings) without chronological data had basaltic-gabbroic origin and the other had trachy-andesitic origin.

5.3. Recommendations

Among the finds discovered in many archaeological excavations in the Near East, stone vessels are common. The amount of such finds varies greatly between the Late Neolithic settlements in the Near East. Such finds were found in many settlements in the Anatolia such as Çayönü, Körtiktepe etc. On the other hand, studies in this area are very limited. For this reason, more holistic approaching the tradition of this stone pot in Anatolia will reveal important findings. For this purpose, the identification of all settlements in which such stone vessels have emerged and the realization of a project in which these settlements are included will provide significant contributions to the field of archeology.

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APPENDIX A

Pottery Samples

4917 PO-2

4916 LB-2

4916 BB-3

4916 BWB-3

67-NB

67 NB-2

67 RB

4927 B-2


4927 MPH

4927 UH-2


67 M

70 P

67 PB

70 B


67 NIN

4927 IN-3


4915 BBBON-3

4928 IN-3

4927 RB-3


4915 U


70 IN


4915 BBBON-3

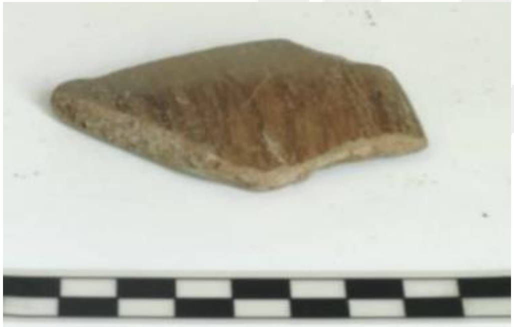
4915 VT-2


4916 BB


4916 LB

4916 LBPB


4916 BWB

4916 PB

4927 LB

4927 RB


4927 BB

4927 BWB

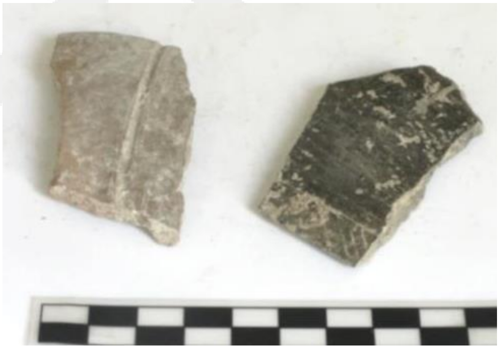

4927 IN


4928 BB


4928 RB


4928 BWB


4928 IN

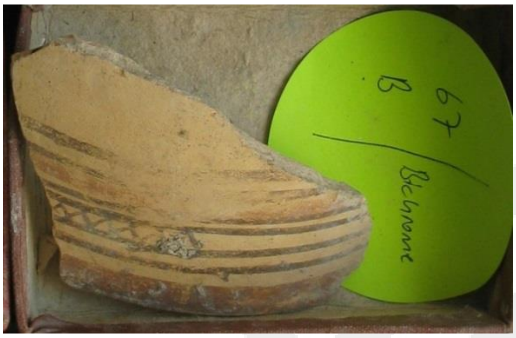

4915 IN


4915 BBBON

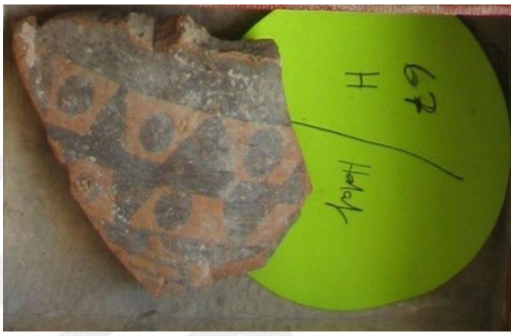

4915 LBBON


4915 PB


4915 BBBON



67 B

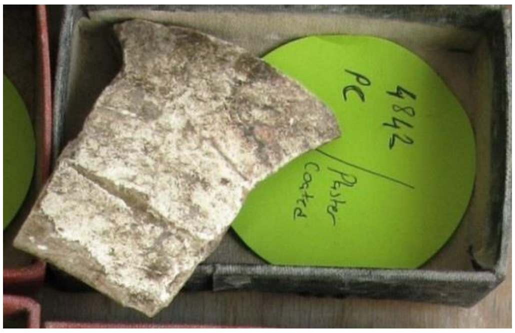


67 H

67 WS

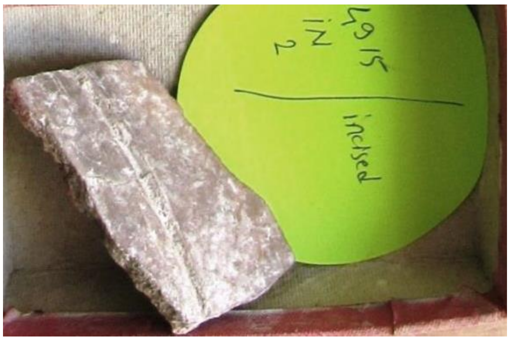
4915 LB-2

4914 PLBAI



4842 PC


70 HIN


4915 IN-2


4915 IN


4924 B

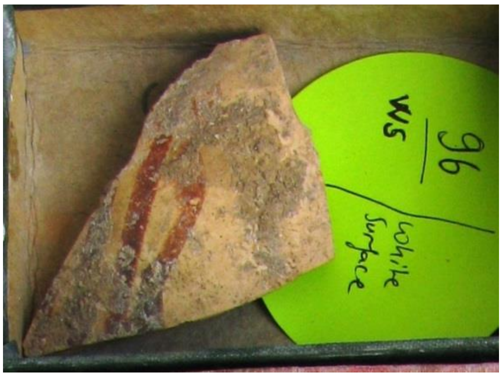

4927 UH


4927 CG


4927 CV


4916 U-2

4916 U-1



96 WS

96 B

96M

96 U

4915 LB-2

APPENDIX B

Stone Bowl Samples

DT 6618

DT 637

DT 592

DT 2200

DT 634

DT 960

DT 2125

DT 1457

DT 629

DT 2444

DT 261

DT 1313

DT 374

DT 3616

DT 2098

DT 330

DT 636

DT 338

DT 3511

DT 501

DT 3867

DT 1479

DT 1480

DT 602

DT 2093

DT 261

DT 1308

DT 2106

DT 1475

DT 962

DT 1315

DT 627


DT 6608


DT 6600


DT 6605


DT 6446


DT 6538


DT 6436


DT 6611


DT 6435


DT 6607


DT 6567


DT 379


DT 6524


DT 6487


DT 6425


DT 6535


DT 6522

APPENDIX C

Results of Thin Section Analysis Table

Pottery samples	SC	OM	H	F	Z	T	RF	S	CA	Q	AF	M
Lot 4915 Vegetable Temperd	C	0	1	0	0	C	1	1	1	1	1	0
Lot 4915 - 1E Black Burnished	B	2	2	0	1z	F	0	0	1	?	?	?
Lot 4915 - 2 Black Burnished	B	2	1	0	0	C	1	1	1c	1	1c	1c
Lot 4915 Brown Burnished	B	2	2	1	0	C	1	1	1	1	1	1
Lot 4915 -1 Incised	I	2	1	1	0	C	1	0	1c	1c	1c	1f
Lot 4915 - 2 Incised	I	0	2	0	0	M	1	0	1c	1	1	1
Lot 4915 Unpainted	UH	1	1	1	1z	M	1	1	1c	1	1	1
Lot 4915 Grid Coarse	C	2	1	0	0	M	1	1	1	2	1f	1c
Lot 4915 Pattern Burnished	B	2	2	1	1?	M	1	0	1	1c	1c	1f
Lot 4915 Painted Pottery	PH	1	2	1	0	C	1	1?	1	2	1	1
Lot 4915 - 2 Leather Burnished	B	2	1	1	0	C	1	1?	1c	1f	1c	0
Lot 4916 - 1 Brown Burnished	B	0	2	0	0	M	1	0	1	1	1f	1f
Lot 4916 - 2 Brown Burnished	B	2	1	1	0	C	1	1	1c	1c	1c	1
Lot 4916 Leather Burnished	B	1	2	1	0	C	1	1	1	1	1	1f
Lot 4916 Leather Burnished	B	2	1	1	0	C	1	1c	1c	1f	1c	1c
Lot 4916 Vegetable Temperd	C	2	0	0	0	C	0	0	0	1f	1c	1c
Lot 4916 Painted	PH	?	1	1?	0	C	1	0	1c	1	0	1
Lot 4916 Pattern Burnished	B	1	2	1	1	C	1	0	1c	1f	0	1
Lot 4916 Black Burnished	B	2	2	1	1z	C	1	0	1	1c	1c	1f
Lot 4916 Unpainted	UH	2	0	0	1	M	1	0	1	1	1	1
Lot 4916 - 1 Unpainted	UH	1	1	0	1z	M	1	1c	1	0	0	1c
Lot 4916 - 2 Unpainted	UH	2	1	1	0	C	0	0	0	1f	1c	1c
Lot 4927 Coarse Vegetable	C	2	1	0	1	C	1	0	1	1c	1c	1c
Lot 4927 Red Burnished	B	2	1	0	0	F	0	0	1c	1	1	1
Lot 4927 Coarse Grit	C	1	2	0	0	C	2	0	0	1c	1c	0
Lot 4927 Unpainted Halaf	UH	1	2	0	0	M	1	0	1c	1	1	1
Lot 4927 Leather Burnished	B	2	2	0	0	M	1	0	1	1f	1f	0
Lot 4927 Painted Orange	PH	0	2	0	0	F	1	0	1c	1f	1	0
Lot 4927 Bichrome	UH	?	1	0	1	F	1	0	1	1	1	0
Lot 4927 Black Burnished	B	2	2	0	1z	M	0	1f	1f	1f	1f	1f
Lot 4927 - 1 Incised	I	0	1	0	0	F	1	0	1c	1	1	1
Lot 4927 - 2 Incised	I	1	1	0	0	C	1	0	1	1c	1c	1
Lot 4927 Brown Burnished	B	1	1	0	0	F	1	0	1	1f	1f	1f
Lot 4927 Mature (painted) Halaf	PH	1	2	0	0	C	1	0	1c	1c	1c	1c
Lot 4928 Coarse Veg	C	1	1	1	0	C	1	0	1	1	1c	1c
Lot 4928 Incised	I	1	1	0	0	M	1	0	0	1	1	1
Lot 4928 - 2 Incised	I	2	1	0	1	C	0	0	1c	1	0	0
Lot 4928 - 3 Incised	I	2	1	0	1	C	1	1	1	1	1	1
Lot 4928 Red Burnished	B	1	1	0	0	M	1	0	0	1	1	1
Lot 4928 - 2 Red Burnished	B	1	2	1?	1	M	1	0	1	1	1	1
Lot 4928 Coarse Grit	C	2	1	0	1	C	1	0	1	1f	1c	1
Lot 4928 Painted	PH	1	2	0	0	C	1	0	1c	1f	1f	0
Lot 4928 - 1 Brown Burnished	B	2	1	0	1	C	1	0	1	1	1	1c
Lot 4928 - 2 Brown Burnished	B	1	2	0	0	C	1	1	0	1c	1c	1c

Lot 4928 - 4 Brown Burnished	B	2	?	1	1	C	1	0	1c	1	1	1
Lot 4928 - 5 Brown Burnished	B	2	0	0	1	F	0	0	0	1	1	1f
Lot 4928 - 1 Black Burnished	B	1	1	0	1	M	1	1	1	1f	1c	1c
Lot 4928 - 2 Black Burnished	B	2	1	1	1z	C	1	1	1	1	1	1
Lot 4928 - 3 Black Burnished	B	1	2	1	1z	F	1	0	1	1	1	1
Lot 4928 Unpainted	UH	1	2	0	0	F	1	0	1	1f	1f	1f
Lot 4924 DT Bichrome	PH	0	1	0	0	M	1	0	1c	1f	0	0
Lot 4914 to leather burnished?	B	2	1	0	1	C	1C	0	1c	1f	1f	1c
Lot 4842 Plaster Coated	C	0	1	0	1	F	1	0	1	1	1	1
67 Halaf	UH	2	2	1	1?	M	1	0	1	1c	1c	1f
67 Neolithic Burnished	B	1	2	1	0	C	1	1?	1	2	1	1
67 Neolithic İncised İmpress	I	2	1	1	0	C	1	1?	1c	1f	1c	0
67 Monochrome	UH	0	2	0	0	M	1	0	1	1	1f	1f
67 Bichrome	PH	2	1	1	0	C	1	1	1c	1c	1c	1
67 White Surface	UH	1	2	1	0	C	1	1	1	1	1	1f
67 Red Burnished	B	2	1	1	0	C	1	1c	1c	1f	1c	1c
96 White Surface	UH	2	0	0	0	C	0	0	0	1f	1c	1c
96 Bichrome	UH	?	1	1?	0	C	1	0	1c	1	0	1
96 Monochrome	UH	1	2	1	1	C	1	0	1c	1f	0	1
96 Ubaid	U	2	2	1	1z	C	1	0	1	1c	1c	1f
70 Halaf İncised	HI	2	0	0	1	M	1	0	1	1	1	1

PS: Pottery samples, SC: Stylistic Class, OM: Organic matter, H: Hematitization, F: Fossil, Z: Zonning, T: Texture, RF: Rock Fragment, S: Serpentine, C: Calcite, Q: Quartz
AF: Alkali Feldspar, M: Mica

During the thin section analysis, some qualitative characteristics were observed. These qualities have been tried to be digitized. The texture is classified as rough (C), medium (M), and thin (F). Stylistic classification display was made according to the classification presented under the title of archeology above.

B – (Early burnished whole mouth jars and bowls, Leather burnished, Black burnished, Red burnished, Brown burnished, Pattern burnished),

I - (Fine incised burnished, Other incised burnished

C - (Vegetable-grit coarse)

PH - Painted

UH - Unpainted Halaf

APPENDIX D

ICP-MS Analysis Results of Pottery Samples.

Elements / Sample Name	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3
	%	%	%	%	%	%	%	%	%	%	%
4915BBBON3	39.93	8.88	5.87	7.20	14.64	0.28	1.18	0.45	0.33	0.09	0.040
4915 U	37.10	7.52	4.41	1.89	23.16	0.18	1.18	0.49	0.20	0.04	0.076
4915 BBBON-2	35.12	6.58	5.57	5.92	20.75	0.25	0.92	0.43	0.27	0.08	0.240
4915 GT	59.21	12.44	7.19	4.46	3.05	1.35	1.66	0.70	0.32	0.12	0.098
4915 VT-2	46.57	4.40	9.59	23.22	0.66	0.16	0.53	0.25	0.06	0.11	0.990
4928 BB-1	45.46	8.29	7.60	6.65	11.72	0.35	1.23	0.57	0.49	0.14	0.579
4928 U	41.74	8.57	5.32	5.37	19.31	0.96	1.14	0.54	0.33	0.13	0.095
4928 CG	48.76	16.13	12.23	2.14	3.86	1.83	2.22	2.83	1.56	0.21	0.020
4928 CV	51.17	8.36	9.78	10.01	3.48	0.37	1.35	0.61	0.75	0.15	0.620
4928 RB-1	47.89	10.58	6.99	5.29	15.32	0.90	1.17	0.80	0.37	0.12	0.171
4927 UH	49.72	10.89	8.69	5.90	12.06	0.56	1.28	0.89	0.29	0.16	0.191
4927 PO-2	48.00	14.29	4.93	2.92	16.16	0.28	2.90	0.71	0.22	0.05	0.016
4927 CV	47.51	13.01	13.75	8.26	5.98	1.37	1.45	2.68	0.80	0.20	0.181
4927 RB	51.38	6.59	11.81	11.98	2.80	0.28	0.94	0.44	0.44	0.15	0.680
4927 BWB	38.14	7.78	5.14	6.55	18.15	0.59	1.41	0.47	0.25	0.12	0.059
4927 MPH	44.39	8.95	7.19	4.73	15.40	0.55	1.67	0.70	0.21	0.13	0.242
4916 BWB-2	48.22	8.62	8.32	7.33	13.11	0.31	0.94	0.60	0.19	0.14	0.743
4916 BB	54.05	11.16	6.07	3.94	9.16	1.31	1.10	0.72	0.28	0.08	0.135
4916 LB	47.58	7.74	9.50	9.76	7.61	0.32	1.00	0.52	0.10	0.14	0.626
4916 LBPA	35.74	6.93	5.88	5.40	20.78	0.26	0.95	0.46	0.25	0.11	0.260
4916 P	53.09	11.17	8.50	8.20	8.20	0.09	0.90	0.90	0.16	0.16	0.215
67 B	39.49	8.19	5.50	6.89	20.14	0.50	0.98	0.44	0.24	0.11	0.061
67 NIN	35.54	6.51	5.01	5.49	21.87	0.45	0.76	0.39	0.11	0.11	0.111
67 RB	42.35	8.30	5.26	5.81	16.75	0.65	1.03	0.51	0.12	0.08	0.116
67 PB	42.43	8.27	5.70	6.15	15.33	0.60	0.89	0.50	0.12	0.10	0.211
67 NB	41.88	8.01	5.54	5.88	16.18	0.59	1.01	0.49	0.12	0.09	0.152
67 WS	47.55	9.43	6.10	6.16	14.43	0.79	2.20	0.60	0.40	0.14	0.097
67 M-2	50.64	10.04	6.82	6.11	13.73	0.97	1.01	0.62	0.18	0.10	0.178
67 H	55.39	21.00	10.09	2.47	2.74	0.83	3.43	1.41	0.29	0.18	0.026
96 U	46.93	10.58	6.81	8.30	17.60	0.68	1.60	0.66	0.34	0.13	0.097
96 M	46.41	10.22	6.64	6.85	14.87	0.71	1.99	0.59	0.68	0.19	0.074
96 B	44.27	9.34	5.96	6.78	16.58	0.73	1.97	0.56	0.27	0.12	0.086
70 HIN	53.00	15.73	8.91	6.24	5.63	2.01	0.74	0.61	0.19	0.13	0.065

Sample Name \ Elements	Ni	Sc	Ba	Co	Cs	Ga	Hf	Nb	Rb	Ta	Th	Sr
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
4915BBBON3	434	15	380	30.7	1.6	9.1	1.7	7.2	23.4	0.4	3.5	469.9
4915 U	242	11	380	17.7	1.8	7.4	2.6	9.6	25.7	0.6	5.3	366.7
4915 BBBON-2	559	13	333	42.3	1.2	5.9	2.8	7.4	19.6	0.5	4.8	394.7
4915 GT	402	18	699	35.0	1.5	12.3	3.1	9.2	32.9	0.6	5.3	408.9
4915 VT-2	2114	11	165	114.6	1.4	4.4	1.4	4.7	15.2	0.2	2.8	115.6
4928 BB-1	1061	15	605	80.8	1.6	9.1	4.2	10.7	22.8	0.7	6.0	504.6
4928 U	309	14	548	28.3	1.5	7.5	2.0	6.3	23.7	0.5	3.7	674.1
4928 CG	108	26	1412	38.1	2.8	20.9	4.8	20.6	54.1	1.4	6.0	885.6
4928 CV	1564	18	717	110.0	1.4	8.1	2.9	9.1	21.1	0.5	3.6	493.3
4928 RB-1	449	16	460	40.4	2.2	10.0	3.1	10.1	32.1	0.8	5.5	447.9
4927 UH	743	16	325	54.7	2.3	10.6	3.4	12.1	32.3	1.0	5.9	279.9
4927 PO-2	48	14	418	11.0	6.5	14.8	4.0	14.7	101.6	0.8	10.8	480.0
4927 CV	550	28	544	63.4	1.2	15.3	4.6	32.4	22.5	2.4	4.7	627.0
4927 RB	2339	17	547	130.0	0.8	6.0	3.2	8.2	17.7	0.4	4.9	273.9
4927 BWB	340	13	263	26.4	1.4	6.6	2.0	6.5	21.1	0.5	3.3	528.7
4927 MPH	644	13	300	50.9	1.3	7.6	3.1	9.0	26.4	0.5	5.1	309.2
4916 BWB-2	1129	16	387	75.2	1.5	7.9	5.0	10.1	29.8	1.0	6.8	254.8
4916 BB	323	17	377	26.7	1.5	9.7	2.7	7.0	23.2	0.4	3.8	293.7
4916 LB	1551	16	325	96.8	1.7	7.8	3.7	8.4	25.2	0.4	5.1	222.4
4916 LBPA	612	13	408	44.8	1.3	5.2	3.1	7.3	19.5	0.2	5.8	366.6
4916 P	526	15	345	44.9	2.2	12.0	3.4	11.3	28.4	0.9	5.9	208.5
67 B	438	14	335	29.5	1.3	6.3	2.0	5.4	24.6	0.6	3.0	296.4
67 NIN	476	11	250	27.2	1.3	5.1	2.1	4.8	17.2	0.2	3.4	267.6
67 RB	373	13	254	23.2	1.6	5.6	2.5	5.8	20.7	0.3	3.6	318.8
67 PB	503	13	287	28.6	1.1	6.6	2.4	6.2	18.3	0.4	3.9	257.0
67 NB	484	13	288	27.9	0.9	4.9	2.3	5.0	17.5	0.4	3.3	251.4
67 WS	427	15	461	30.5	1.3	9.0	2.2	7.7	30.4	0.5	3.4	316.7
67 M-2	652	17	279	39.3	1.9	8.3	2.5	6.6	21.9	0.3	4.7	232.8
67 H	142	23	603	33.3	9.3	23.9	5.7	21.5	122.8	1.6	15.3	161.4
96 U	440	17	513	34.8	1.6	9.8	3.0	7.5	36.5	0.7	5.0	442.3
96 M	440	17	626	35.7	1.9	8.2	2.2	7.3	33.9	0.7	4.3	441.4
96 B	376	15	479	33.2	1.1	6.9	2.1	6.4	26.0	0.4	3.7	360.9
70 HIN	259	37	354	36.4	0.6	11.9	1.6	3.1	10.2	0.2	1.8	124.4

Elements / Sample Name	Tb	U	V	Zr	Y	La	Ce	Pr	Nd	Sm	Gd	Eu
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
4915BBBON3	0.36	1.3	131	61.4	11.7	13.4	25.3	2.91	11.2	2.20	2.46	0.58
4915 U	0.52	1.3	73	98.8	18.5	22.4	38.9	4.48	16.6	3.37	3.45	0.79
4915 BBBON-2	0.42	0.8	94	104.7	13.5	15.0	32.4	3.53	14.1	2.71	2.85	0.65
4915 GT	0.59	1.3	153	114.4	19.7	17.6	36.6	3.99	16.6	3.23	3.67	0.90
4915 VT-2	0.21	0.7	101	60.4	5.9	8.4	20.6	1.86	7.4	1.53	1.55	0.31
4928 BB-1	0.55	2.0	122	163.9	18.2	22.4	49.2	4.79	18.1	3.99	3.26	0.85
4928 U	0.46	1.8	111	81.8	15.6	14.5	26.0	3.31	13.4	2.84	2.62	0.69
4928 CG	1.11	2.6	329	195.9	28.9	32.5	68.9	8.39	34.8	8.18	7.48	2.45
4928 CV	0.45	2.5	154	121.9	15.2	16.7	35.3	3.72	15.5	2.74	2.93	0.85
4928 RB-1	0.61	2.3	131	121.6	19.7	20.1	41.2	4.50	18.8	3.59	3.87	0.96
4927 UH	0.62	1.5	147	122.3	18.1	21.4	44.1	4.62	19.3	3.79	4.13	0.94
4927 PO-2	0.83	2.7	121	130.6	23.6	35.4	67.2	7.67	29.9	5.32	5.18	1.16
4927 CV	0.89	2.1	300	185.0	21.2	32.1	69.5	8.07	31.5	6.62	6.62	2.07
4927 RB	0.38	1.0	173	104.3	12.1	13.3	33.3	3.34	13.0	2.80	2.58	0.60
4927 BWB	0.43	1.0	121	66.9	13.3	12.8	25.3	2.94	11.2	2.51	2.61	0.66
4927 MPH	0.54	1.1	119	110.3	16.8	17.2	39.9	4.06	16.2	3.28	3.61	0.94
4916 BWB-2	0.55	1.7	130	170.7	15.9	22.0	49.0	4.85	17.5	3.22	3.56	0.92
4916 BB	0.51	1.6	164	106.9	15.6	16.5	30.8	3.67	15.1	3.10	3.36	0.97
4916 LB	0.45	1.3	112	137.6	15.4	18.0	40.2	3.90	16.1	2.98	3.00	0.68
4916 LBPA	0.48	0.7	91	115.1	13.5	17.4	34.6	3.78	14.2	2.81	2.90	0.75
4916 P	0.68	1.3	143	125.3	18.9	22.6	47.7	4.94	22.0	4.29	4.58	1.09
67 B	0.39	0.8	87	58.4	11.4	12.8	22.2	2.63	11.1	2.02	2.42	0.67
67 NIN	0.33	0.6	75	60.2	10.9	11.0	21.1	2.57	10.3	2.14	2.42	0.54
67 RB	0.45	1.0	85	75.6	14.5	13.8	26.3	2.94	11.4	2.48	2.65	0.67
67 PB	0.41	0.7	91	74.6	13.4	14.1	27.1	3.07	11.7	2.63	2.70	0.62
67 NB	0.38	0.5	91	71.0	12.6	11.9	23.1	2.81	11.6	2.47	2.72	0.66
67 WS	0.50	0.9	102	87.9	15.5	13.9	29.3	3.33	13.6	2.85	2.99	0.71
67 M-2	0.56	1.3	113	108.1	17.6	16.0	33.3	3.73	14.0	2.69	3.56	0.79
67 H	1.21	3.2	185	206.7	32.4	53.1	109.9	12.19	46.2	8.92	8.15	2.12
96 U	0.55	1.6	124	104.9	16.6	17.8	33.0	3.79	16.4	3.15	3.46	0.80
96 M	0.48	1.4	163	85.5	16.1	15.5	30.3	3.63	14.6	3.03	3.01	0.72
96 B	0.48	0.8	99	78.3	16.3	13.8	28.1	3.15	13.5	2.93	3.00	0.75
70 HIN	0.42	0.4	224	51.0	16.2	6.8	13.0	1.59	6.6	2.06	2.32	0.58

Elements / Sample Name	Dy	Ho	Er	Tm	Yb	Lu	Mo	Cu	Pb	Zn	Ni	As	Cd
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
4915BBBON3	2.20	0.44	1.29	0.19	1.08	0.20	0.2	25.3	6.9	81	448.8	12.8	0.2
4915 U	3.17	0.63	1.95	0.26	1.84	0.25	0.2	19.7	9.1	66	267.0	3.9	0.3
4915 BBBON-2	2.38	0.47	1.39	0.19	1.25	0.20	0.0	19.2	7.7	62	565.1	8.9	0.2
4915 GT	3.51	0.64	1.99	0.31	2.00	0.28	0.2	26.0	8.3	67	363.0	12.9	0.0
4915 VT-2	1.11	0.19	0.54	0.10	0.65	0.08	0.2	14.2	4.5	49	2250.5	2.8	0.0
4928 BB-1	3.25	0.64	1.82	0.24	1.97	0.27	0.2	22.7	11.0	68	1090.1	11.8	0.2
4928 U	2.68	0.62	1.79	0.24	1.40	0.21	0.2	23.4	5.9	62	324.4	6.5	0.2
4928 CG	5.59	1.12	3.03	0.41	2.51	0.34	0.4	33.5	22.9	181	123.9	20.1	0.3
4928 CV	2.84	0.49	1.60	0.23	1.37	0.21	0.4	31.5	7.3	82	1528.5	15.7	0.2
4928 RB-1	3.92	0.80	2.23	0.36	2.00	0.27	0.2	23.7	4.4	64	371.5	6.6	0.1
4927 UH	3.68	0.72	1.98	0.25	2.21	0.30	0.4	24.1	3.8	56	588.0	7.6	0.2
4927 PO-2	4.80	0.95	2.66	0.39	2.39	0.39	0.3	27.3	14.6	80	54.5	7.4	0.3
4927 CV	5.06	0.94	2.43	0.34	1.75	0.30	0.4	39.4	3.2	97	545.0	27.5	0.0
4927 RB	2.25	0.50	1.34	0.18	1.52	0.20	0.3	20.3	7.2	77	2384.9	23.7	0.2
4927 BWB	2.52	0.51	1.45	0.20	1.34	0.24	0.1	22.3	5.6	48	331.2	11.8	0.2
4927 MPH	3.10	0.65	1.88	0.25	1.63	0.24	0.2	21.1	7.5	75	638.2	6.5	0.3
4916 BWB-2	2.92	0.65	1.78	0.29	1.82	0.26	0.2	16.4	7.2	47	911.9	9.4	0.2
4916 BB	3.48	0.71	1.78	0.30	1.76	0.25	0.1	19.3	6.2	54	314.1	9.3	0.0
4916 LB	2.71	0.55	1.77	0.22	1.62	0.21	0.3	20.1	8.5	71	1532.7	2.9	0.2
4916 LBPA	2.54	0.52	1.62	0.22	1.46	0.21	0.0	21.9	7.6	50	591.4	9.0	0.2
4916 P	4.10	0.80	2.07	0.34	2.12	0.26	0.2	16.5	3.9	39	350.1	4.2	0.0
67 B	2.37	0.48	1.46	0.20	1.20	0.21	0.2	25.6	4.3	52	418.1	3.4	0.1
67 NIN	2.18	0.45	1.22	0.17	1.49	0.19	0.1	18.9	5.6	46	496.8	2.4	0.2
67 RB	2.87	0.55	1.61	0.20	1.36	0.20	0.1	17.9	6.7	50	364.3	2.0	0.2
67 PB	2.65	0.55	1.51	0.25	1.37	0.20	0.1	19.4	6.8	54	499.1	1.9	0.2
67 NB	2.38	0.50	1.50	0.20	1.47	0.21	0.0	21.8	7.2	51	481.9	2.1	0.2
67 WS	2.66	0.61	1.60	0.22	1.41	0.23	0.3	30.3	4.1	53	355.1	6.4	0.2
67 M-2	3.21	0.64	1.65	0.29	1.93	0.28	0.0	17.3	3.2	39	500.3	3.6	0.0
67 H	7.13	1.39	3.61	0.55	3.88	0.54	0.3	18.4	3.2	12	35.9	4.1	0.0
96 U	3.00	0.70	1.72	0.31	1.77	0.28	0.2	23.4	2.4	39	226.9	10.9	0.2
96 M	3.39	0.67	1.85	0.26	1.72	0.26	0.4	46.4	5.7	64	371.9	34.8	0.4
96 B	2.85	0.46	1.67	0.20	1.58	0.21	0.2	31.0	5.4	62	350.8	5.2	0.3
70 HIN	2.94	0.60	1.91	0.28	1.68	0.26	0.1	33.0	2.9	34	217.5	2.0	0.0

APPENDIX E

ICP-MS Analysis Results of Stone Vessels.

Elements	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ni
S.Name	%	%	%	%	%	%	%	%	%	%	%	PPM
dt6425	25.45	21.05	28.00	14.73	0.15	0.01	0.01	0.40	0.02	0.27	0.022	271
dt6535	29.67	17.41	25.30	16.18	0.66	0.03	0.04	0.26	0.02	0.09	0.151	255
dt6524	26.59	20.38	27.15	15.47	0.16	<0.01	<0.01	0.39	0.04	0.16	0.077	191
dt6618	26.38	21.13	26.73	15.31	0.06	<0.01	0.03	0.41	0.04	0.10	0.067	120
dt6487	31.93	20.96	8.02	20.30	7.43	0.24	0.03	0.66	0.01	0.05	0.035	630
dt6522	29.05	19.75	15.71	22.47	0.15	<0.01	0.02	0.34	0.03	0.43	0.146	217
dt637	28.66	20.88	13.19	23.93	0.11	<0.01	<0.01	0.56	0.02	0.09	0.034	659
dt592	26.31	20.09	26.57	16.13	0.12	<0.01	<0.01	0.37	0.01	0.27	0.016	153
dt2200	27.74	19.28	22.96	18.59	0.16	<0.01	<0.01	0.34	0.04	0.09	0.251	421
dt1480	26.65	20.32	25.68	16.85	0.08	<0.01	0.01	0.37	0.02	0.09	0.069	207
dt634	28.61	21.26	13.88	23.86	0.12	<0.01	<0.01	0.20	0.01	0.04	0.044	1020
dt960	51.30	14.37	11.35	5.18	9.12	3.09	1.10	1.58	0.24	0.14	0.032	133
dt2125	26.75	20.30	26.19	16.51	0.07	<0.01	<0.01	0.22	0.03	0.10	0.147	190
dt1457	26.42	21.34	24.65	16.94	0.20	0.01	<0.01	0.33	0.02	0.17	0.032	275
dt629	26.92	21.05	15.95	11.35	11.82	0.04	0.05	2.65	1.25	0.05	<0.002	189
dt2444	26.22	20.66	26.48	15.54	0.29	<0.01	<0.01	0.40	0.03	0.27	0.048	165
dt379	24.75	24.28	23.74	15.84	0.05	<0.01	<0.01	0.42	0.02	0.15	0.003	196
dt261	43.27	0.22	7.73	33.21	0.62	<0.01	<0.01	<0.01	0.02	0.04	0.495	2645
dt1313	27.75	21.57	18.41	20.86	0.19	<0.01	<0.01	0.35	0.08	0.08	<0.002	372
dt374	28.70	17.88	12.53	24.85	0.56	<0.01	<0.01	3.15	0.36	0.17	0.117	401
dt3616	40.74	0.54	9.96	33.31	0.29	<0.01	0.02	0.01	0.01	0.12	0.787	2800
dt2098	29.23	19.22	17.55	21.89	0.05	<0.01	<0.01	0.35	<0.01	0.05	0.172	376
dt330	40.38	0.11	8.11	36.01	0.14	<0.01	<0.01	<0.01	<0.01	0.09	0.432	2411
dt636	29.62	21.00	10.25	26.12	0.25	<0.01	<0.01	0.56	<0.01	0.03	0.026	683
dt338	26.12	18.40	23.76	20.84	0.04	<0.01	<0.01	0.32	<0.01	0.13	0.189	408
dt3511	28.40	21.91	15.82	21.93	0.09	<0.01	<0.01	0.13	0.05	0.07	<0.002	759
dt501	42.41	0.18	8.71	34.46	0.09	<0.01	<0.01	<0.01	<0.01	0.05	0.281	2534

Elements	Sc	Ba	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Au	Ta	Sr
S.Name	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM	PPM
dt6425	64	3	<1	133.9	<0.1	13.7	0.4	2.1	0.4	<1	<0.5	0.1	2.7
dt6535	59	6	<1	220.4	<0.1	16.7	0.4	1.9	1.0	<1	<0.5	0.2	8.6
dt6524	52	3	<1	145.2	<0.1	17.2	1.0	7.6	0.1	2	1.1	0.4	3.8
dt6618	54	7	<1	219.1	<0.1	12.8	1.7	5.8	0.2	<1	<0.5	0.3	6.8
dt6487	36	5	<1	92.2	<0.1	8.2	<0.1	0.4	<0.1	<1	<0.5	<0.1	12.8
dt6522	87	5	<1	73.8	<0.1	15.5	0.4	1.0	0.4	<1	3.8	<0.1	4.5
dt637	61	3	<1	137.6	<0.1	17.5	0.8	2.0	<0.1	<1	0.9	0.2	2.2
dt592	58	2	<1	117.4	<0.1	16.3	0.5	1.5	<0.1	<1	2.1	<0.1	1.3
dt2200	71	1	<1	216.1	<0.1	18.6	0.4	1.4	0.2	<1	0.7	0.1	1.5
dt1480	62	3	<1	195.9	<0.1	14.9	0.6	1.5	0.2	<1	1.4	0.1	1.8
dt634	26	<1	<1	144.9	<0.1	13.1	5.6	3.1	<0.1	<1	1.2	0.4	1.6
dt960	20	233	1	40.5	0.7	18.1	2.9	12.7	23.8	1	<0.5	0.9	321.6
dt2125	51	3	<1	234.9	<0.1	19.0	0.3	1.5	0.1	<1	2.0	<0.1	1.2
dt1457	64	3	<1	212.5	<0.1	17.5	0.9	2.9	0.2	<1	1.9	0.2	2.8
dt629	44	23	1	154.6	<0.1	19.4	6.5	57.3	0.2	<1	1.1	3.2	146.5
dt2444	65	2	<1	111.4	<0.1	14.1	0.6	2.5	<0.1	<1	2.6	0.2	1.1
dt379	13	1	2	240.7	<0.1	11.8	7.5	38.7	<0.1	<1	1.9	2.8	1.3
dt261	5	7	<1	84.4	<0.1	<0.5	<0.1	<0.1	0.3	<1	1.8	<0.1	6.1
dt1313	13	2	3	149.1	<0.1	17.4	4.8	24.1	<0.1	<1	<0.5	2.5	1.6
dt374	32	4	<1	45.0	<0.1	16.5	11.3	103.6	<0.1	<1	<0.5	7.7	6.4
dt3616	5	12	<1	131.6	<0.1	0.8	<0.1	0.4	0.3	<1	1.5	<0.1	8.1
dt2098	66	1	<1	178.1	<0.1	17.0	0.3	1.6	<0.1	<1	0.6	0.1	0.8
dt330	3	16	<1	137.6	<0.1	<0.5	<0.1	0.3	0.1	<1	<0.5	<0.1	4.2
dt636	57	<1	<1	141.2	<0.1	11.0	0.6	2.4	<0.1	<1	<0.5	<0.1	6.0
dt338	68	2	<1	117.3	<0.1	14.7	0.5	1.5	0.1	<1	0.9	0.1	2.4
dt3511	2	1	<1	179.1	<0.1	7.3	4.1	52.7	<0.1	<1	2.7	13.9	0.9
dt501	4	3	<1	131.5	<0.1	<0.5	0.1	0.9	0.2	<1	<0.5	0.3	5.0

Elements	Th	U	V	W	Zr	Y	La	Ce	Pr	Nd	As	Eu	Sm
S.Name	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
dt6425	0.2	<0.1	300	4.1	12.0	14.6	0.6	0.5	0.07	0.6	<0.5	0.03	0.51
dt6535	<0.2	<0.1	276	0.6	14.1	12.2	0.9	0.5	0.05	<0.3	<0.5	0.02	0.12
dt6524	1.5	1.0	294	1.4	30.4	10.8	0.7	1.5	0.12	0.6	0.6	<0.02	0.29
dt6618	0.3	0.3	230	0.6	40.2	10.2	8.4	14.4	1.61	7.7	0.8	<0.02	2.42
dt6487	<0.2	<0.1	238	<0.5	2.1	1.1	0.6	0.6	0.04	0.3	<0.5	0.12	<0.05
dt6522	<0.2	<0.1	430	<0.5	9.2	9.6	2.1	3.6	0.44	1.6	<0.5	0.11	0.52
dt637	0.2	0.1	407	0.6	19.9	12.0	1.5	4.1	0.52	2.9	<0.5	0.25	0.96
dt592	<0.2	0.1	354	2.1	10.0	22.9	0.9	1.2	0.10	0.5	0.8	0.03	0.51
dt2200	<0.2	<0.1	362	2.0	11.7	11.2	0.4	0.5	0.04	0.3	<0.5	0.02	0.19
dt1480	0.2	0.1	336	1.0	16.4	9.9	0.6	0.5	<0.02	<0.3	<0.5	<0.02	0.08
dt634	10.5	0.6	110	<0.5	210.1	13.3	0.7	1.9	0.28	1.7	<0.5	0.08	0.66
dt960	2.3	0.9	184	<0.5	112.3	18.3	12.9	26.5	3.40	14.9	0.7	1.33	3.61
dt2125	<0.2	<0.1	265	0.5	8.7	3.9	2.2	0.8	0.05	<0.3	<0.5	<0.02	0.07
dt1457	0.3	0.1	350	3.4	24.8	28.8	1.1	0.7	0.08	<0.3	<0.5	0.02	0.44
dt629	6.7	2.0	415	1.8	263.6	53.1	67.0	130.7	14.82	59.9	<0.5	0.87	12.30
dt2444	0.6	0.2	364	0.6	19.7	13.5	3.8	5.6	0.39	1.8	<0.5	0.20	0.67
dt379	17.6	2.2	10	3.0	347.2	24.5	3.5	5.6	0.56	2.0	1.1	<0.02	0.66
dt261	<0.2	0.2	76	2.1	1.9	0.1	0.5	0.3	<0.02	<0.3	4.3	<0.02	<0.05
dt1313	7.4	1.1	35	0.6	154.6	10.7	1.5	3.5	0.42	2.1	<0.5	0.06	0.53
dt374	34.4	7.0	194	23.3	502.2	76.4	117.2	203.9	22.74	84.7	<0.5	1.03	17.93
dt3616	<0.2	0.4	68	1.2	1.3	0.7	0.6	0.5	0.08	0.4	2.6	0.03	0.12
dt2098	<0.2	0.2	405	0.6	9.4	10.2	0.6	0.4	0.04	<0.3	<0.5	<0.02	0.14
dt330	<0.2	0.1	45	<0.5	0.9	0.2	0.4	0.2	<0.02	<0.3	1.5	<0.02	<0.05
dt636	<0.2	0.1	339	<0.5	13.8	0.7	0.3	0.3	0.04	<0.3	<0.5	0.04	<0.05
dt338	<0.2	0.1	793	0.5	13.7	12.5	0.4	0.3	<0.02	<0.3	<0.5	<0.02	0.15
dt3511	19.0	2.7	57	<0.5	77.6	18.1	1.2	2.4	0.31	1.7	<0.5	0.02	0.80
dt501	<0.2	0.3	82	<0.5	4.2	0.2	0.4	0.4	0.03	<0.3	2.5	<0.02	<0.05

Elements	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Mo	Cu	Pb	Zn	Ni	Hg
S.Name	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
dt6425	1.32	0.28	2.29	0.50	1.72	0.29	1.83	0.27	0.4	5.8	0.1	75	279.6	<0.01
dt6535	0.84	0.21	1.67	0.43	1.38	0.23	1.59	0.27	0.2	0.6	0.3	21	246.3	<0.01
dt6524	0.81	0.21	1.75	0.39	1.38	0.22	1.46	0.28	0.1	0.6	<0.1	29	199.5	<0.01
dt6618	1.76	0.25	1.38	0.33	1.24	0.22	1.75	0.33	0.5	0.5	<0.1	30	134.1	<0.01
dt6487	0.09	0.02	0.14	0.04	0.15	0.02	0.20	0.04	0.1	0.9	<0.1	5	277.9	<0.01
dt6522	1.07	0.23	1.58	0.39	1.21	0.19	1.25	0.17	0.4	1.9	0.2	122	199.5	<0.01
dt637	1.53	0.30	2.22	0.50	1.73	0.26	1.73	0.29	0.5	2.3	0.2	13	500.1	<0.01
dt592	1.91	0.42	3.38	0.88	2.71	0.44	2.55	0.39	<0.1	0.7	0.1	66	166.3	<0.01
dt2200	0.82	0.19	1.66	0.42	1.49	0.24	1.52	0.29	0.4	1.0	<0.1	24	382.7	<0.01
dt1480	0.69	0.19	1.39	0.32	1.10	0.18	1.24	0.20	0.4	0.5	<0.1	16	197.9	<0.01
dt634	1.24	0.27	1.85	0.46	1.65	0.26	1.95	0.33	0.1	0.7	0.1	9	658.1	<0.01
dt960	4.17	0.68	3.88	0.71	1.95	0.25	1.57	0.21	1.3	39.3	0.7	43	117.5	<0.01
dt2125	0.37	0.07	0.47	0.14	0.49	0.07	0.64	0.12	0.3	0.5	<0.1	33	196.9	<0.01
dt1457	2.15	0.56	4.42	1.08	3.65	0.56	3.81	0.60	<0.1	0.8	<0.1	80	264.7	<0.01
dt629	13.15	2.02	11.41	2.02	5.54	0.69	4.30	0.61	0.3	1.1	0.1	11	169.3	<0.01
dt2444	1.46	0.31	2.15	0.51	1.63	0.26	1.82	0.28	0.4	0.7	0.1	63	171.7	<0.01
dt379	1.90	0.47	3.49	0.84	3.08	0.47	3.55	0.60	0.2	1.1	0.2	14	210.9	<0.01
dt261	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05	<0.01	0.7	4.1	0.3	37	2791.6	<0.01
dt1313	0.99	0.19	1.48	0.36	1.29	0.23	1.83	0.33	<0.1	0.4	0.1	12	245.4	<0.01
dt374	18.72	2.85	15.62	2.71	7.03	0.92	5.47	0.71	0.3	0.4	0.2	36	291.5	<0.01
dt3616	0.12	0.02	0.12	<0.02	0.08	<0.01	0.07	0.01	0.5	7.3	0.3	35	3012.5	0.01
dt2098	0.58	0.17	1.37	0.35	1.11	0.19	1.29	0.24	0.1	0.4	<0.1	13	295.8	<0.01
dt330	<0.05	0.01	<0.05	<0.02	<0.03	<0.01	<0.05	<0.01	0.9	3.4	4.7	37	2698.1	<0.01
dt636	0.10	0.02	0.09	<0.02	0.09	0.01	0.14	0.03	<0.1	0.2	<0.1	5	272.5	<0.01
dt338	0.78	0.23	1.87	0.47	1.48	0.26	1.76	0.30	0.4	52.0	<0.1	31	259.6	<0.01
dt3511	1.64	0.43	2.90	0.69	2.12	0.32	2.00	0.30	0.2	0.4	0.2	10	561.5	<0.01
dt501	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05	<0.01	0.4	1.9	0.2	25	2812.6	<0.01

APPENDIX F

ICP-MS Analysis Results of Field Rock Samples.

Elements	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ni
Sample	%	%	%	%	%	%	%	%	%	%	%	PPM
NP19-1	41.66	0.39	7.75	33.46	0.09	<0.01	<0.01	<0.01	<0.01	0.08	0.399	2211
NP19-2	35.40	0.12	6.19	38.54	0.09	0.02	<0.01	<0.01	<0.01	0.08	0.514	2375
NP19-3	42.67	0.46	7.80	32.48	0.08	<0.01	<0.01	<0.01	<0.01	0.09	0.363	2116
NP18-3	38.09	0.89	6.38	36.08	0.10	<0.01	0.01	0.01	<0.01	0.09	0.367	1984
YP3-7a	36.50	0.51	6.01	31.62	5.14	<0.01	<0.01	<0.01	0.04	0.06	0.258	1473
NP28-6	42.55	0.59	7.36	32.47	0.15	0.01	<0.01	<0.01	0.01	0.09	0.290	2056
YP3-10	38.14	0.81	7.91	33.57	1.70	<0.01	<0.01	<0.01	<0.01	0.11	0.358	2195
NP18-6a	37.51	0.74	6.93	36.32	0.18	<0.01	<0.01	<0.01	<0.01	0.08	0.339	2040
NP18-6b	38.33	0.55	6.72	36.19	0.10	<0.01	<0.01	<0.01	<0.01	0.09	0.202	2117
NP38-b	24.28	0.23	3.62	23.97	19.32	<0.01	<0.01	<0.01	<0.01	0.07	0.188	1054
NP38-c	39.48	0.78	6.72	34.41	0.11	<0.01	<0.01	<0.01	<0.01	0.11	0.439	1745
NP38-d	28.67	0.39	4.49	26.90	13.87	<0.01	<0.01	<0.01	<0.01	0.07	0.220	1260
NP38-e	36.30	0.30	7.45	38.02	0.11	<0.01	<0.01	<0.01	<0.01	0.10	0.396	2268
NP38-f	39.08	0.57	7.19	35.83	0.10	<0.01	<0.01	<0.01	<0.01	0.11	0.403	2309
YP3-7b	33.27	0.71	6.95	29.15	8.66	<0.01	<0.01	<0.01	0.05	0.06	0.333	1886
YP3-9	33.49	0.51	6.23	32.60	5.73	<0.01	<0.01	<0.01	0.06	0.05	0.311	1685
YP3-3	40.03	0.98	6.92	34.39	0.67	<0.01	<0.01	0.01	<0.01	0.09	0.348	2044
Dt08-8	42.59	0.39	8.58	31.40	0.08	<0.01	<0.01	<0.01	<0.01	0.12	0.382	2397
Dt08-13b	52.76	14.06	12.60	4.10	6.24	5.76	0.04	1.99	0.19	0.14	0.004	49
Dt08-13c	64.15	16.20	4.93	1.89	3.06	7.01	0.18	0.41	0.19	0.10	<0.002	<20
Dt08-13d	50.51	15.32	9.54	7.09	8.62	4.21	0.20	1.76	0.18	0.16	0.027	89
Dt08-2b	90.11	0.23	5.44	1.54	0.06	0.02	<0.01	<0.01	0.01	0.05	0.351	644
Dt08-9b	41.92	0.39	8.62	31.64	0.28	<0.01	<0.01	<0.01	<0.01	0.11	0.389	2351
Dt08-6	41.14	0.27	7.99	33.90	0.23	<0.01	<0.01	<0.01	<0.01	0.11	0.343	2219
Dt10-2d	42.11	0.24	7.28	35.94	0.08	<0.01	<0.01	<0.01	<0.01	0.07	0.267	2023
Dt10-7a	40.84	0.28	7.62	34.84	0.05	<0.01	<0.01	<0.01	<0.01	0.08	0.431	2229
Dt10-7b	40.67	0.17	7.96	34.38	0.06	<0.01	<0.01	<0.01	<0.01	0.10	0.481	2125
Dt10-6a	40.39	0.36	8.51	33.79	0.19	<0.01	<0.01	<0.01	<0.01	0.11	0.451	2364
Dt10-6b	41.10	0.31	7.89	34.38	0.12	<0.01	<0.01	<0.01	<0.01	0.12	0.420	2344
Dt10-5a	40.32	0.73	7.53	35.20	0.06	<0.01	<0.01	<0.01	<0.01	0.10	0.516	2017
Dt10-1d	41.83	1.98	7.36	32.62	0.09	<0.01	<0.01	0.03	<0.01	0.09	0.373	1954
Dt10-1b	42.29	1.14	6.81	33.43	0.04	<0.01	<0.01	0.02	<0.01	0.08	0.376	2110
Dt13-24	40.88	0.78	8.08	35.01	0.18	<0.01	<0.01	0.02	<0.01	0.10	0.469	2311
Dt13-3b	41.72	1.34	6.30	35.10	0.38	<0.01	<0.01	0.01	<0.01	0.13	0.458	2310
Dt13-23a	40.09	0.38	7.44	35.01	0.15	<0.01	<0.01	<0.01	0.02	0.09	0.401	2309
Dt13-17	37.42	0.63	7.20	36.86	0.09	0.02	<0.01	0.02	0.01	0.10	0.328	2222
Dt13-7	41.07	1.25	7.12	35.02	0.86	<0.01	<0.01	0.01	0.01	0.12	0.386	2060

Elements	Sc	Ba	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr
Sample	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
NP19-1	8	8	2	89.1	0.2	2.9	<0.1	3.6	0.5	<1	1.6
NP19-2	2	<1	2	86.9	0.1	2.5	<0.1	<0.1	0.5	<1	<0.5
NP19-3	8	6	<1	91.1	<0.1	1.6	<0.1	0.4	0.5	<1	2.1
NP18-3	7	<1	<1	86.5	<0.1	3.0	<0.1	0.7	1.3	<1	0.6
YP3-7a	7	5	<1	71.3	<0.1	1.8	<0.1	0.6	0.5	<1	32.2
NP28-6	7	5	<1	96.3	<0.1	1.9	<0.1	0.3	0.7	<1	2.7
YP3-10	9	<1	<1	97.0	<0.1	3.7	<0.1	2.6	0.5	<1	16.7
NP18-6a	7	<1	<1	89.4	0.2	2.8	0.1	0.8	1.6	<1	0.6
NP18-6b	5	<1	<1	92.5	<0.1	3.0	<0.1	0.6	1.8	<1	1.8
NP38-b	3	58	<1	55.3	<0.1	1.1	<0.1	0.2	0.4	<1	1042.7
NP38-c	9	1	<1	82.9	<0.1	1.8	<0.1	0.2	0.6	<1	5.7
NP38-d	5	39	<1	55.6	<0.1	1.0	<0.1	0.2	0.4	<1	752.7
NP38-e	6	<1	<1	98.8	<0.1	2.6	<0.1	<0.1	0.7	<1	14.8
NP38-f	9	<1	<1	101.0	<0.1	2.7	<0.1	<0.1	0.8	<1	6.4
YP3-7b	8	2	<1	82.1	<0.1	2.4	<0.1	<0.1	0.7	<1	8.1
YP3-9	8	4	<1	76.4	<0.1	1.8	<0.1	1.0	0.6	<1	21.3
YP3-3	8	<1	<1	84.8	<0.1	2.2	<0.1	0.7	0.6	<1	2.5
Dt08-8	8	8	<1	100.1	<0.1	1.6	<0.1	0.2	0.4	<1	2.4
Dt08-13b	29	20	<1	29.2	<0.1	18.8	4.2	2.2	0.5	1	78.3
Dt08-13c	6	67	<1	7.8	<0.1	13.8	3.0	3.9	1.8	<1	251.1
Dt08-13d	33	38	3	31.5	<0.1	17.1	3.4	3.4	1.7	2	185.0
Dt08-2b	3	10	<1	60.8	<0.1	1.6	<0.1	0.2	0.6	<1	2.1
Dt08-9b	9	4	<1	105.5	<0.1	2.2	<0.1	<0.1	0.8	<1	2.4
Dt08-6	7	3	<1	99.4	<0.1	1.8	<0.1	<0.1	0.7	<1	3.4
Dt10-2d	5	<1	<1	81.7	<0.1	2.2	<0.1	0.2	0.5	<1	2.5
Dt10-7a	7	<1	<1	101.9	<0.1	2.1	<0.1	<0.1	0.7	<1	0.5
Dt10-7b	6	<1	<1	101.4	<0.1	1.5	<0.1	0.1	0.5	<1	<0.5
Dt10-6a	9	<1	<1	93.2	<0.1	1.7	<0.1	<0.1	0.5	<1	3.0
Dt10-6b	6	<1	<1	106.9	<0.1	1.4	<0.1	<0.1	0.7	<1	1.4
Dt10-5a	10	<1	<1	85.3	<0.1	1.6	<0.1	<0.1	0.6	<1	<0.5
Dt10-1d	12	6	1	92.7	<0.1	2.4	<0.1	<0.1	0.4	<1	3.3
Dt10-1b	8	2	<1	89.0	<0.1	1.5	0.1	0.2	0.4	<1	1.8
Dt13-24	11	<1	<1	96.6	<0.1	2.5	<0.1	<0.1	0.6	<1	1.1
Dt13-3b	14	<1	<1	120.4	<0.1	1.8	<0.1	<0.1	0.6	<1	1.0
Dt13-23a	8	5	<1	98.0	<0.1	<0.5	<0.1	<0.1	0.2	<1	7.4
Dt13-17	6	<1	<1	107.9	0.2	<0.5	<0.1	<0.1	<0.1	<1	1.1
Dt13-7	10	3	<1	103.5	<0.1	<0.5	<0.1	0.2	<0.1	<1	2.5

Elements	Ta	Th	U	V	W	Zr	Y	La	Ce	Pr
Sample	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
NP19-1	<0.1	<0.2	<0.1	38	0.7	0.5	0.2	0.9	0.6	0.12
NP19-2	<0.1	<0.2	<0.1	28	<0.5	0.3	0.2	0.8	0.4	0.09
NP19-3	<0.1	<0.2	<0.1	33	<0.5	0.3	0.2	0.3	<0.1	0.03
NP18-3	<0.1	<0.2	0.1	33	0.6	1.0	0.4	0.9	0.4	0.06
YP3-7a	<0.1	<0.2	0.3	33	<0.5	1.0	0.3	1.5	1.4	0.13
NP28-6	<0.1	<0.2	<0.1	38	0.8	0.4	0.3	0.7	0.5	0.07
YP3-10	0.1	<0.2	<0.1	39	1.4	0.8	<0.1	1.0	0.4	0.08
NP18-6a	<0.1	<0.2	<0.1	34	<0.5	0.9	0.2	1.0	0.5	0.06
NP18-6b	<0.1	<0.2	<0.1	24	<0.5	0.4	0.2	1.0	0.1	0.04
NP38-b	<0.1	<0.2	<0.1	16	<0.5	0.2	<0.1	0.4	0.1	0.02
NP38-c	<0.1	<0.2	<0.1	37	<0.5	0.2	0.2	0.3	0.2	<0.02
NP38-d	<0.1	<0.2	<0.1	22	<0.5	0.4	0.2	0.3	0.2	<0.02
NP38-e	<0.1	<0.2	<0.1	28	<0.5	0.7	<0.1	1.3	0.4	0.07
NP38-f	<0.1	<0.2	<0.1	41	<0.5	1.5	0.2	1.1	1.1	0.08
YP3-7b	<0.1	<0.2	0.3	40	<0.5	0.6	0.2	0.6	<0.1	0.06
YP3-9	<0.1	<0.2	<0.1	33	<0.5	1.0	0.5	1.0	0.4	0.08
YP3-3	<0.1	<0.2	<0.1	43	0.7	1.7	0.3	1.5	0.5	0.05
Dt08-8	<0.1	<0.2	<0.1	30	<0.5	0.5	0.1	0.9	1.1	0.13
Dt08-13b	0.2	0.4	0.2	352	<0.5	137.1	42.5	6.8	18.6	3.02
Dt08-13c	0.3	8.1	1.9	85	<0.5	105.6	17.5	26.4	54.3	6.04
Dt08-13d	0.3	0.2	0.2	276	<0.5	125.9	32.3	5.6	15.7	2.50
Dt08-2b	<0.1	<0.2	0.3	22	<0.5	3.2	0.4	0.6	0.8	0.08
Dt08-9b	<0.1	<0.2	0.6	47	1.5	0.6	0.3	1.4	0.1	0.06
Dt08-6	<0.1	0.2	<0.1	31	0.6	1.4	<0.1	1.2	0.2	0.06
Dt10-2d	<0.1	<0.2	0.3	23	<0.5	1.2	0.9	1.0	0.8	0.13
Dt10-7a	<0.1	<0.2	<0.1	24	<0.5	1.6	<0.1	0.8	0.5	0.09
Dt10-7b	<0.1	<0.2	<0.1	28	0.5	0.2	<0.1	1.1	0.4	0.07
Dt10-6a	0.1	<0.2	<0.1	45	<0.5	0.7	0.1	0.9	0.8	0.07
Dt10-6b	<0.1	<0.2	<0.1	28	1.6	0.7	<0.1	0.9	0.4	0.03
Dt10-5a	<0.1	<0.2	<0.1	63	0.5	0.4	0.2	0.7	<0.1	0.05
Dt10-1d	<0.1	<0.2	<0.1	59	0.6	0.8	1.1	1.3	1.4	0.18
Dt10-1b	0.1	0.3	<0.1	34	0.5	4.4	0.7	4.2	9.6	1.19
Dt13-24	<0.1	<0.2	<0.1	46	<0.5	0.8	0.4	0.7	0.3	0.07
Dt13-3b	<0.1	<0.2	<0.1	55	0.8	0.2	0.4	0.3	0.3	0.03
Dt13-23a	<0.1	<0.2	<0.1	31	<0.5	0.3	<0.1	0.2	0.1	<0.02
Dt13-17	<0.1	<0.2	<0.1	30	<0.5	0.8	<0.1	<0.1	0.2	<0.02
Dt13-7	<0.1	<0.2	<0.1	36	<0.5	2.4	0.6	0.2	0.5	<0.02

Elements	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Sample	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
NP19-1	0.4	0.11	<0.02	0.06	0.01	0.07	<0.02	0.04	<0.01	0.06
NP19-2	<0.3	0.08	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP19-3	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP18-3	<0.3	<0.05	0.02	<0.05	0.02	<0.05	<0.02	0.04	<0.01	0.07
YP3-7a	0.4	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP28-6	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	0.04	<0.01	<0.05
YP3-10	0.3	<0.05	<0.02	<0.05	0.01	<0.05	0.03	0.06	<0.01	<0.05
NP18-6a	<0.3	0.10	<0.02	0.05	<0.01	<0.05	<0.02	0.04	<0.01	0.06
NP18-6b	<0.3	0.06	<0.02	0.07	0.01	<0.05	0.02	<0.03	<0.01	<0.05
NP38-b	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP38-c	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP38-d	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
NP38-e	<0.3	0.09	0.02	0.07	<0.01	<0.05	<0.02	0.06	<0.01	<0.05
NP38-f	<0.3	0.08	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	0.08
YP3-7b	0.4	0.09	<0.02	0.07	<0.01	0.07	<0.02	<0.03	<0.01	<0.05
YP3-9	<0.3	<0.05	0.03	<0.05	0.01	<0.05	0.03	<0.03	<0.01	<0.05
YP3-3	<0.3	0.11	<0.02	<0.05	0.02	0.06	0.03	0.06	<0.01	0.06
Dt08-8	0.6	0.11	<0.02	0.06	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt08-13b	15.6	4.86	1.73	6.59	1.21	7.65	1.60	4.86	0.73	4.61
Dt08-13c	25.1	4.11	1.08	3.61	0.55	3.03	0.62	1.85	0.30	1.98
Dt08-13d	13.8	4.04	1.40	5.22	0.94	5.71	1.24	3.71	0.52	3.31
Dt08-2b	0.4	0.09	<0.02	0.08	0.02	0.07	0.02	0.06	<0.01	<0.05
Dt08-9b	<0.3	0.08	<0.02	<0.05	0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt08-6	<0.3	<0.05	0.03	<0.05	0.01	0.07	<0.02	<0.03	<0.01	<0.05
Dt10-2d	0.3	<0.05	0.04	0.13	0.02	0.09	0.02	0.03	<0.01	<0.05
Dt10-7a	<0.3	0.10	0.02	<0.05	0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt10-7b	<0.3	<0.05	0.03	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt10-6a	<0.3	0.11	0.03	0.07	<0.01	0.05	<0.02	<0.03	<0.01	<0.05
Dt10-6b	<0.3	<0.05	0.03	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt10-5a	<0.3	0.09	<0.02	<0.05	0.01	<0.05	<0.02	0.05	<0.01	<0.05
Dt10-1d	0.6	0.09	0.03	0.13	0.03	0.15	0.04	0.12	0.02	0.16
Dt10-1b	4.3	0.74	0.12	0.34	0.04	0.15	<0.02	0.09	0.01	0.06
Dt13-24	<0.3	0.06	0.03	<0.05	0.02	0.08	0.03	0.04	<0.01	0.10
Dt13-3b	<0.3	0.09	<0.02	0.07	0.02	<0.05	0.03	0.07	<0.01	<0.05
Dt13-23a	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	<0.05
Dt13-17	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01	0.08
Dt13-7	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	0.03	0.06	<0.01	0.08

Elements	Lu	Mo	Cu	Pb	Zn	Ni	As	Sb	Au	Se
Sample	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	PPM
NP19-1	<0.01	<0.1	3.1	0.1	23	2363.8	<0.5	<0.1	<0.5	<0.5
NP19-2	<0.01	<0.1	0.9	<0.1	21	2512.6	<0.5	<0.1	<0.5	<0.5
NP19-3	<0.01	<0.1	5.5	<0.1	21	2337.5	<0.5	<0.1	<0.5	<0.5
NP18-3	0.01	<0.1	9.1	<0.1	27	2099.5	<0.5	<0.1	<0.5	<0.5
YP3-7a	<0.01	<0.1	4.6	<0.1	26	1609.8	<0.5	<0.1	<0.5	<0.5
NP28-6	<0.01	<0.1	2.0	<0.1	22	2275.8	0.7	<0.1	0.7	<0.5
YP3-10	<0.01	<0.1	12.6	<0.1	35	2288.8	<0.5	<0.1	0.7	<0.5
NP18-6a	<0.01	<0.1	1.3	<0.1	17	2125.2	5.0	<0.1	<0.5	<0.5
NP18-6b	0.02	<0.1	0.4	<0.1	23	2210.7	2.0	<0.1	<0.5	<0.5
NP38-b	<0.01	<0.1	3.3	<0.1	16	1109.8	<0.5	<0.1	<0.5	<0.5
NP38-c	<0.01	<0.1	5.9	0.2	46	1897.5	<0.5	<0.1	<0.5	0.5
NP38-d	<0.01	<0.1	4.4	<0.1	18	1302.0	<0.5	<0.1	<0.5	<0.5
NP38-e	<0.01	<0.1	0.6	<0.1	26	2412.2	<0.5	<0.1	<0.5	<0.5
NP38-f	0.02	<0.1	1.3	0.1	23	2449.6	<0.5	<0.1	<0.5	<0.5
YP3-7b	0.01	<0.1	17.8	<0.1	31	1888.8	<0.5	<0.1	<0.5	<0.5
YP3-9	0.01	<0.1	6.0	0.2	27	1744.0	<0.5	<0.1	<0.5	<0.5
YP3-3	0.01	<0.1	5.8	<0.1	28	2117.9	<0.5	<0.1	<0.5	<0.5
Dt08-8	<0.01	<0.1	6.5	<0.1	43	2579.9	<0.5	<0.1	1.1	<0.5
Dt08-13b	0.72	0.3	2.7	0.2	18	45.3	0.8	<0.1	<0.5	<0.5
Dt08-13c	0.32	0.2	4.1	1.3	58	14.3	0.7	0.1	<0.5	<0.5
Dt08-13d	0.49	0.2	35.5	0.2	23	53.3	1.4	<0.1	<0.5	<0.5
Dt08-2b	<0.01	0.4	4.1	0.3	15	603.3	0.9	<0.1	<0.5	<0.5
Dt08-9b	<0.01	<0.1	3.7	<0.1	42	2532.2	<0.5	<0.1	<0.5	<0.5
Dt08-6	0.01	<0.1	3.7	<0.1	33	2356.5	<0.5	<0.1	<0.5	<0.5
Dt10-2d	<0.01	0.1	0.8	0.1	26	2039.5	<0.5	<0.1	<0.5	<0.5
Dt10-7a	<0.01	0.1	2.6	<0.1	37	2390.3	<0.5	<0.1	<0.5	<0.5
Dt10-7b	<0.01	<0.1	4.0	<0.1	46	2296.3	<0.5	<0.1	<0.5	<0.5
Dt10-6a	<0.01	<0.1	9.8	0.1	41	2532.1	<0.5	<0.1	<0.5	<0.5
Dt10-6b	<0.01	<0.1	3.2	<0.1	42	2506.9	<0.5	<0.1	<0.5	<0.5
Dt10-5a	0.01	<0.1	23.4	<0.1	36	2214.9	<0.5	<0.1	0.6	<0.5
Dt10-1d	0.03	<0.1	20.8	<0.1	26	2109.7	<0.5	<0.1	1.2	<0.5
Dt10-1b	0.02	<0.1	8.2	<0.1	23	2302.3	<0.5	<0.1	<0.5	0.5
Dt13-24	<0.01	<0.1	1.6	<0.1	38	2450.2	0.8	<0.1	<0.5	<0.5
Dt13-3b	0.02	<0.1	23.9	<0.1	28	2536.3	<0.5	<0.1	<0.5	<0.5
Dt13-23a	<0.01	<0.1	8.9	<0.1	31	2354.6	<0.5	<0.1	1.8	<0.5
Dt13-17	<0.01	<0.1	4.3	<0.1	37	2290.8	<0.5	<0.1	<0.5	<0.5
Dt13-7	0.01	0.1	5.5	0.4	28	2009.6	0.6	<0.1	1.3	<0.5

VITA

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EDUCATION		
Year of Graduation	**Degree**	**Institution**
2018	Phd	METU Archaeometry
2004	MS	METU Archaeometry
1999	BS	A.Ü. Department of Geology Engineering

WORK EXPERIENCE		
Year	**Place**	**Enrollment**
2015-2018	Mavi Anadolu LTD.	Researcher
2011-2015	-	Freelence researcher, editor
2006-2011	Zirve LTD.	Manager
2004-2006	Tarih Vakfı	Editor
2000-2004	-	Freelence researcher, editor
1995-2000	TUBİTAK	Editor, popular science author

EXCAVATION AND SURVEY EXPERIENCES		
Year	**Place**	**Enrollment**
2016-2018	Uğurlu Excavations	Geoarchaeologist
2016	Ulucak Excavations	Geoarchaeologist
2015-2016	Mihallçık Field Survey	Geoarchaeologist
2009-2016	Domuztepe Excavations	Geoarchaeologist
2002-2004	Knidos Excavations	Geoarchaeologist

FOREIGN LANGUAGES
English

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