

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

**PROVENANCE STUDY of THE LATE BRONZE AGE CYPRIOTE POTTERIES:
WHITE SLIP and MONOCHROME WARES from TELL ATCHANA/THE
ANCIENT ALALAKH (HATAY) and ARCHAEOMETRICAL APPROACHS**



M.Sc. THESIS

Sinem HACIOSMANOĞLU

Department of Geological Engineering
Geological Engineering Programme

JUNE 2016

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

**ATCHANA HÖYÜK'TE (ANTİK ALALAK) GEÇ BRONZ ÇAĞINA AİT
KIBRIS SERAMİK BULUNTULARININ (WHITE SLIP ve MONOCHROME)
KAYNAK ALAN ANALİZİ VE ARKEOMETRİK AÇIDAN İNCELENMESİ**

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To my family,



FOREWORD

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ABBREVIATIONS

BC	: Before Christ
DSF	: Dead Sea Fault
EAF	: East Anatolian Fault
HREe	: High Rare Earth element
ICP-MS	: Inductively Coupled Plasma Mass Spectrometry
LBNL	: Lawrence Berkeley National Laboratory
LOI	: Loss on Ignition
LREe	: Light Rare Earth element
Ma	: Million Age
MN	: Monochrome
n	: number
NAA	: Neutron Activation Analyse
NE	: North East
NW	: North West
ppm	: part per million
REE	: Rare Earth Elements
WBR	: World Reference Base for Soil Resources
WS	: White Slip
wt.	: weight in gram
XRF	: X-Ray Fluorescence
µm	: micrometer



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SUMMARY

Tell Atchana/The ancient Alalakh is an ancient city located in south of the Amuq Valley. Large amount of Cypriot ceramics was found in Tell Atchana/The Ancient Alalakh. This ancient city is one of the biggest settlement in Amuq region and was the capital city of the Mukish Kingdom during the Middle and Late Bronze Age. Ancient Alalakh has significant geographic location because of junction point of Anatolia, Mediterrean and Mesopotamia. Therefore, this site play an important role on culture and trade exchange with other different cultures, especially Hittite and Mitanni. Due to the being city of kingdom and interaction with other cultures, this provide to much information about Mid-Late Bronze Age. One of the significant archaeologic finding is ceramic which plays a significant role to reach to information about socio-economic, socio-cultural, politic and trade balance.

A vast quantity of The White Slip (both White Slip I and II) and the Monochrome wares are two Late Bronze Age Cypriote pottery types found in a large area in the Tell Atchana/ Alalakh excavation. We selected a total of 56 samples of White Slip (WS I=6, WS II= 30) and Monochrome ware (MN= 20) from Tell Atchana/Alalakh and analyzed using archaeometrical methods. The chemical compositions of the selected samples were determined by X-ray Fluorescence (XRF) and Inductively Coupled Mass Spectrometry (ICP-MS), and mineralogical contents were investigated using petrographic thin-sections technique. The main aims of the study are to explore the compositional characteristics of the wares (e.g. chemical and petrographic groups), and to ascertain that whether they are local variant of the Cypriot White Slip and Monochrome ware types or represent Cypriot imports to this region. In addition, another aim is explore the possible clay source by use of these archaeometric methods. According to these analyses, we determined petrographic and geochemical characterization of the potteries and determined subgroups for both WS and WS II ware. Moreover, we confirmed local variation between WS I and WS II ware. We revealed petrographic and geochemical differences between White Slip and Monochrome ware.

For the provenance, when the analytical results of the White Slip and Monochrome was compared with the reference group from the previous study, It was seen no relationship selected samples with refereance group that was established based on

extensive clay sampling in Amuq plain. Other steps for the provenance, selected sample WS and MN wares from Tell Atchana was compared with White Slip and Monochrome samples from the different regions that are collected from previous studies. After comparison, we understood that our White Slip pottery have similar geochemical characterization with Cyprus ceramics from previous study. The analytical results proved that White Slip I and II were produced from raw clay of mafic and ultramafic source rocks exposed in the Troodos massif, available in the Limassol area of South Cyprus and traded to Tell Atchana. Likewise, Monochrome ware are import material and have similar geochemical features with other Monochrome pottery. These results demonstrate a close trade connection between Tell Atchana/Alalakh and South Cyprus during the Middle-Late Bronze Age.



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KAYNAK ALAN ANALİZİ VE ARKEOMETRİK AÇIDAN İNCELENMESİ**

ÖZET

Amik Ovası, Türkiye'nin güneydoğusunda Hatay ili sınırları içerisinde yer almaktadır. Doğu Akdeniz, Mezopotamya, Anadolu bölgeleri için önemli geçiş yolları üzerinde bulunmasından dolayı jeopolitik bir öneme sahiptir. Ayrıca, önemli konumunun yanı sıra; ovanın coğrafik ve iklimsel yapısının elverişliliği nedeniyle de Neolitik dönemden beri bir çok medeniyete de ev sahipliği yapmıştır. Bu medeniyetlerden en önemlilerinden biri ovanın güneyinde bulunan Açıne Höyük, Alalakh antik kentidir. Orta ve Geç Tunç çağında bölgesel bir krallık olan Mukiş Krallığının başkenti konumunda olan bu kent, 22 hektarlık bir alanla da bölgedeki en büyük antik yerleşkelerden birini temsil eder. Anadolu'da Hitit, Doğu Akdeniz ve Batı Mezopotamya'da Mitanni ve Mısır uygarlıklarıyla yakın ilişkileri nedeniyle de, dönemin tarihsel ve kültürel, sosyo-ekonomik özelliklerini aynı zamanda çevre kültürlerle olan kültürel, ticari ve politik ilişkilerini anlayabilmek açısından önemli bir yerleşkedir. Tüm bunların etkisiyle, dönemi aydınlatacak bir çok buluntu içerir. Bunların önemli bir kısmını ise çanak çömlekler oluşturur. Kentte, yerel üretim olduğu bilinen seramiklerin yanı sıra ithal olduğu düşünülen seramiklerde vardır. Bunların büyük bir kısmını Kıbrıs seramikleri oluşturur.

Bu çalışma kapsamında, Geç Tunç Çağı Kıbrıs seramiği olarak temsil edilen White Slip (White Slip I ve White Slip II) ve Monochrome seramikleri kullanılacaktır. Bu seramik grubunun tipolojisindeki benzerlik ve farklılıklardan ziyade hammadde karakterlerinin belirlenmesi önemlidir. Bu sayede, kaynak alanları belirlenecek ve üretim teknolojileri hakkında bilgi sahibi olunabilecektir. Bunun yanında, orjinal veya imitasyon olup olmadıkları da anlaşılabilecektir. Bunlar hem Geç Tunç Çağında Mukiş Krallığı hakkında daha çok bilgi sahibi olunmasını sağlayacak hem de Kıbrıs ve diğer bölgeler arasındaki, ticari ve kültürel ilişkilerinin daha iyi anlaşılmasına katkı sağlayacaktır.

Bu tez temel olarak 5 bölümden oluşmaktadır. Tezin birinci bölümünde, konuya giriş yapılarak tezin amacından bahsedilmiştir. Konuyla ilgili önceki çalışmalar özetlenerek, bu tez çalışmasının gerekliliği ve konuyla ilgili problemler ortaya konmuştur.

İkinci kısımda, Atchana höyüğün coğrafik konumu ve Amik ovasındaki yeri

gösterilmiştir. Ayrıca bu bölümde, Amik Ovası ve çevresinin coğrafik özellikleri ortaya konmuştur. Daha sonra Ovayı çevreleyen ve ovanın gelişimine etki eden kayaların jeolojik birimleri ve özellikleri anlatılmıştır. Son olarak, ovanın tektoniği ve jeolojik evrimi birlikte anlatılmıştır. Bu bölüm, ileri kısımlarda bahsedilecek olan Amik ovasını beslediği kil yataklarının özelliklerini anlamak açısından önemlidir.

Üçüncü bölümde, tezde kullanılacak arkeolojik malzemenin bulunduğu kazı alanından (Atchana Höyük) bahsedilmiştir. Kazının başladığı tarihten günümüze gelişimi ve önemi, ayrıca kazının bölgeleri ve yerleşim planı hakkında bilgiler verilmiştir. Kazının tarihi, stratigrafik gelişimi, tarihsel seviyeleri, arkeolojik buluntuları ve önemleri anlatılmıştır. Bunlara ilaveten, tez kapsamında kullanılacak White Slip ve Monochrome seramikleri hakkında arkeolojik olarak fikir sahibi olabilmek için, genel Kıbrıs Seramikleri hakkında bilgi verilmiştir ve bunların içinde White Slip ve Monochrome'lar ele alınmıştır. Ayrıca, bu seramiklerin kullanım amaçları, yayılımları vs. gibi arkeolojik önemi ve makroskopik özellikleri de bu bölümde anlatılmıştır.

Dördüncü bölüm, kullanılacak malzeme ve yöntemleri içermektedir. Öncesinde ise arkeolojik buluntular üzerinde jeolojik yöntemler kullanılarak izlenecek bilimsel yol hakkında bilgi verilmiştir. Burada disiplinler arası arkeoloji ve jeolojiyi kapsayan çalışma arkeometri başlığı altında anlatılmıştır. Seramiklerin hammadde özelliklerinin belirlenebilmesi, üretim yeri ve üretim teknolojisi hakkında fikir sahibi olabilmek için petrografik ve jeokimyasal yöntemlere ihtiyaç vardır. Bunun için, Atchana Höyükten, 6 adet White Slip I, 30 Adet White Slip II ve 20 adet Monochrome parça örneği alınmıştır. İlk olarak, Mineralojik özelliklerin belirlenebilmesi aynı zamanda üretim tekniği ile ilgili veriler alınabilmesi için ince kesit yöntemiyle petrografik özellikler ortaya konmuştur. İkinci olarak, kil kaynağının elemental düzeyde özelliklerinin belirlenebilmesi için, ana elementler için X-Ray Fluorescence (XRF) metodu kullanılmıştır. İz element tayini için ise Inductively Couple Plasma Mass Spectroscopy (ICP-MS) metodu kullanılmıştır. İleri kısımlarda analiz sonuçlarıyla kıyaslanacak olan önceki çalışmalardan derlenmiş veriler de bu bölümde anlatılmıştır.

Beşinci bölüm, analiz sonuçlarının anlatıldığı kısımdan oluşmaktadır. İlk kısım petrografik yöntem sonuçlarının açıklandığı bölümdür. Burada her bir seramik grubunun mineralojik, petrografik özellikleri ortaya konmuştur. İkinci kısımda ise XRF ve ICP-MS analizleri sonucu, yine her bir seramik grubunun jeokimyasal özellikleri ortaya konmuştur. Bu sayede seramik gruplarının hammadde kaynakları hakkında bilgi sahibi olunabilecek hem de üretim süreçleriyle ilgili fikir sahibi olunabilecektir.

Çalışmanın altıncı ve en geniş bölümü, sonuçların değerlendirildiği ve önceki çalışmalarla kıyaslama yapıldığı tartışma bölümüdür. Burada sırasıyla, seramik gruplarının hammadde kaynaklarının nasıl bir kaynaktan türemiş olduğu ile ilgili yorumları içerir. Analiz sonuçları değerlendirilerek kökenleri hakkında yoruma gidildiği kısımdır. White Slipler mafik-ultramafik bir kaynağı işaret ederken, Monochrome'lar asidik bir sedimanter kaynağı işaret ettiği görülmüştür. Aynı

zamanda, seramik grupları arasındaki benzerlik ve farklılık da bu kısımda tartışılmıştır. White Slip ve Monochrome seramiklerinin birbirlerinden farklı olduğu görülmüştür. “Tartışma” bölümünün ikinci kısmında kısmında; seramiklerin imitasyon olup olmadıkları veya ticaretle mi itaat edildiklerini anlamak için, önceki çalışmalardan derlenen Kıbrıs seramikleri verileri kullanarak kıyaslama yapılmıştır. Bu sayede imitasyon olup olmadıkları anlaşılabilir. Kıyaslama sonunda Atchana höyükte bulunan White Slip seramiklerin diğer White Slip’lerle aynı kaynak alandan geldiği anlaşılmıştır. Aynı şekilde Monochrome seramiklerin diğer Monochrome’lar ile aynı kaynak alandan gelmiş olabileceği düşünülmektedir. Böylece imitasyon olmadıkları anlaşılmıştır. “Tartışma”nın üçüncü kısmında, referans malzeme olarak Amik ovası killerinin jeokimyasal verileri, seramiklerin hammaddesiyle karşılaştırılmak için kullanılmıştır. Bunun için, Amik ovasının kil yataklarından sistematik bir şekilde toplanan kil örneklerinin analiz sonuçları önceki çalışmadan alınmıştır. Bunun sonucunda, Antik Alalakh kentinde bulunan White Slip ve Monochrome ların Amik ovasıyla kaynak alan ilişkisi bulunmadığı görülmüştür. Bunlara ilaveten, Kıbrıs’ın belirli yerlerinden önceki çalışmalardan alınan kil örnekleri kullanılmıştır. Bu örnekler sayesinde karşılaştırma yapılarak, olası kaynak alan hakkında yaklaşımda bulunulmuştur. Bu sayede, White Slip seramikler için Troodos Masifi’nin (Kıbrıs) güney kesiminden alınan killerle yakın ilişkisi görülmüştür. Geç Bronz Çağını kapsayan dönemde Kıbrıs’ın güneyinden direk olarak Amik ovasına bu seramiklerin ticaretle taşınmış olabileceği söylenebilir.

Son bölüm ise sonuç kısmından oluşur. Burada tüm çalışma sonuçları özetlenerek sunulmuştur.



1. INTRODUCTION

During the second millennium BC, the Amuq valley, which is located in Hatay, southern Turkey, was an important geographic location. The valley connected four-principle cultural zones such as the Anatolian (Hittite and Hurrian), eastern Mediterranean (Aegean and Cypriot), Levantine-Palestinian (Egyptian and Canaanite) and northern Syro-Mesopotamian (Hurrian-Mitanni and Assyrian-Babylonian) sites (Yener et al., 2000). Therefore, it became a significant geopolitical position for trade and exchange of cultural goods. Moreover, the valley was very suitable for settlement because of very fertile plain and temperate climate for agriculture and for living. Additionally, being surrounded by mountains and having river systems provide suitable condition for settlement to humans. Therefore, it was known that there were many ancient settlements in the Amuq Valley. According to Braidwood (1937), 178 settlements are documented in the valley but recent researches recorded almost 400 sites (Welton, 2011; Dodd et al., 2011).

The Tell Atchana / the Ancient Alalakh is known to be one of the biggest settlement in the Amuq region and is the capital city of the Mukish Kingdom during the middle and late Bronze Age. Both being capital city and having strategic geographic location on trade routes cause conservation of many archaeological materials not only traditional but also different cultural material in this region. Hittite and Mitanni effects are seen on Tell Atchana. Especially, some antique material, which was found in excavation, bore the traces of these antiquity. Therefore, Alalakh plays an important role due to the validation of too much information and having abundant archaeological remains for especially Middle and Bronze Age. One of the significant archaeological finding is ceramic material in this excavation. Because, ceramic material has been used by various cultures since neolithic time and can show wide variety. In addition, they are well conserved under the ground for a long time and are convenient for analytical analysis. Therefore, ancient ceramics (potteries) provide critical knowledge for researchers and are very important materials to understand ancient history.

Huge amount of ceramics were found in the Tell Atchana, some of them are known to be local production but others most probably for import from other sites. The Cypriot ceramics, which are considered as import materials, form a major part of pottery findings in Tell Atchana. In the Tell Atchana the main Cypriot wares are the Basing I-II, White Slip I-II, Monochrome, Red Lustrous Wheelmade, White Lustrous Wheelmade, White Shaved, Red on Black (Kozal, 2010). In the scope of this study, White Slip I, White Slip II and Monochrome wares are investigated. The White Slip ware (WS) is one of the prominent ware type among the Late Bronze Cypriot ceramic assemblage, dates to the 1300-1400 BC (Wolley, 1938; Pfälzner, 1995). It was used in a very large area in the Eastern Mediterranean including Cyprus, Anatolia, Levant and Egypt (Karageorgis, 1994; Bergoffen, 1991). Likewise, the Monochrome (MN) ware was also popular during late Bronze era and is known as one of the main trade goods in beginning of the late Bronze Age (Sjöqvist, 1940; see Bergoffen, 1991).

1.1 The Frame Of The Study

A huge amount of the White Slip and Monochrome wares were found in Tell Atchana. This case brings a debate whether these wares are imitation or not. Sometimes, popular and useful potteries could be imitated by other cultures. Although they have same archaeological features such as; slip colour, painting and decoration, their raw materials reveal different material features (different clay sources). In the Tell Atchana there are local productions of potteries (exp. The Nuzi ware), also ceramic workshop and kilns (Akar and Yener, 2013). Therefore, raw clay materials of the White Slip and Monochrome wares might be taken from the Amuq basin and those ceramics might be imitated there.

The archaeometric studies on the Monochrome ware are very scarce. Therefore, mineralogical and chemical composition of the raw material of the Monochrome ware are not known and thus its origin. Some studies suggested that the Monochrome and the White Slip ware have a similar raw material, which were found in Sanidha (Rautman et al. 1993). Todd (1990) suggests that the White Slip and the Monochrome wares in Sanidha contain same raw material and Monochrome ware is an unslipped state of the White Slip ware (see Gomez and Doherty, 2000). This opinion is also supported by Renson et al. (2013), they explained that the Monochrome and the White Slip ware in Sanidha include similar raw material according to isotope study (Pb) and

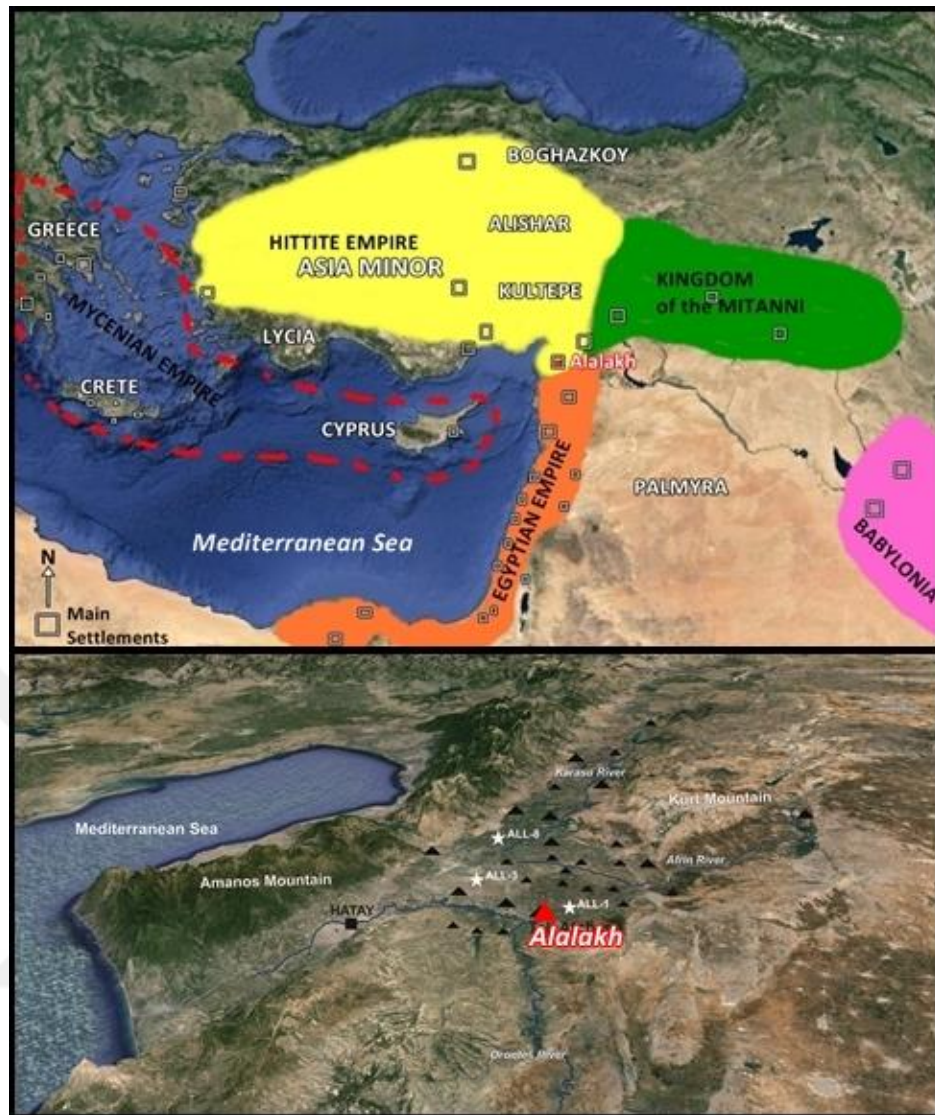


Figure 1.1: Late Bronze Age cultural zones and main settlements of the Tell Atchana/Alalakh surrounding area. Ancient settlements of the Amuq Plain (cultural zones modified after <http://web.ics.purdue.edu/~rauhn/LBA1.jpg>).

they were both produced in Sanidha. On the other hand, Knapp and Cherry, (1994) put the Monochrome ware in Basing groups (different from the White Slip ware) among the Cyprus potteries. Moreover, they point out that raw materials of the Monochrome ware have diverse origin deriving from eastern Cyprus, Troodos Massif and the Karpas (Knapp and Cherry, 1994; see Russel, 1991).

In the previous studies almost every body indicate that the raw material of the White Slip ware are composed of mafic, ultramafic minerals deriving from Troodos ophiolite (Courtois 1970; Artzy et al. 1976; Courtois and Velde 1980; Todd and Hadjicosti 1991). Likewise, some studies suggest that the production center of White Slip ware

is in Sanidha which is located in southeast of Troodos Massif (Todd and Hadjicosti 1991; Todd and Pilides 1993; Renson et al. 2013). Some studies indicate multiple production sites for the White Slip ware (Henrickson and Blackman 1996, Gomez, 2012, Renson et al. 2013). According to Renson et al. (2013) raw material of the WS ware is the Troodos ophiolite, and Sanidha is not the only production center. If we take account the the geology of the surrounding areas of the Amuq Valley and Cyprus region, they have similar rock types such as ophiolitic complex and some volcanics. Thus, the Amuq region could be one of the production center of these ceramics.



Figure 1.2: Topographic map of study area and surrounding region, showing location of Tell Atchana and archaeological sites mentioned in the text.

1.2 The Scope Of The Study

In this study, we aimed to approach the characterization of the raw material of the MN and WS potteries. Owing to analitic analyses, we can determine the mineralogic/petrographic and geochemical features of these wares. In addition, we can assume the production technology and probable production center of the ceramics. In addition, we can understand their trade and the social role within Cyprus and Amuq region during the Late Bronze age. Moreover, this study will contribute to archaeometry literature on understanding of the White Slip I, White Slip II and especially the Monochrome wares.

As a summary, this thesis includes following steps,

- 1) Determination of the mineralogic/petrographic and geochemical characterization of the White Slip I, White Slip II and Monochrome wares.
- 2) Lightening the smiliarites and the differences between the White Slip and Monochrome wares and between White Slip I and White Slip II wares.
- 3) Geochemical comparison of clays of the Amuq region with these potteries in Tell Atchana.
- 4) Geochemical comparison of the White Slip ware belongs to Tell Atchana with previously collected White Slip wares from the other regions.
- 5) Geochemical comparison of the Monochrome ware belongs to Tell Atchana with previously collected the Monochrome wares from the other regions.
- 6) Identification of provenance of the WS and Monochrome wares foun in Alalakh excavation.



2. STUDY AREA AND GEOLOGY

In this section we will give information about geography and regional geology of the Amuq Valley and its surroundings.

2.1 The Geography and Geomorphology of the Amuq Valley

The Amuq Valley is located in Hatay village, southern part of Turkey (Figure 2.1). This Valley, which is a well-watered and fertile plain, is represented by pull apart basin resulted from regional tectonics (Bridgland et al., 2012). Size of the basin is about 40 km from north to south and 35 km from east to west and is about 80-100 meters above the sea level. Annual average precipitation of the Amuq Plain is about 1,124mm and mean yearly temperature is 18°C (Gün and Erdem, 2013).

The Plain is surrounded by mountains; The Amanos (Nur) Mountains in the western, The Kurt Mountain in the eastern and Akra (Keldağ) mountain in the south. The Amanos Mountain is the highest mountain having an elevation up to 2262 m in the north and 1750 m in the south and is represented by a large anticline (Oner, 2008). There are many small vallies and runnel system flowing to west to Mediterranean and to east to Amuq valley. Thus, the Amanos (Nur) Mountains has a well developed drainage network. The Kurt Mountain extends from south to north in the eastern part of the Amuq basin. This mountain show relatively low topography having an elevation up to 800 m and the slopes of the mountain overlooking the Amuq Valley show more eroded topography. The Akra (Keldağ) Mountain has steep slope through 2.5 km and has average elevation of 1740 m (Korkmaz et al., 2010).

Three major rivers draining in to the Amuq plain are the Orontes (Asi), the Afrin and Karasu (Figure 2.1). The Orontes river is the largest and most important river in the area. It arises from Lebanon and drain trough north to Turkey. When it arrives at the Amuq Plain, it turns to west and continue through Mediterranean Sea. The length of the River is 386 km. The Afrin River arises from the Kartal Mt. in Gaziantep, flows through the city Afrin in Syria and then drains from east, into the Amuq plain. The

third important river is the Karasu that arises from Kahramanmaraş region, flows to southwest through the Karasu Graben and drains into the Amuq plain. Another feature of the Amuq plain is the Lake of Antioch, which existed until 1960s; later lake is dried in an attempt to increase in agricultural efficiency (Wilkinson, 1970; Casana, 2003).

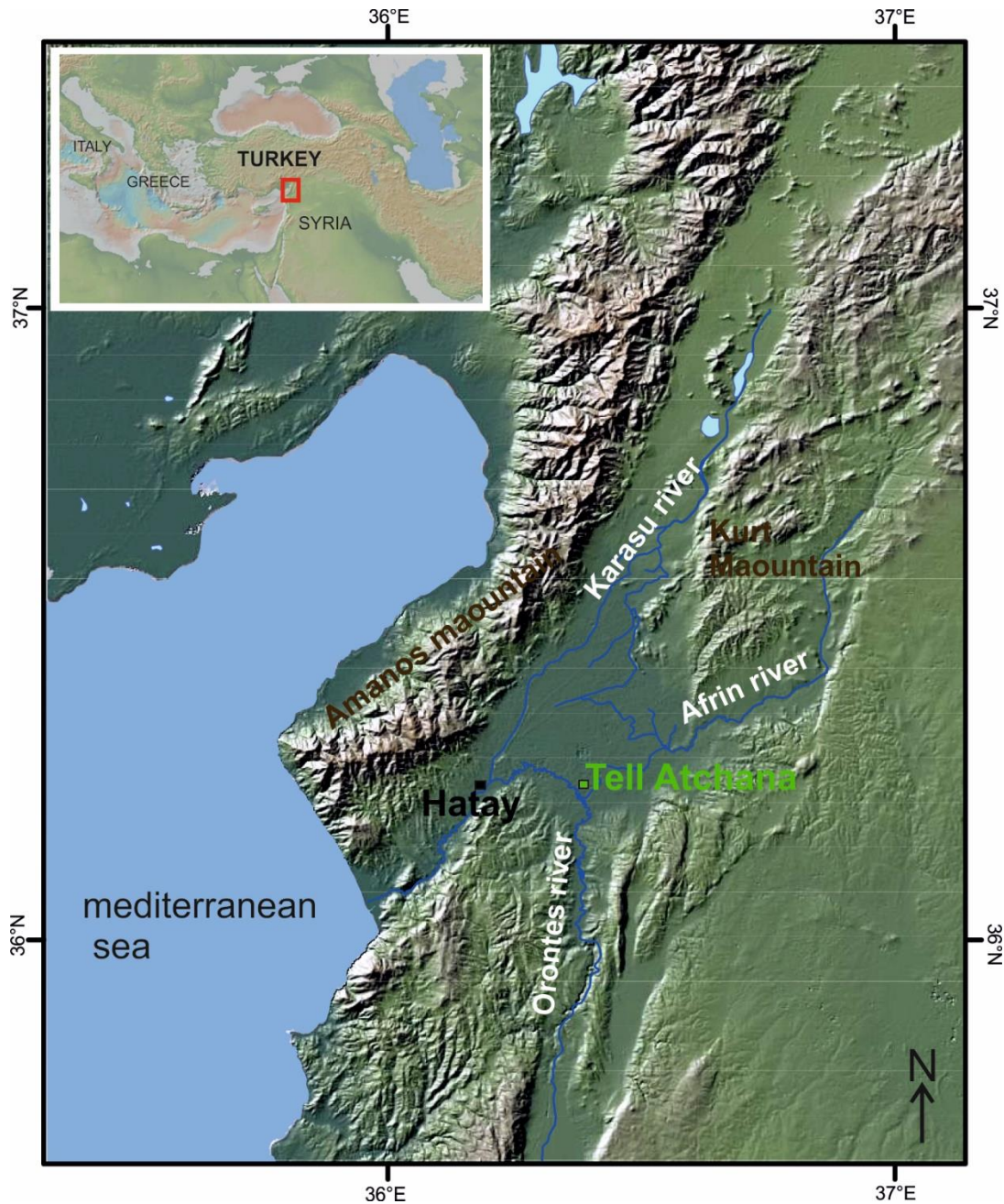


Figure 2.1: Inset map is the location map of the Amuq Valley. Map shows geomorphological features of the area and its vicinity. Main rivers are; Afrin, Orontes and Karasu. Mountains are; the Amanos and the Kurt.

2.2 Tectonic Setting of The Amuq Basin

The study area is located in south of Turkey near the triple junction of Arabian, Asian and African plate. During the Mesozoic time, African and Arabian plate migrated to northwest (to eastern Anatolia) with respect to Europe (Dercourt et al., 1993; Görür, 1998). From the Late Cretaceous to present, the N-S convergence of the African-Arabian plates have been continued. As a result of this convergence, continental collision occurred between the Arabian and Anatolian plates along the Bitlis-Zagros Suture Zone and southern branch of the neo-Thetis Ocean was closed in the late middle Miocene (Le Pichon & Angelier, 1979; McKenzie, 1972; Şengör, 1979).

This activity simply called as neo-tectonic interval of Anatolia (Şengör, 1979). During and after this northward movement and the continent-continent collision created new faults in the Anatolian platform, which have effect on the Amuq valley. The propagation of the Dead Sea Fault zone (DSF) and linkage of the Dead Sea Fault with the East Anatolian Fault (EAF) zone during Late Miocene mark the beginning of the neo-tectonic period in the area. The tectonic configuration of the faults and their movement vektors created a pull-apart basin where the Amuq Plain formed.

The DSFZ, between the Arabian and African plates, is one of the most typical intracontinental transforms in the world (Quennel, 1984; see Kavuzlu, 2006; Jackson and McKenzie 1984) (Figure 2.2). More than 1000 km in length, it runs from the Red Sea to the Bitlis belt at the Maraş triple junction. In its northern part, the recent fault system is confusedly traced. The Dead Sea fault allowing movement between Arab and African plates, after the opening of the Suez Gulf is reported to now be active in the Late Miocene (Lyberis et al., 1992). The studies on Dead Sea Fault Zone are determined that in the southern part of the fault has a maximum of 105-107 km left-lateral strike slip (Garfunkel and Freund, 1981; Quannel, 1959). It is thought that 60 km of this slip realized between Middle Miocene and Oligocene, other part of the slip has realized since early Miocene to present (Perinçek and Eren, 1990).

According to Gülen et al. (1978) the north-south striking Dead Sea Fault zone changed its direction to northeast-southwest in southeast of Beirut and separated segments caused Palmyra Kink. Later, Dead Sea Fault changed again its direction and move through the North and this segments are known Gharb Fault. After Gharb Fault DSF enters to the Amuq Valley from south. In the valley it changes its direction to northeast (Gülen et al, 1987).

Another system that controls the Amik Plain is East Anatolian Fault Zone (EAFZ) (Figure 2.2). The EAFZ formed during late Miocene-Pliocene interval (Arpat and Şaroğlu, 1971). It is a sinistral strike slip fault and has approximately 500 km long (Arpat and Şaroğlu, 1972; Gülen et al., 1987).

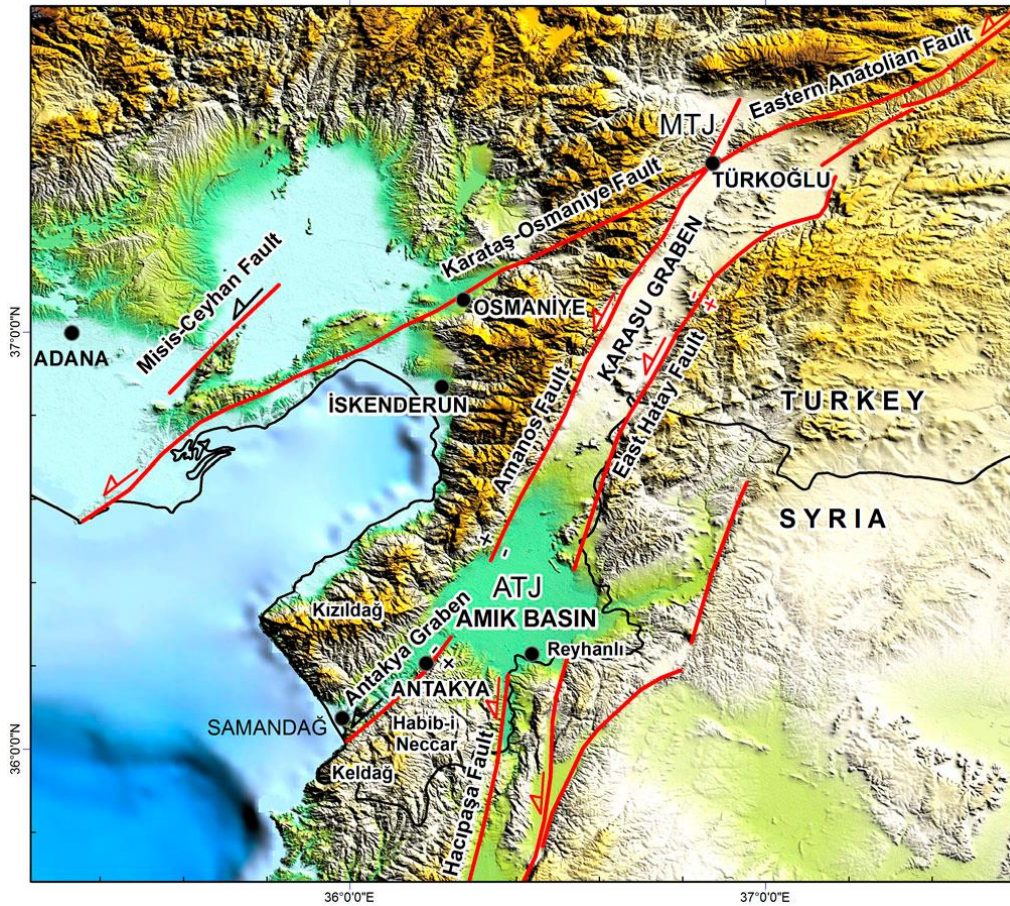


Figure 2.2: The Amuq (Amik) Basin and its surroundings. Map showing the major active faults and the morphotectonic units in the region. MTJ: Kahramanmaraş or Türkoğlu Triple Junction, ATJ: Amik Triple Junction (map after Tarı et al, 2013).

The East Anatolian Fault forms the southern border of Anatolian Block that moves through west (McKenzie, 1972). East Anatolian Fault Zone starts Karlıova where EAFZ intersects with North Anatolian Fault, lies through NE 66° from Karlıova (Rojay et. al., 2000). According to Şengör et al, (1985) the EAFZ traces a path from Karlıova among to Bingöl Valley, Hazar Lake, Pötürge, Çelikhan, Gölbaşı and Maraş.

Taking into all the tectonic background, there are two different views for the occurrence of Amuq Valley. Firstly, Gülen et. al. (1987) suggest that because segment of Gharb Fault, which is part of the Dead Sea Fault Zone, jump to left and create Amanos Fault. Therefore, Gülen et. al. (1987) indicate that Amuq pull-apart Basin occur because of these occurrence style of fault.

2.3 The Geology of the Amuq Valley

The Amuq Plain is located in south of Turkey in Hatay, reside southeastern corner of Anatolian Plate near the triple junction of Anatolian, Arabia and Africa. The geology of the Amuq valley and surrounding area is composed of basically three different rock groups based on tectonic zones. These are (1) Arabian platform, (2) Kızıldağ ophiolite and (3) Neo-autochthonous cover units. The rocks of these units are shown on simplified geological map of the study area in Figure 2.3. (modified after Işıker, 2002).

2.3.1 Arabian Platform

The rocks associations of the Arabian Platform were exposed to the south of the Amuq Valley and is represented mainly by different rock types dated from Cambrian to Upper Cretaceous. The Paleozoic rocks are mostly clastics with rare dolomites, ranging from Cambrian to Carboniferous (Dean and Krummenacher, 1961; Dean and Monod, 1985; Tekeli and Erendil, 1984). Mesozoic succession is composed of Triassic clastics at the base and passes upward into dolomites (Blumenthal, 1938; Atan, 1969; Tekeli and Erendil 1984). Although Triassic is represented by dolomites, Jurassic is mostly limestone (Tekeli and Erendil, 1984). The youngest rocks of the Arabian Platform dated is Cenomanian-Turonian in age (Dubertret, 1953). The uppermost part of the Platform is overlain by the olistostrome that contains limestone and ophiolitic blocks. The limestone blocks give Senonian ages (up to Campanian) (Atan, 1969; Aslaner, 1973; Tekeli and Erendil 1984).

2.3.2 Kızıldağ Ophiolite

The second unit is the Kızıldağ Ophiolitic succession covers about 720 km² area in İskenderun-Belen-Bedirge-Antakya-Çevlik area. It is striking southwest to northeast (Yıldız and Taptık, 2003). The Kızıldağ Ophiolitic succession crops out in the northwestern and western part of the Amuq Valley (Figure 2.3).

The Kızıldağ Ophiolite is remnant of the Neo-Tethys Ocean (Şengör and Yılmaz, 1981) and from bottom to top it contains mantle tectonites, ultramafic and mafic rocks, gabbros, sheeted dykes and pillow lavas (Tekeli et al., 1983; Erendil 1984; Dilek and Thy 1998; Bağcı et al., 2008; Dilek and Thy 2009). Rocks of the Kızıldağ Ophiolite is thrust over the Arabian Platform carbonates (Tekeli et al. 1983; Erendil 1984; Dilek and Thy 1998; Bağcı et al., 2008). The age of the Kızıldağ Ophiolite is given as ~95 Ma from zircons of the thronjomites dykes (Dilek and Thy 2009).

The mantle tectonites constitute the core of the ophiolite body. Tectonites are represented by serpantinized harzburgite and dunite and they constitute the amount of %70-80 of the complex. There are large blocks of the limestones in the base of the tectonites approximately 10-20 m thick and 20-40 m long (Tekeli and Erendil, 1986; Bağcı et al, 2008). They intruded by pegmatitic gabbro and pyroxenitic dikes. Other part of the ophiolite composed of gabbroic and ultramafic cumulates are characterized by dunite, wehrlite, olivine gabbro, olivine gabbro and gabbro and these cumulates contact between mantle rocks and plutonic sections (Dilek and Thy, 1998). Isotopic gabbros visible near the top of plutonic section, which contain gabbro, diorite, and quartz diorite. At the top of isotopic gabbro contain plagiogranites and sheeted dike complex (Dilek and Thy, 2009; Bağcı et al, 2008). Sheeted dykes has cross cutting relationships with isotropic gabbros. They crop out in southeastern and northwestern part of the Kızıldağ ophiolite and constitute approximately % 10 of the massif. The rock assemblages of the dyke complex compose of three stage dykes. The first generation and oldest are composed of basalt-dolerite; second generation dikes are composed of basaltic andesite, andesite and rare dasite. The third generation dikes are made up of high-Mg andesites or boninites (Dilek and Thy, 2009). The volcanic complex consists of pillow basalt, massif lavas and crosscutting dikes.

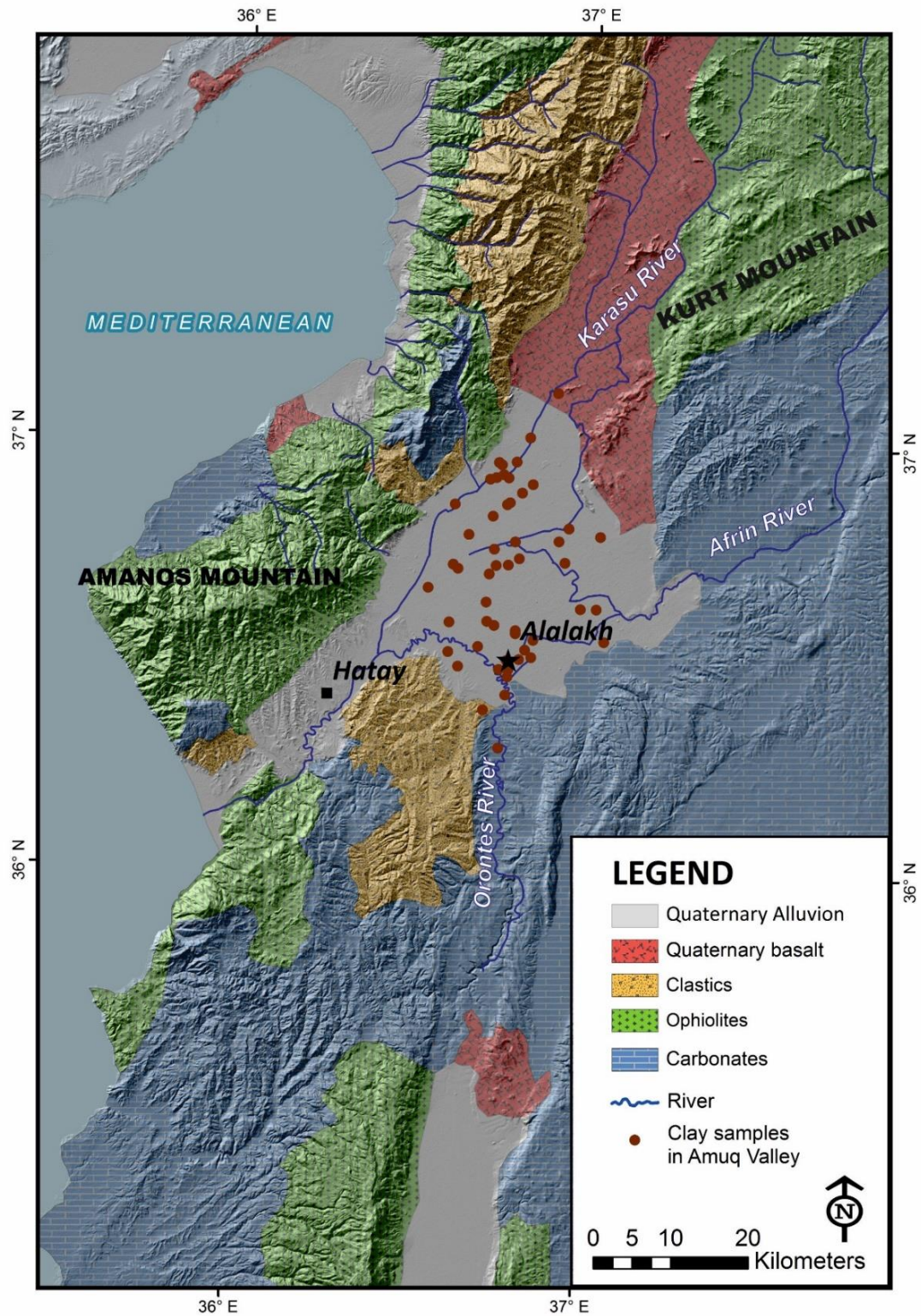


Figure 2.3: Simplified geological map of the study area (modified after Işikeret al., 2002).

2.3.3 Cover Units

The third and the last succession is the cover units. They developed from Late Cretaceous to recent. The cover starts with conglomerates containing ophiolite fragments and passes upward into sandy limestones (Upper Cretaceous). Then Paleocene aged fossiliferous limestone beds overlie. Eocene –lower Miocene interval is represented by open sea carbonates. Upper Miocene is represented by turbidites (Selçuk, 1981; Aslaner, 1973; Tekeli et al., 1983; Erendil 1984; Tekeli and Erendil, 1984). During the Pliocene mainly lacustrine sediments formed (Tolun and Pamir, 1975; Rojay et al., 2001). Pliocene lacustrine sediments are marls and sandstones. These sediments mainly expose NW and SE parts of the River Orontes that joins the Amuq valley there. Quaternary alkaline volcanics are also exposed in the valley (Parlak et al. 1998; Rojay et al., 2001; Alici et al., 2001). These volcanics generally flowed along the Karasu river (Rojay et al. 2001) and reached to NE of the Amuq valley. Rojay et al. (2001) claim that, according to the drills performed in the Amuq valley, such volcanics are also present beneath the recent sediments of the Amuq Lake. The K-Ar ages reveal that volcanics erupted between 2.2 and 0.05 Ma (Pleistocene) (Parlak et al., 1998; Rojay et al., 2001). The last deposits of the Amuq valley are old and recent alluviums, colluviums and slope deposits (Erol 1963; Öner, 2008).

3. ARCHAEOLOGY

3.1 Excavation of Tell Atchana

Braidwood and his team started the first archaeological surface exploration in Amuq Plain in 1933. Because of the geographical location, Amuq Plain was transitional point and buffer zone in sea and land trade for the Eastern Mediterranean. Braidwood wanted to reveal the traces of east-west culture. As a result of studies, he showed that The Plain was rich in archaeological aspect. Also, he determined 179 archaeological settlements in Amuq Plain and he specified the chronology of Amuq Valley (Braidwood, 1937).

Tell Atchana which the largest mid-late Bronze Age settlement, was designated as AS136 by Braidwood (Figure 3.1). Afterwards, board of trustee of British Museum and Oxford University appointed Sir Richard Woolley who excavated in Ur and Karkamış before, to investigate early period correlation of east-west cultural in 1936 (Akar and Yener, 2013). After he had information of about the region's geography and archaeology, he had started extensive excavation in the Ancient Alalakh in 1937 for two years. Because of World War II, excavation was suspended for a long time. After the War, Amuq Plain that was under the French mandate was given Turkey in 1945. Woolley had been continuing the excavation with the necessary permission between 1946 and 1949 (Woolley, 1955). His excavation focused on the northwestern part of the area and they dug out written document and some building such as; temples, palace, monumental buildings, several private houses and other structures (Woolley, 1955; Casana, 2009). These structure presented important knowledge for archaeology of near east and Anatolian to understand chronology of Bronze Age (Woolley, 1955; Akar and Yener, 2013). Woolley also defined continuous mid-late Bronze Age layer and 18 archaeological phases in The Alalakh. However, in studies last 50 years it was seen that Woolley's excavation was not sufficient because of using conventional methods in the period of excavations and inadequate achieving. Therefore, it was needed new study which uses scientific method and carries out systematically.

The excavations of Alalakh have begun again under the presidency of Prof. Dr. Aslihan Yener with the academic support of the Koç University since 2003 (Pamir, 2009). This new era excavation of the Ancient Alalakh was targeted to review Alalakh layers and to find the answer for the question about chronology and cross-cultural interaction that was associated with second millennium BC of the Near East (Yener and Akar, 2014). This excavation has been carried out in 36 square plan and 4 separate areas totally since 2003 (Figure 3.2 and 3.3). Aslihan Yener and hers team explain in excavation reports which publish every year in detail so it is known that there are supporting data closely associated Middle and Late Bronze age. It is seen to be city life in capital position because of revealed palace gates, palace tablets, other monumental palace building, temples, royal tombs (exp. Idrimi king of Alalakh) and necropolis. Mitanni style seals, Hittite palace ax, a verity of jewelry, time-variant city structure also show to be under different civilization. Moreover, it is understood that the production activities owing to local production of Nuzi Ware and ceramic kiln (Akar and Yener, 2013) which is very important because of good example the typology of industrial furnace in mid-Bronze age II.



Figure 3.0.1: Google Earth Image, showing locations of Tell Atchana/Alalakh and Orontes River.

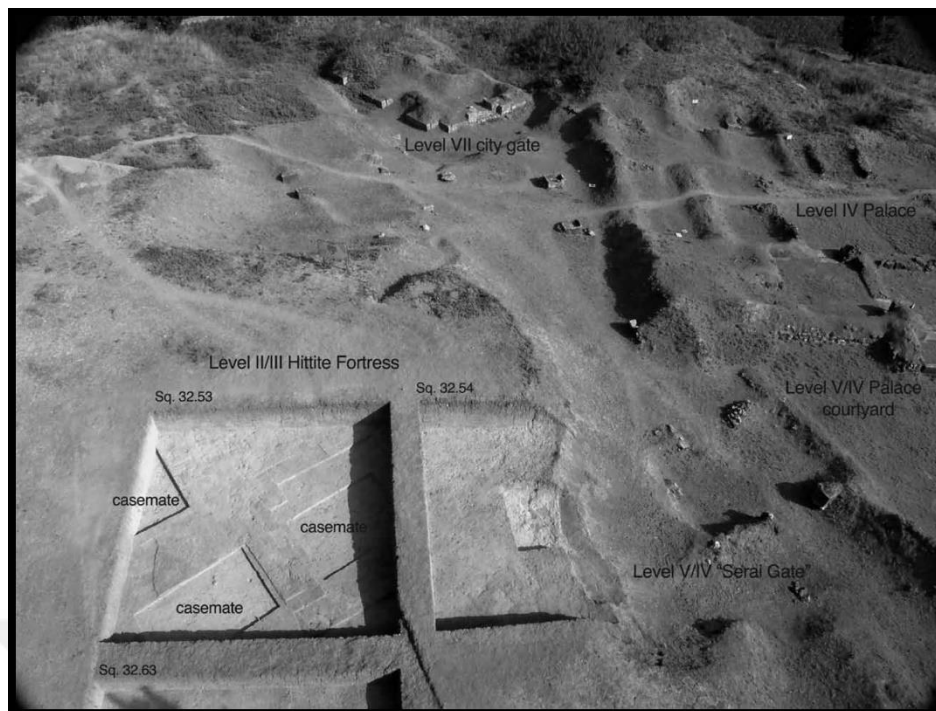


Figure 3.0.2: Excavation image of Tell Atchana, showing Area 1, Phase 2 (Yener, 2010, p:38).

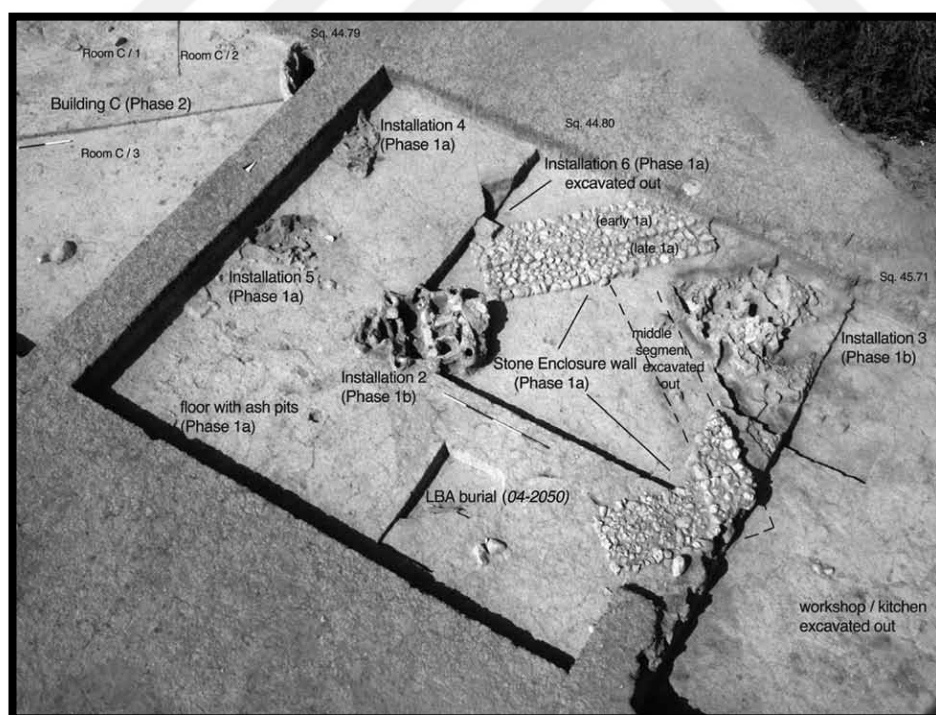


Figure 3.0.3: Excavation image of Tell Atchana, showing Area 2, Phase 1 (Yener, 2010, p:40).

3.2 History of Tell Atchana

In Amuq Valley, there was a settlement, which were depending on agriculture and stockbreeding during the Bronze Age. Most of these settlements became intense in down valley and lake shore. Also, there were some trade route in southern part of the Amuq Valley for second and first millennium BC (Figure 3.4). Since Bronze Age, these routes was opened to Mediterranean and Aegean by seaway and was very important from the point of trade (Braidwood, 1937; Yener, 2005). Therefore, this area connected these important cultural zones, which are Anatolian (Hittite and Hurrian), Eastern Mediterranean (Aegean and Cypriot), Levantine and Palestinian (Egyptian and Canaanite) and northern Syro-Mesopotamian (Mitanni and Syrian-Babylonian). 178 settlements was found in studies which has conducted in Amuq Basin and chronology of Amuq Valley was been created by Braidwood (Braidwood, 1937). In subsequent studies, which was conducted by Aslihan Yener, it was understood that there were approximately 400 settlement in Amuq Valley (Welton, 2011; Dodd et al. ., 2011, Yener, 2005).

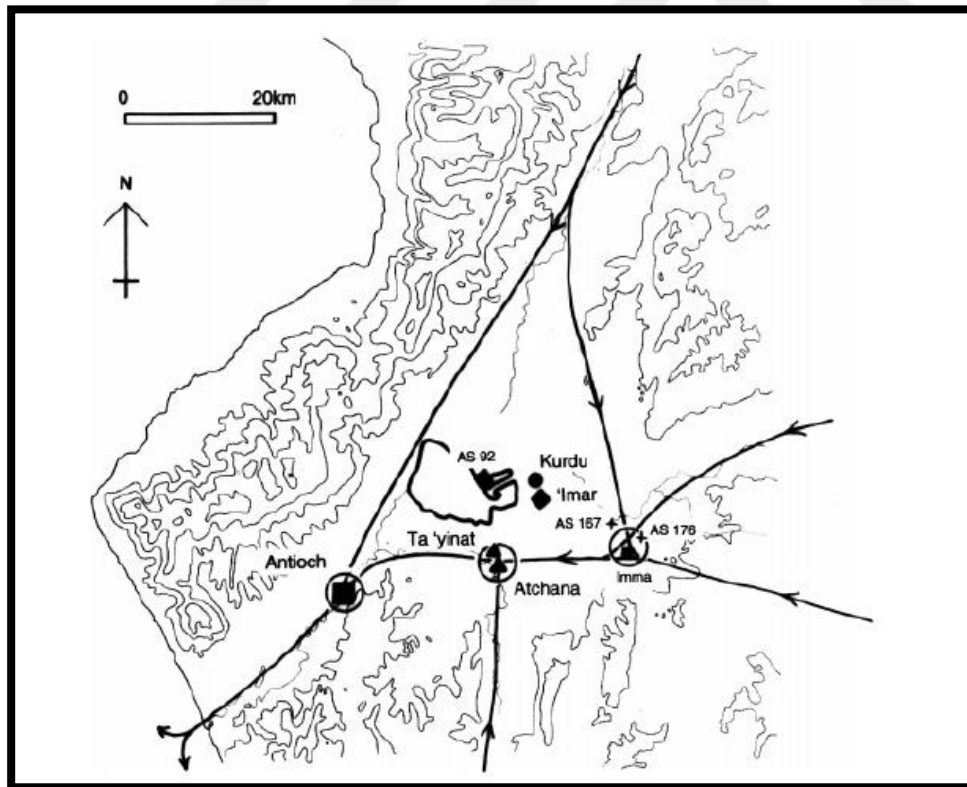


Figure 3.0.4: The Hypothetic roads main road and junction point of map that used between first and second millennium BC (Yener et al., 2000: figure 13).

The City of Ancient Alalakh is the biggest settlement in Amuq Valley. The Alalakh represents the middle and late bronze age and it is known that it was capital city of Mukish Kingdom. Although The Alalakh came under the rule of various Kingdoms, it had been continuing as the capital from 19th century BC to 12th century BC (Yener, 2005). Additionally, according to excavations in Alalakh, this time period coincide with Level VII-0. Firstly, between 19th century BC and 16th century BC (Level VII), the King of Alalakh had been vassal to the Yarimlim Dynasty of the Kingdom of Yamhad (Casana, 2009). Also, Haleb is the center of Kingdom Yamhad and this place had been administered by Abban who was brother of king of Alalakh (Casana, 2009). In the 19th centuries were the period of emergence of the city-state among the Alalakh. Therefore, it was seeming defense system, small scale industry, temple area and cemetery besides palace architecture in the Alalakh. Moreover, it is known that they was trading especially with Cyprus. According to mid-chronology of Level VII Palace, Hattuşili I who was the king of Hittite (Yener, 2014) destroyed this city between 1750 and 1650 during the conquest of northern Syria. Between the period of 1575-1460 BC is called dark age because there is not written instrument and there is no describing period of archeological resources. After the dark age, it was seen that the Alalakh was coming under the influence of Mitanni Kingdom from half of the 16th century BC to beginning of the 15th century BC. Because of this, Paratarna who was king of Mitanni was supporting to Idrimi king of Alalakh against threat of Hittite. Thanks to Mitanni, Idrimi was again won his authority. Changing political situation shows mainly differences in social and city structure. These are palace archives, tablets which regulate daily life and management and Mitanni style seals, cylinder and print (Yener and Akar, 2014). Moreover, enclosed courtyards separated by high walls and high-walled narrow Street also show the structure of the city has changed (Woolley, 1955; Yener, 2005; Naumann, 1991). A short time before 1400 BC, it is known to happened a second period of chaos in Alalakh. Although the exact reason is not known, it is thought that Tuthaliya I the king of Hittite had devastated to Alalakh City during the conquest of northern Syria (Yener and Akar, 2014; Woolley, 1955; Wiseman, 1953). After half of the 14th century BC, City of Alalakh had been under the Hittite domination (level III). By the way, it is defined that it had not been used city between 1400-1390 BC and then city had entered in the process of restoration four times.

Therefore, it is described that this short period is transitional stage from Mitanni to Hittite management (Yener and Akar, 2014). According to archaeological excavation in Alalakh, some structure relate to Hittite. These are Hittite castle structure, ceremonial broad-axe and some ware which are used in Hattusa. In addition, it was constructed new place where royal families had attended to and performed the ceremony. Rituals of people in Alalakh had been similar like Hittite. Their cemeteries also had been different than the previous time which they had been under the Mukish Kingdom (Yener and Akar, 2013b). All of them show that there had been domination of Hittite in the city. Influence of Hittite's culture continued to be seen, until the early 13th century BC (level II-I). And after that time city of Alalakh was abandoned and ended settlement in there (Level 0). The reason for the abandonment is, according to Hoffner, Muršili II taken away as a slave community of Mukish from Alalakh to Hattusa during the conquest of Syria (Hoffner, 2002). In addition, because of not found destruction and fire damage in city of Alalakh (Level 0), it was supported to abandonment (Yener and Akar, 2014).

3.3 Cypriot Pottery

Since the early second millennium BC, there was some changes, which has production style and ware type in terms of pottery in Cyprus. The new potteries which are seen together this new era, are White Slip Ware, Monochrome and Base Ring, Bichrome, Black slip ware etc. (Merrillees, 1971; Steel, 2010).

During the second millennium BC, Cyprus had a bearing on some socio-economic and demographic conversion because of increasing population and join in East Mediterranean trade networks (Steel, 2010). Because of socio-economic structure, people transmigrated different areas such as living in rural villages and coastal town. Small-scale industries was not enough to meet the requirement in town owing to increasing population (Rise, 1984). Therefore, Cypriot potters' strategies was applied like full-scale ceramic production rather than household production to satisfied the needs (Feinman et al., 1984; Steel, 2010). On the other hand, numbers of large-scale and household workshops increased with specialist potters in Cyprus. All of this impacted the diversification of potteries.

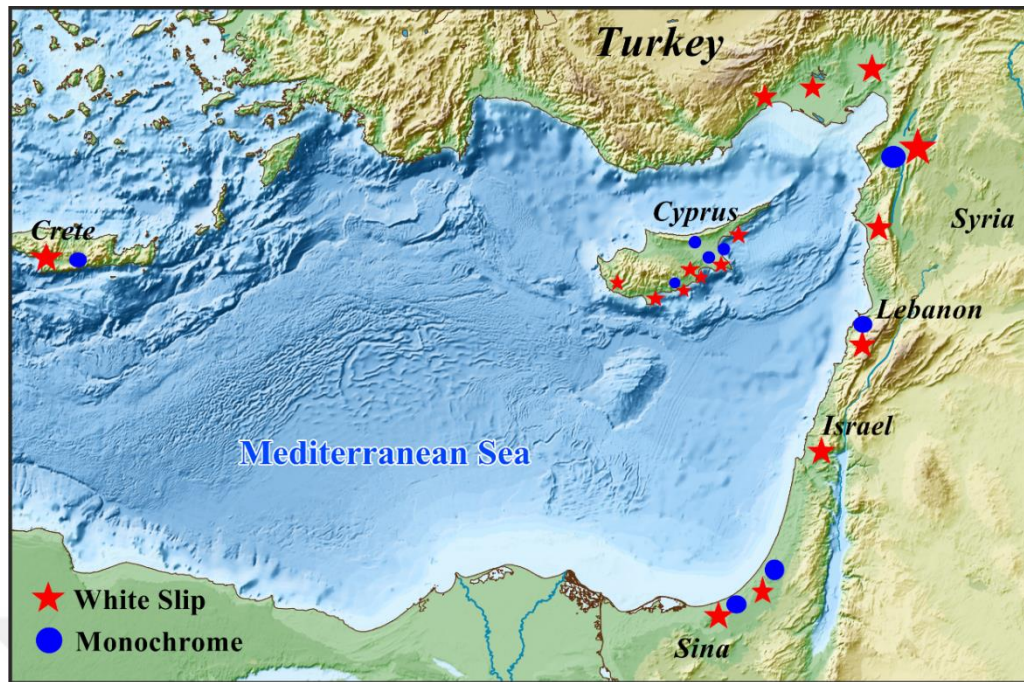


Figure 3.0.5: According to location, pottery distribution in Levant, Eastern Mediterranean and Anatolia.

3.3.1 White Slip Wares

White Slip Wares had very popular in Late Cypriot Age. This wares is known to represent famously among potteries of Late Bronze Age in Cyprus and to spread very large area such as Mediterranean, Levant and Anatolian sites (Casana, 2000). White Slip potteries, except the minor changes, had been used for a long time approximately 400 years (Karageorgis, 2001). The reason why very long prevalence and spread around the areas can be long-lived fabric and attractive decoration. According to Karageorgis, White Slip I and White Slip II, was used in funeral ceremony for drinking approximately in second millennium B.C. in Cyprus (2001). They were produced hand-made technics and were kiln-dried about 800-1000 °C high temperature. These wares have commonly wishbone handle and ware types are seen hemispherical bowl, jag, jaglet which has rounded based, flat based and ring based. In addition, White Slip I wares are characterized by a thick white slip and red and brown vertical and horizontal paint bands. A thick white slip and brown vertical and horizontal paint bands like WSI also characterize White Slip II wares which is known to late version of WSI, using of the single color, having less strict decoration, rhombuses shape bands separate WSII from WSI.



Figure 3.0.6: Photo of White Slip hemispherical bowl from Hatay Archaeology Museum Achieve (HAMA) (photo by Sinem Haciosmanoğlu).

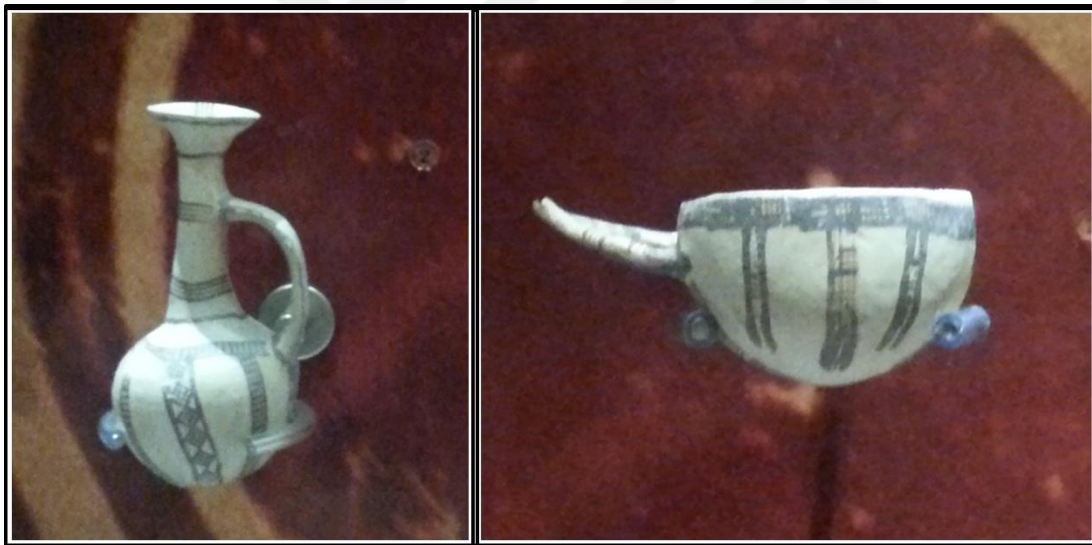


Figure 3.0.7: Photo of White Slip pottery from Hatay Archaeology Museum Achieve (HAMA), a: White Slip juglet, b: White Slip bowl (photo by Sinem Haciosmanoğlu)

3.3.2 Monochrome Ware

Monochrome ware, as well as White Slip wares, represent in group of Cyprus pottery. Monochrome wares is generally known to have without slip and without painting but some have single color painting (Yon, 1981; Todd and Hadjicosti, 1991), and consist of finer clayey (Todd and Hadjicosti, 1991). In addition, Monochrome ware has basic pottery features and produced hand-made techniques but these wares were utilitarian pottery in Late Bronze Era. This ware has confusing terminology, therefore it was subject of considerable discussion, with increasing recognition of its regional and chronological variations (by Ellen Hersher, Todd and Hadjicosti, 1991).



Figure 3.0.8: Representative image of Monochrome ware from Turner Bequest Excavation Enkomi, a: Monochrome jug, b: Monochrome bowl (British Museum Achieve) /web: <http://twoway.st/things/GAA54164,GAA54289>.



4. METHOD AND MATERIAL

4.1 Archaeometry

Archaeology mainly seek humanity's cultural history, cultural exchange and interrelation of each other and contains many different branches of science in itself such as; prehistoric archaeology, classic archaeology etc. Especially, studying prehistoric archaeology have difficulties because of no written sources. Understanding cultures and relations. Archaeologist try to understand prehistoric cultures and relations with using historical ruins such as; ancient tools, furniture, sculpture etc. Moreover, in order to resolve the uncertainty retrospective, archaeologist diversely can comment in his/her own perspective or can be influenced by some political perspective or theirs questions and answers can modify depending on time. Because of the reasons like this, new method that includes more precise results and repeatable feature in evaluation of the archaeological findings, was required. Therefore, new experimental methods, like archaeometry, are developed in order to contribute to the field of archaeology.

In its broadest sense, archaeometry is interdisciplinary method which collaborate with archaeology and science that mostly contains geology, chemistry, physic, material science, etc. According to Tite (1991); achievement in archaeological science depends on successful collaboration between archaeology and science and also between different sciences. There are many interdisciplinary applications in this field. For example; research study like remote sensing, geophysical survey techniques for burial archaeological sites and dating techniques like radiocarbon, K-Ar, thermoluminescence, dendrochronology etc. Another important technique is provenance studies which represent one of the most wide-ranging applications of science to archaeology (Tite, 1991). Moreover, Tite (1991) suggested that provenance studies have always been of major interest to archaeologists; because it provide clear information for trade and exchange on different cultural groups. And this utilizes to obtain directly evidence between cultural groups, so they can understand clearly

irrespective of whether a culture-historical, economic-ecological, processual or contextual approach has been predominant.

Scientific study of raw material and product (artifact) used hold important role as a key to understanding many aspects as mentioned above. Especially, pottery is one of the most frequently recovered artifacts, it provides many perspective of the development in ancient societies. Because potteries are fashioned material into unlimited variety of shape and size, using variety of techniques during preparing and production process and all of which leaves physical and chemical traces on vessel, (Skibo, 1999, 2013). Moreover, potteries can stay undeformed for a long time under the ground and they provide information for a wide-period because it has been used since Neolithic time. Therefore, pottery is the ideal artifact for archaeological investigations. According to Maggetti (2006), scientific analysis of these objects follow to answer some questions: (1) Where does the raw material come from? (2) Where was the object manufactured? (3) How was it manufactured (technique)? (4) What was its purpose (function)? (5) When was it manufactured (dating)?

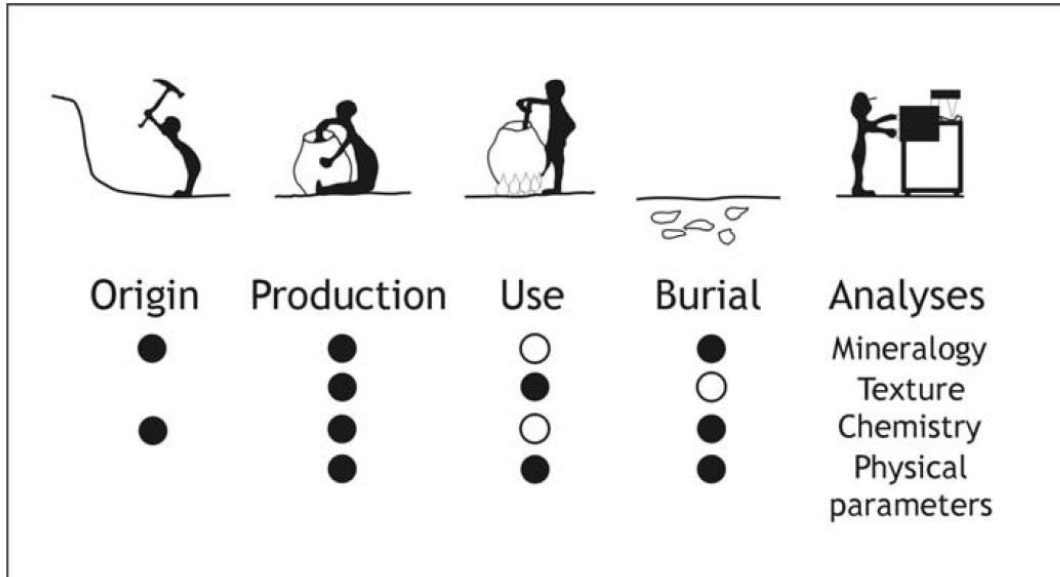


Figure 4.0.1: The five steps of the lifespan of a ceramic object and analytical methods and their significance in the investigation of the history of a sherd (Pinter, 2005; after Maggetti, 1994).

The ancient ceramics which are found in archaeological research has a long and complex lifespan. Maggetti's (2001, s.924) opinion on this issue: "any ceramic fragment, however insignificant it may appear, can be compared to a potential 'book', because it contains, as if stored on pages, a wealth of information about its history". To better understand this complex lifespan, it can be separated into five stage (Figure 4.1); (1) extraction of the clay from the pit, (2) manufacture of the object (processing of the clay, finishing, firing), (3) use, with the subsequent breakdown, (4) burial and (5) excavation, cleaning, treatment and analysis (Maggetti, 2001 : 924). Understanding of this stages by using analytic method can provide to obtain several information about characterization of the material, production center or production technology.

To reveal characteristics of a pottery, its compositional and structural properties such as elemental, mineralogical and textural features must be described. Elemental features are usually determined by geochemical methods like Neutron Activation Analysis, X-Ray Spectrometer or Inductively Couple Plasma Mass Spectroscopy etc. For mineralogical features, petrography under the polarizing microscope and X-Ray Diffraction method are mostly used. Textural features of the potteries are defined mainly with thin-sections petrography. A compilation of the studies related to characterization of the materials can be found in various studies such as Rice (1987), Riederer (1987), Velde and Drug (1999), Pollard (2007), Rapp (2009), Quin (2013). The help of the material characterization, the origin of the ceramics, techniques in production process, their function, area of usage, meaning of the object within the society can be lightened (Rehren, 2012). Moreover, it is also possible to reveal nature of the ceramic weather it is imitation or not by comparison them with the reference material.

Another aim of an archaeometric study is to identify the provenance area of the potteries, which means geographical location of the raw clay used for the producing of the vessels. For this purpose, it is required to know geologic features of source area, which is responsible for the clay deposits' mineralogy and geochemistry. Comparing clay sources with raw material of the potteries will lead provenance study in archaeometry. Especially, to know geology, geomorphology, drainage pattern and basin of the study area provide valuable information to gain for effective provenance identification (Pinter, 2005). However, only comparison of the raw material of the pottery with material from the potential source area may be not sufficient to determine

the provenance, so any reference material which was known to be local production in this archaeology site is required (Maggetti, 2001). Beside chemical analysis like XRF, ICP-MS, and NAA and petrographic thin-sections analysis, recent chemical methods, especially radiogenic isotopes (exp. Sr and Pb) are increasingly used to identify provenance (Li et. al., 2005, Pinter, 2005, Carter et. al., 2011, Makarona et. al., 2012; Renson et. al., 2013, Kibaroglu and Hartmann, 2015).

Production techniques is another important issue for the archaeometric study. It can give an opinion about all process of ceramic production like clay preparation process (grinding, mixing, screening), forming techniques (handmade or wheel made), firing technique (bonfire or pit), firing temperature (Velde and Drug, 1999). When information about manufacture techniques is obtained, it explains not only ancient technology but also human behavior, social and cultural information.

4.2 Analytic Methods

The first step in the analyses was petrographic investigations and classification of the sherds. With the petrographic analyses, it was aimed to determine the mineralogical features of the raw clay material and to gain valuable information for effective provenance identification. The second step, to understand major and minor element concentrations in the raw clay material of the ceramics, it was used X-ray Fluorescence and Inductively Couple Plasma Mass Spectrometer analytic techniques. Especially, XRF and ICP-MS analysis are required because all comparative data, which were collected from previous studies, have chemical analyzes (Appendix 1).

4.2.1. Petrography

A total amount of 48 sherds were selected for petrographic investigation from the Alalakh excavation including three ceramic types; White Slip I (4), White Slip II (26) and Monochrome (18) wares. Petrography is an important technique which allows material identification, grouping specimens according to microscopic features, identifying possible geological source of the raw materials, reconstructing production techniques, technological changes and variation over time and also space and choice strategy of the raw materials (Peterson and Betancourt, 2009; Reedy, 2008; Riederer, 2004).

For the analysis 48 thin-sections were prepared by standard techniques in Faculty of Mines thin-section laboratory in Istanbul Technical University. Ceramic samples were cut perpendicularly to the surface of the vessel by diamond saw and the core of the sample was crushed using an agate pestle and mortar until the core material are thinned out to 0,03mm. After that, thin-sections are put on glass slide and are covered by bonding substance like epoxy. Petrographic features of the thin-sections were investigated using a Leica polarizing microscope to determine the coarse minerals and rock fragments (i.e., inclusions), matrix, pores and textural features. The percentage of the inclusions, grog and pores were estimated using the comparison chart of Rice (1987) and also mineral size and distribution were estimated using nomenclature of Riederer (2004).

4.2.2. XRF

To determine major element concentration of the sherds (and also some trace elements), all potsherds (White Slip I, White Slip II, Monochrome) were analyzed using a Bruker S8 Tiger wavelength dispersive X-Ray Fluorescence Spectrometer (WDXRF) at the Department of Geology Engineering, Istanbul Technical University. For the preparing process, the internal and external surface of the all sherds are removed using diamond coated saw to eliminate contamination (Figure 4.2) (Wilson, 1978; Schwedt et. al., 2004). After this, the samples are grounded by agate mortar to reduce them under powder size (<50 micron) (Figure 4.3). Pottery powders are dried at a constant temperature of the 100°C for 24h in oven. A total of 0,5 ($\pm$ 0,003) g powder and 8 g flux (2,72 lithium metaborate and 5,28 lithium tetraborate) are mixed and fused at 1100 °C into fusion machine to obtain homogeneous glass disk (Figure 4.4 and 4.5). For the evaluation of the major element results, the computer program the Quantexpress and trace element result, the Geoquant are used. Loss on ignition (LOI), equivalent with the loss of weight, occurring during the ignition results from the reactions of H₂O and Fe^{2+/3+} conversions. LOI is calculated after heating the samples to 1000°C for one hour.



Figure 4.0.2: Image of sample preparation process. Contaminations were removed from internal and external surface of the pottery sherds using diamond coated abrader.

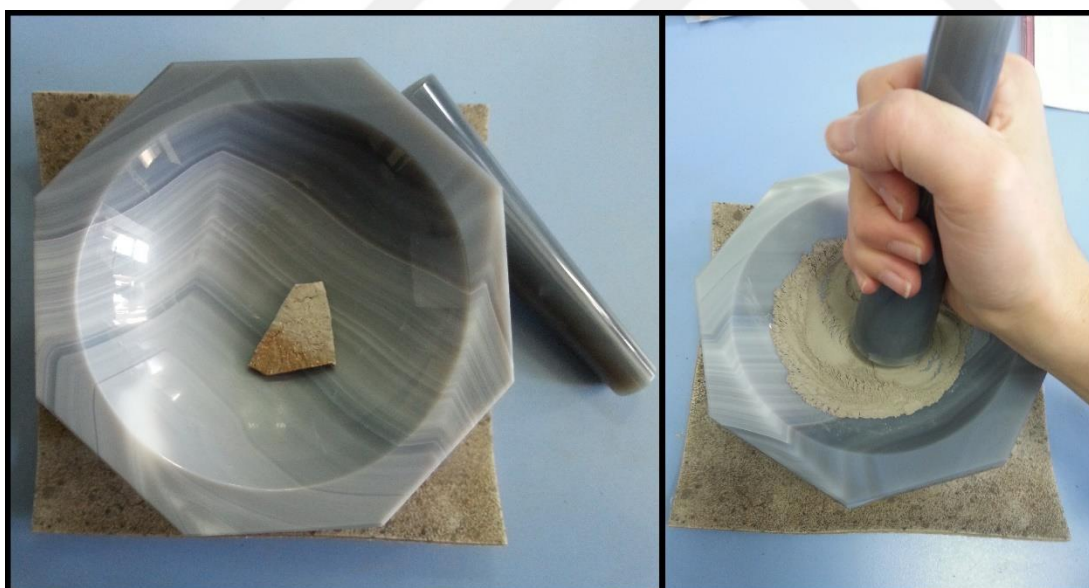


Figure 4.0.3: Images of sample preparation processes. a: Cleaned pottery sherds and agate mortar, b: grinding process by using agate mortar.



Figure 4.0.4: Fusion machine and glass disk preparation process.



Figure 4.0.5: Pictures of the sample preparation process. Homogeneous glass disks are prepared by using fusion machine.

4.2.3. ICP-MS

In order to measure trace and REE element compositions, ICP-MS technic was applied on 56 samples containing White Slip I, White Slip II and Monochrome wares. All samples analyzed using a Perkin Elmer Elan 6100 DRC inductively coupled plasma mass spectrometer at Department of Geology Engineering - Geochemistry Laboratory in Istanbul Technical University. We used 0,1g ($\pm$ 0,001) ceramic powder and acid mixture (2ml HNO and 2ml HF) for each sample. After preparing the samples, result was obtained from the Perkin Elmer ELAN 6100 DRC fitted with an automatic sampler in laboratory and they were calibrated according to Merck Multi-element ICP-MS calibration Standard 2 and Standard 3.



4.3 Material and Sampling

Ceramic samples, the White Slip I, White Slip II, and the Monochrome wares, which are known to be Cypriot ceramics, were selected for sampling by archaeologist studying at Tell Atchana/The ancient Alalakh in the Amuq Plain (Figure 4.5, see appendix 2).

- The White Slip I ware = 6 sherds
- The White Slip II ware = 30 sherds
- The Monochrome ware = 20 sherds

4.3.1. The White Slip I Ware

In this study, it was taken White Slip I sherds from excavation in Tell Atchana/ The Ancient Alalakh that have been conducting by Aslihan Yener. WSI sherds was found in excavation Area 1 (phase-2) and Area 2 (surface, phase 2) and these sherds was identified by Ekin Kozal. According to Kozal, these all WSI were are part of body of the bowls. Exterior decoration of sherds have parallel and wavy lines and characterized by in brown-black paint on typical cream-colored slip. Exterior fabric colors seem to diversity such as; brown, red-brown (2,5 YR 4/4, 4/6, 4/8), dark brown and gray (2004).

4.3.2. The White Slip II Ware

Second group, White Slip II ware is largest group of Cypriot pottery in excavation was found in Area 1 (Surface), Area 2 (Surface and Phase 1), Area 3 (Phase 2). In this study, we have 30 sherds of WSII, which refers to excavation Level VI-II (Bergoffen, 2005), was recognized by Ekin Kozal. According to Kozal, fabric of wares is gray (5 Y 5/3), brown (2,5 YR 4/4, 5 YR 3/4, 4/4; 7,5 YR 4/6, 4/8), red-brown (2,5 YR 3/6, 4/4, 4/6, 4/8, 5/6; 5 YR 3/6), red-brown or brown with a gray core. Slip color of interior and exterior of vessels is cream-colored slip and some of including mica has grayish on interior of vessel. WSII wares has brown-black paint on the outside and it is known that the most common motif is ladder pattern, as well as hook chain pattern is seen rarely on vessels (2004-2010).

4.3.3. The Monochrome Ware

Third group is Monochrome sherds was found in Area 1 (phase 1), Area 2 (surface, phase 1 and phase 2) and was identified by Ekin Kozal. Kozal claims that all fragments are different part of bowl such as; rim, handle, base and body. The most common fabric is reddish-brown (2,5 YR 4/6, 5/6, 5/8) and also is rarely seen gray, brown (7,5 YR 3/4) and light brown (2,5 Y 6/6). Slip of wares is red, brown and black (2004).

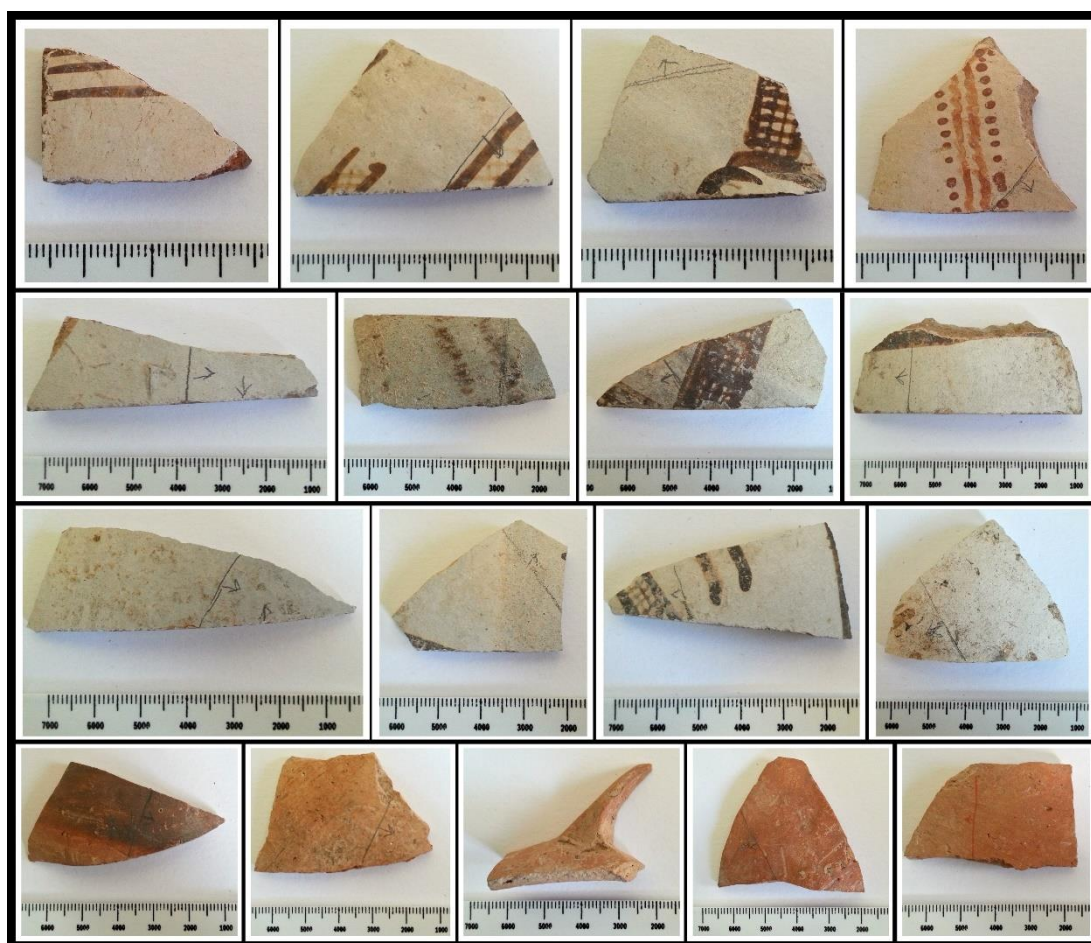


Figure 4.0.6: Pictures of White Slip I, White Slip II and Monochrome ware from Tell Atchana. (for all pictures and detail see appendix 2).

4.4 Data Compilation

In order to comparison sample with potteries, which was collected from previous study, are summarized below (Figure 4.6 and 4.7) (For the detail, see appendix 1).

First data source was taken from online data source of Lawrence Berkeley National Laboratory (LBNL) archaeometry achieves. This database includes mainly archaeological ceramic specimens from Cyprus and their elemental abundance (vol.2, July, 2014). They were created at the University of Missouri Research Reactor Archaeometry Laboratory under the direction of Matthew T. Boulanger. Thanks to this study, we reached the analytic data of total 26 White Slip I sample from Palaepaphos (n=20), Morphou (n=6) and total 70 White Slip sample from Enkomi (n=16), Ayios Jakavos (n= 20), Larnaca (n=20), Milia (n=15) and 14 Monochrome sample from Kalapsidha. For the detail of the samples, see appendix 1.

Second data source was taken from Provenience Studies and Bronze Age Cyprus achieve, which was prepared by Knapp and Cheery. They collected many Cyprus ceramic analytic data from the various laboratory until 1994. Thanks to this study, I use 30 White Slip sample from Cyprus and Israel. Cyprus sites are Ambelia (n=3), Beth Shan (n=5) and Idalion (n=2) whereas Israel sites are Tell Gezer (n=2), Tell Akko (n=17). Moreover, these data provide us chemical data of Monochrome samples from Phlamoudhi-1 (n=3), Phlamoudhi-2 (n=3) in Cyprus and from Tyre (n=1) in Lebanon.

Other previous study which made by Renson et al. (2013), provide us chemical data of White Slip samples. These samples represent three different site, Sanidha (n=8), Hala Sultan Tekke (n=18) from Cyprus and Minet El-Beidha (n=5) from Syria.

Another source data was taken from study which was made by Tomlinson et al. (2010). According to this study, they give chemical result of White Slip samples (n=29) which was found in Kommos, Crete Island.

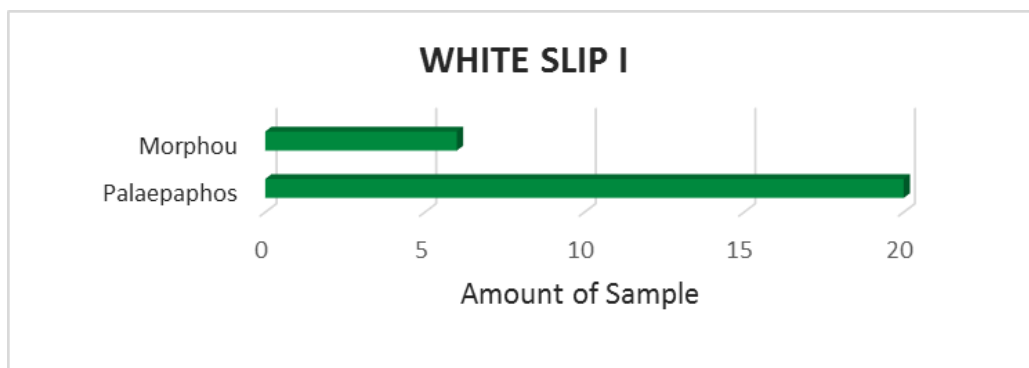


Figure 4.0.7: Bar chart of White Slip I ware showing its sample locations and amounts (data from previous study).

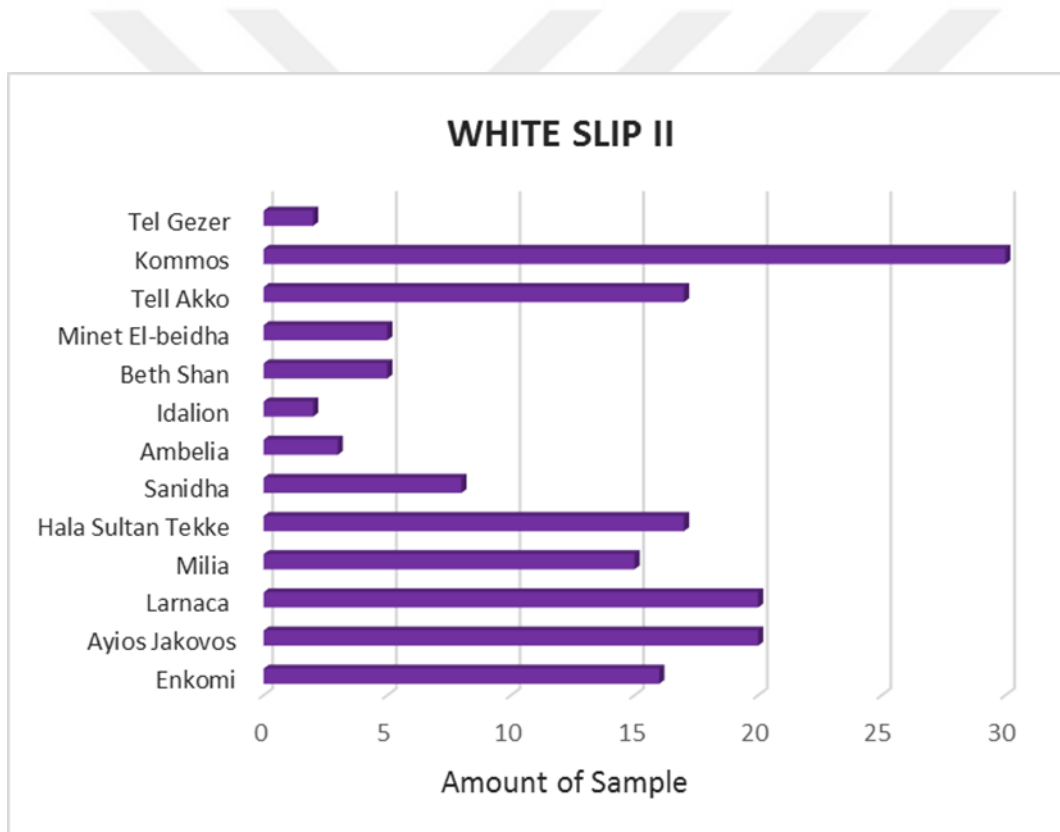


Figure 4.0.8: Bar chart of White Slip II ware showing its sample locations and amounts (data from previous study).

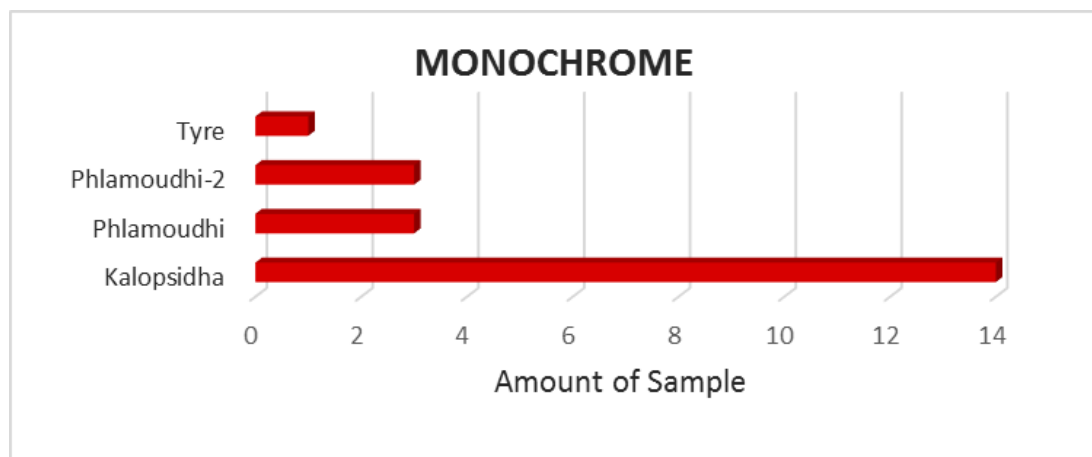


Figure 4.0.9: Bar chart of Monochrome ware showing its sample locations and amounts (data from previous study).

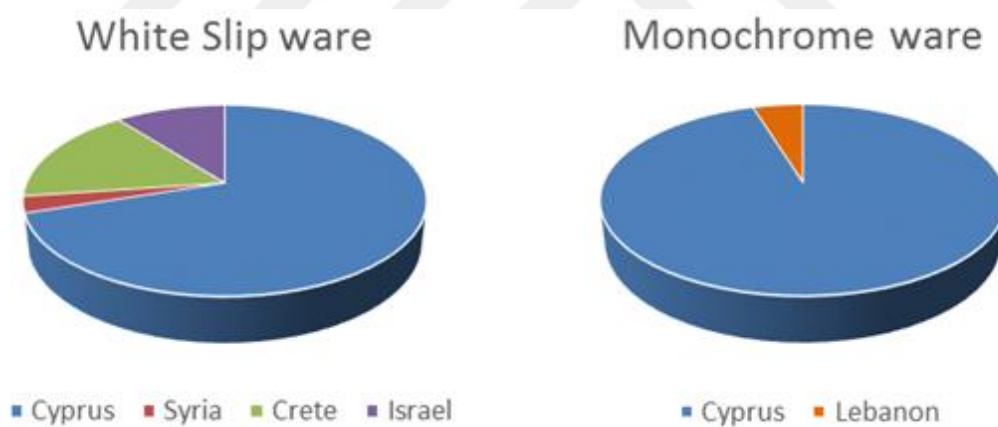


Figure 4.0.10: Pie charts of the White Slip and Monochrome ware, showing pottery distribution according to countries.



1. RESULTS

In this chapter results obtained from the pottery samples are provided below. First, petrographic thin-section analysis that are done by using petrographic microscope are represented. Secondly, I discuss the results of X-Ray Spectrometer (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS), respectively.

5.1 Petrographic Analysis

A total amount of 48 thin-sections of the potsherds, including the White Slip I (n= 4), White Slip II (n= 26), and Monochrome wares (n= 18) unearthed in Tell Atchana, were prepared for petrographic characterization from selected ceramic samples. I studied several characteristics of textural features and fabrics such as; grain size, grain size distribution, orientation of grains, main inclusions and the ratio of them, matrix and pore features. My results are summarized in Table 5.1.

5.1.1 White Slip I Ware

Based on petrographic observations, White Slip I sample was separated into two subgroups, WSI-A, WSI-B (see Table 5.1).

The first subgroup, WSI-A, is consist of 3 samples; WSI-1, WSI-4 and WSI-5 that have similar petrographic properties (Figure 5.1). They have a total amount of 25% temper material like grogs and mineral inclusions. Paste features of them are observed generally oriented and concordance with the matrix. Moreover, grain size distribution shows moderately sorted texture, changing from fine (0,1-0,33 mm)- small (0,33-1mm) to medium grain (1-3,33mm) (grain size classification by Riederer, 2004). Mainly mineral inclusions are quartz (7%), pyroxene (10%) and plagioclase (5%). All grains, except quartz, appear to be rounded and subhedral that contain diffuse grain boundary. Quartz minerals appear monocrystalline and their grain size change from fine to small. They have optical features such as low relief in plane and low interference color in cross polarized light and have normal, but some of them show

undulatory extinction. Feldspars, as other mineral inclusion, are mainly made of plagioclases, which have small grain size, rounded shape and polycrystalline structure. Moreover, plagioclases show polysynthetic twinning and low interference color in cross polarized light. Clinopyroxenes are unihedral, fine grained and well-sorted. They have diffuse boundaries. Optical features of the clinopyroxenes show medium relief and two set of cleavage in plane polarized light and high birefringent color, oblique extinction in cross polarized light. Moreover, near the mineral inclusions, there are some grog material that were added during clay preparing process. Grog material ranges from small to medium grain size, has about 1-2% matrix of the first subgroup of WSI-A, and is non-calcareous type. This subgroup mostly has two paste colors; grayish brown in core but reddish brown throughout rim. This probably is the result of firing process. The voids take up 25% of the paste and show several features. Most of them show elongated and tiny structures, whereas non-elongated forms have fine and small size. The other pores are secondary and probably occurred after the burning of organic components or alteration of minerals during the firing. Some voids are seen to be surrounded by Fe or Mg oxides, but also other Fe, Mg-rich minerals are dispersed in the matrix.

Second subgroup WSI-B, containing WSI-3, shows different petrographic properties. Although many features are similar to the WSI-A, like general grain distribution, orientation and void shape, there are some differences. These differences are, for example, matrix color, grain features and inclusion types. In contrary to the first group WSI-A, quartz fragments show polycrystalline structure, rounded shape and diffused boundary, whereas some of them still have monocrystalline form. Plagioclase content is approximately 10%, more than other groups. They range from small to medium grain size. Moreover, they show cumuloportrophic structure (Figure 5.2), most probably representing volcanic rock fragments (probably andesite). Furthermore, it is difficult to see some inclusions like pyroxene that has high birefringence color, and amount of Fe-rich minerals are more than the other group. Paste color of this subgroup WSI-B is more homogenous than WSI-A and is brownish gray.

Table 1.1: Petrographic result of selected ceramics from Tell Atchana showing petrographic groups, fabric and matrix features, inclusion types and pore rate.

Pottery	Sample	Fabric	Matrix	Inclusion	Pore
WSI-A	WSI-1, WSI-4, WSI-5	Oriented, concordant, moderately sorted, fine to medium grain size, rounded, subhedral, defuse boundary	non-calcerous clay, grayish brown (interior), reddish brown (outward)	pyroxenes(%10), quartzs(%7), plagioclase(%5), grog (%1-2)	25%
WSI-B	WSI-3	Oriented, concordant, moderately sorted, fine to medium grain size, rounded, subhedral, defuse boundary	non-calcerous clay, brownish gray	plagioclase(%10), quartz(%5), grog(% 1-2)	25%
WSII-A	WSII14, WSII-18, WSII-10, WSII-4, WSII-26	oriented and concordant, moderately sorted, fine to small grained, rounded, clear boundary	non-calcerous clay, grayish brown (interior), greyish (outward)	clinopyroxene and ortopyroxene (%8), hornblend (%7-8), biotite (%4), quartz (%6)	20%
WSII-B	WSII-1, WSII-6, WSII-12, WSII-23, WSII-19	sub-oriented and concordant, moderately sorted, fine to medium grained, rounded, defuse boundary	non-calcerous silty clay, homogenous color, greyish brown	hornblend (%10), orthopyroxene and clinopyroxene (%8-9), biotite (%6-7), quartz (%5-6) plagioclases (%2-3)	18%
WSII-C	WSII-2, WSII-17	oriented and concordant, fine to small grained, unhedral, clear boundary	non-calcerous clay, reddish brown color	pyroxenes (%10), hornblend (%10),quartz (% 8), biotite (%5-6)	20%
WSII-D	WSII-9, WSII-24	oriented, sorted, fine to small grained, very defuse boundary	brownish gray color and tiny brown color in the edge.	hornblend (%7-8), quartz (%5-6), biotites (%5), pyroxenes (%2), grog (%3)	25%
WSII-E	WSII- 3, WSII-8, WSII-15, WSII-16, WSII-20, WSII-21, WSII-11	not oriented and concordant, moderately sorted, fine to medium grain size, defuse boundary	non- calcerous silty clay, homogene color brownish gray	plagioclase (%10-15), quartz (% 6-8), hornblende (% 1-2), Fe-Mg rich opaque minerals (%6), grog (%5)	18%
MN	MN-1,2,3,4..20	oriented and concordant, well sorted, small to medium grained, moderately clear boundary	non-calcerous silty clay, red, brown and reddish brown	mudstone(%2), sandstone fragments (%1), quartz (%1-2)	15%

5.1.2 White Slip II Ware

Based on the petrographic study, my observations shows that the White Slip II wares can be divided into subgroups, WSII-A, WSII-B, WSII-C, WSII-D and WSII-E. Although there are no distinct differences between these subgroups, there are still some minor variations such as fabric features, inclusion types, ingredients and paste color etc. These subgroups are summarized in Table 5.1.

5.1.2.1 Subgroup – WSII-A

The first subgroup of the samples (Table 5.1) has total amount of 20-25% temper material, containing some mineral inclusions and grogs. Grain distribution are mostly moderately sorted and grain size changes from fine (0,1-0,33mm) to small (0,33-1mm) size (Riederer, 2004). Grains appear to be generally oriented and concordant with the matrix and most of them, especially mineral inclusions, have clear boundaries (Figure 5.3). The characteristic mineral inclusions of this group are pyroxenes (clinopyroxene and orthopyroxene) of about 8% by volume, amphibole (hornblende) of apx. 7-8% by volume, mica (biotite) of apx. 4-5% by volume and quartz of apx. 6% by volume. These inclusions are more easily describable than other subgroups. Grains of this subgroup, especially quartzes and orthopyroxenes, appear to be mostly rounded, but biotites and hornblendes are less rounded than others. Mafic mineral inclusions, pyroxenes, of this subgroup have in apx. 7-8% by volume and their grain size is mostly small (0,33-1mm, Riederer, 2004). Clinopyroxene grains are sub-hedral and sub-rounded, whereas orthopyroxenes appear mostly unhedral and rounded (Figure 5.4). Moreover, Clinopyroxenes show distinct optical features like high relief, medium pleochroism and fractures in plane polarized light and also high relief, oblique extinction and two set of cleavage in cross polarized light. Optical features of orthopyroxenes show high relief and low paleocroism in cross polarized light and have low birefringence color, cleavage and thick fractures in plane polarized light.

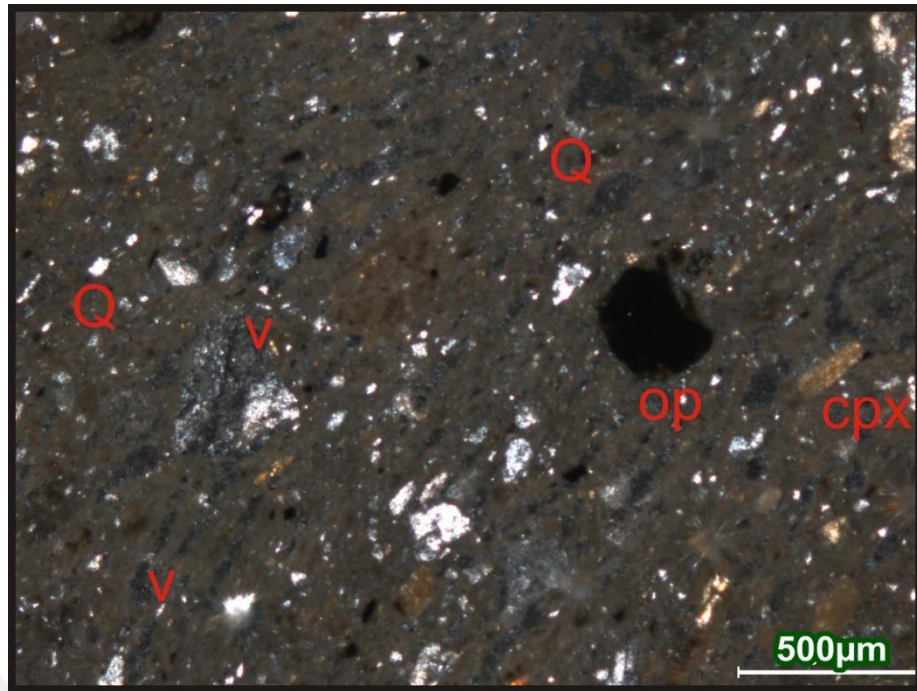


Figure 1.1: General petrographic thin-sections view of the White Slip I from polarizan microscope (sp: WSI-5). Q: quartz, cpx: clinopyroxene, op: opaque mineral, V: voids.

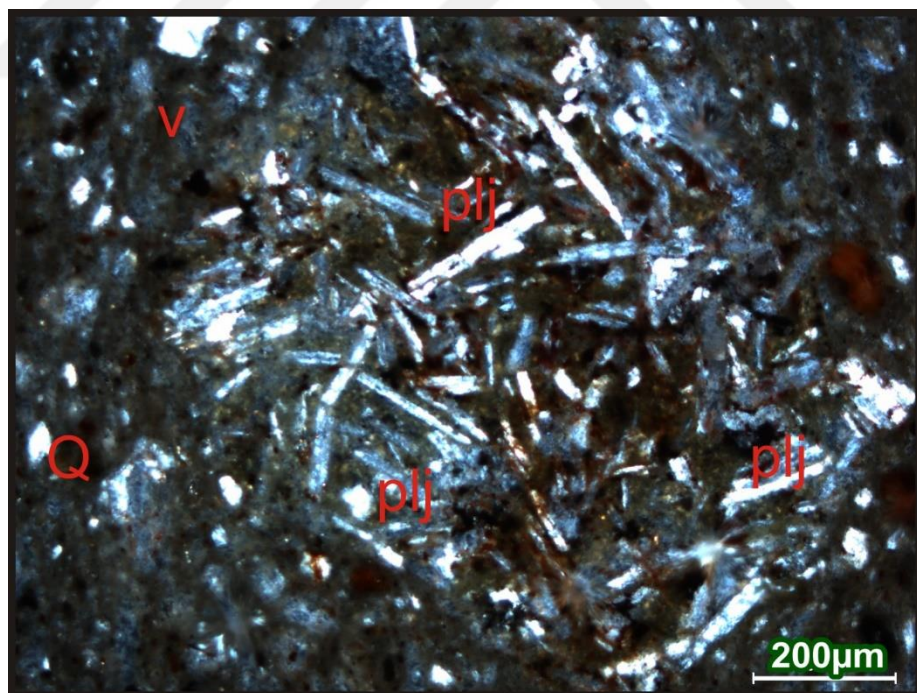


Figure 1.2: Photomicrograph of WS I from polarizan microscope (sp: WSI-3). It is seen cumuloportphric texture on andesitic rock fragment. Q: quartz, plj: plagioclase, v: voids.

Other mineral inclusions, hornblende (amphibole) are seen elongated, subrounded, and unhedral. Most of hornblende minerals have fine grain size and they cannot be observed clearly. However small size hornblendes (amphibole) show characteristic optical features like two set of cleavage, pleochroism, high birefringence color and oblique extinction. Moreover, there are volcanic mineral inclusions as quartz minerals, which are mostly monocrystalline and their grains are rounded but also partly show angular shapes. Grain size of the quartz inclusions range from fine (0,1-0,33mm) to small grain (0,33-1mm), and grain distribution are well-sorted. Optical aspects of low relief and low birefringence colors point out typical quartz characteristics. In this subgroup, there is also minor amount of plagioclase minerals. These grogs have small and medium grain size and form 1% of the paste.

Matrix shows non-calcareous formation and dominantly has clay rich paste, but partly contains some silty material. Additionally, paste color shows heterogenic color like brown color in the edge and greyish brown color in the core; instead of matrix has single clay type. Void types are similar to other subgroups and they are mostly elongated and have very small and little bit bigger size. Other ones, probably organic components or burned/altered minerals show irregular shapes, have bigger sizes, and these pores are also covered alongside by iron rich oxides.

5.1.2.2 Subgroup – WSII- B

The secondary petrographic group WSII-B contains five samples WSII-1, WSII-6, WSII-12, WSII-23, and WSII-19 (Table 5.1). This subgroup shows almost identical petrographic properties with WSII-A, WSII-C and WSII-D in terms of their matrix type and the same inclusions; however there also have distinct features, differing them from other groups. For example; their paste color appears greyish brown that is more homogenous than WSII-A, WSII-D and WSII-E. The matrix appears to have more silty-clay rich paste compared to WSI-A (Figure 5.3). Moreover, the amount of temper material, which is mainly made of inclusions, is higher than other groups, but shows similarities only to the WSII-C. Pyroxenes (orthopyroxene and clinopyroxene) are in apx. 8-9%, amphibole (hornblende) in apx. 10% by volume, mica (biotite) in apx. 6-7%, quartz in apx. 5-6% and feldspars (plagioclases) in apx. %2-3 in this group.

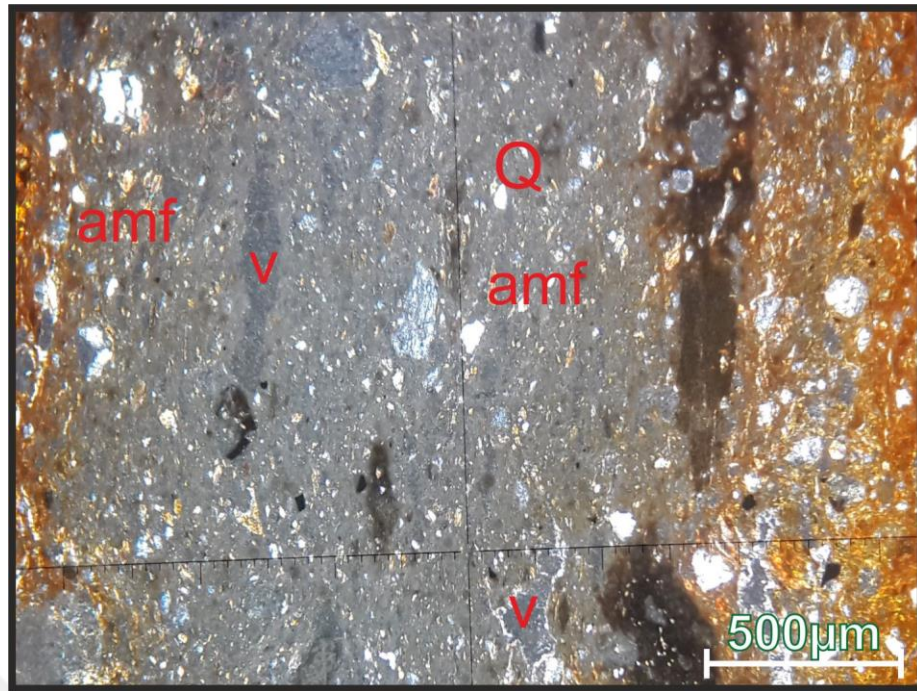


Figure 1.3: General petrographic thin-sections view of the subgroup 1 of White Slip II from polarizan microscope. Q: quartz, amf: amphibole (hornblende), v: void.

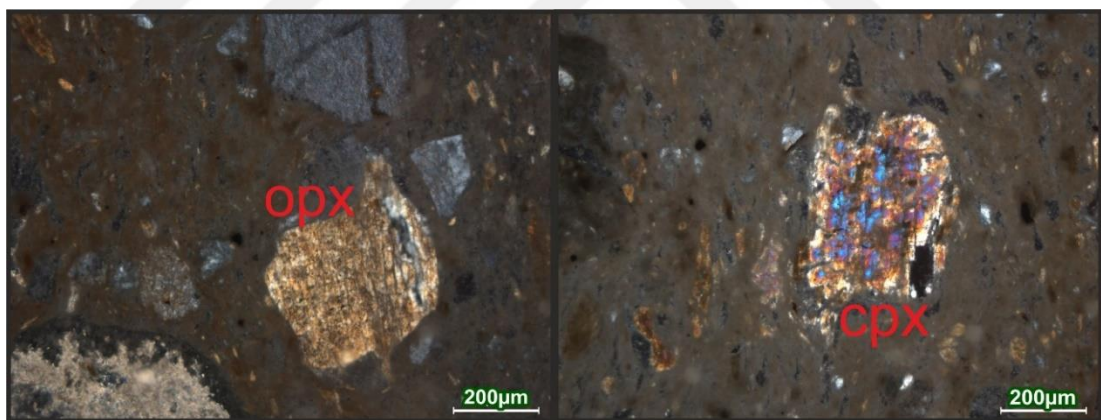


Figure 1.4: Photomicrograph of WS II from polarizan microscope (sp: WSII-26, WSII-4). It is seen clearly mineral inclusions opx: orthopyroxene and cpx: clinopyroxene.

Moreover, some of the orthopyroxenes appear medium grain size and some biotite and hornblende inclusions shows nearly medium grain size (Figure 5.4). The amount of small size quartz is more than WSII-A and WSII-C. Besides, temper of this subgroup appear oriented with matrix but orientation shows a single direction in half section, while has different direction in the other half. The reason is that samples can be part of the ceramic handle.

5.1.2.3 Subgroup – WSII-C

The tertiary subgroup of the White Slip II, WSII-C, contains two samples WSII-2 and WSII-17 (Table 5.1). Samples of this group mostly show the similar petrographic properties with the subgroup WSII-A and WSII-B. In comparison to subgroup WSII-A and WSII-B, WSII-C presents different properties such as the matrix color, grain size and the total amount of grains. For example, paste color of WSII-C is reddish brown. Mineral inclusions show a clear boundary, having unhedral and small grain size. Main mineral inclusions are pyroxenes in apx. 10%, hornblende (amphibole) in apx. 10%, biotites in apx. 5-6%, quartz in apx. 8% in the paste (Figure 5.6). The amount of mineral inclusions is very close to the WSII-B, but WSII-C have higher amount of fine grain size than the WSII-B (Figure 5.5). In addition to this, some clinopyroxenes show coarse (3,3-10mm) grain size (size classification by Riederer, 2004). Minor amount of rock fragments, ranging from small to medium size, are seen in this group. These rock fragments are composed of plagioclases (probably albite) and appear to have a clear mineral boundary.

5.1.2.4 Subgroup – WSII-D

Subgroup WSII-D contain two samples, WSII-9 and WSII-24 (Table 5.1). This group also shows similarities with subgroups WSII-A, WSII-B and WSII-C, but it has some different petrographic properties than others. For example; paste color of this group has two varieties, brownish gray color in the core and tiny brown color in the edge. Grain size distribution shows similar features with the subgroup WSII-A. When this subgroup is compared with other subgroups, grain distribution of the WSII-D appears to be more sorted and more oriented in its matrix and has mostly fine grain size material (Figure 5.7).

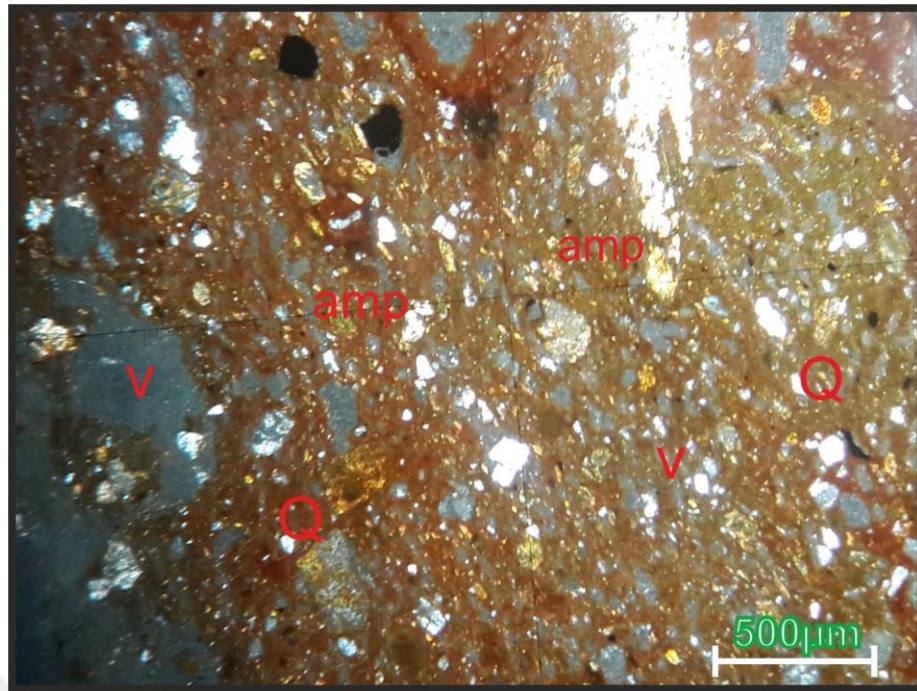


Figure 1.5: General petrographic thin-sections view of the subgroup 3 of White Slip II from polarized light microscope. Q: quartz, amp: amphibole, v: void.

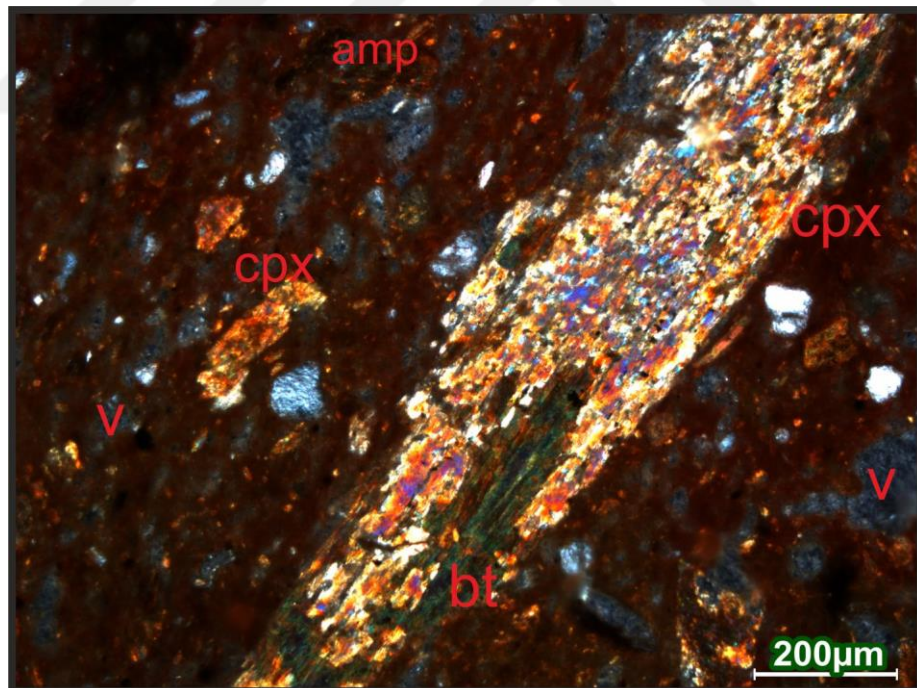


Figure 1.6: Photomicrograph of WS II from polarized microscope (sp: WSII-26, WSII-17). Clearly seen mineral inclusions; cpx: clinopyroxene, bt: biotite, amp: amphibole (hornblende) and v: void.

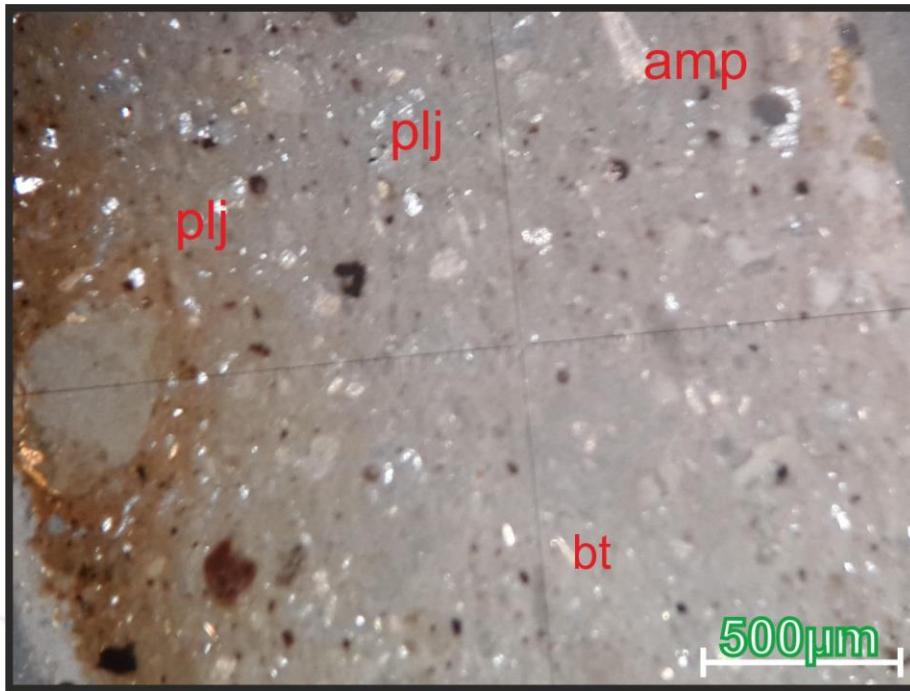


Figure 1.7: General petrographic thin-sections view of the subgroup 4 of White Slip II from polarizan microscope. amp: amphibole, plj: plagioclase, bt: biotite.

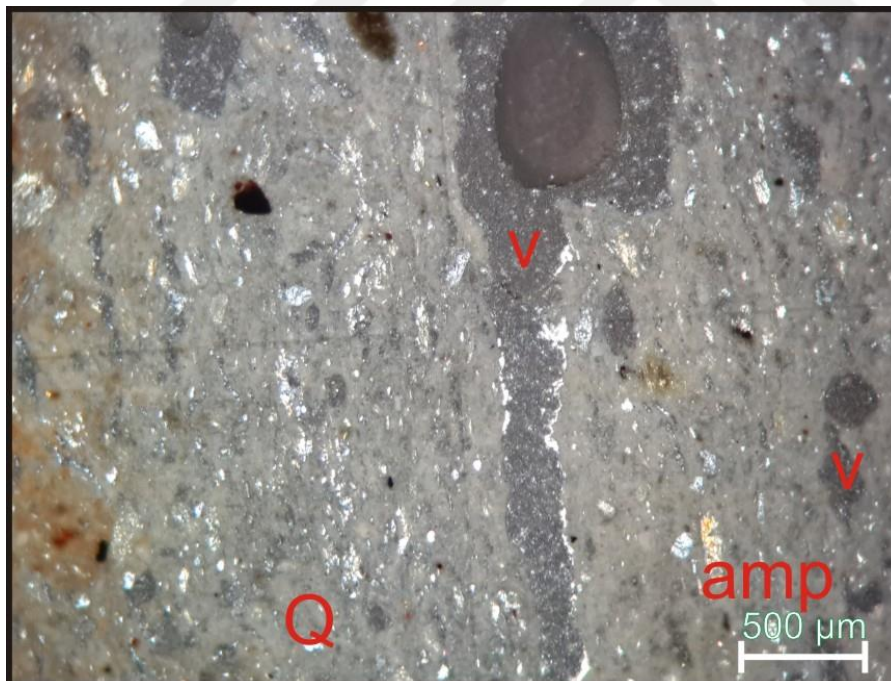


Figure 1.8: Photomicrograph of WS II from polarized light microscope (sp: WSII-9). Mineral inclusions; cpx: clinopyroxene, bt: biotite, amp: amphibole (hornblende) and v: void.

Mineral inclusions of this subgroup are similar to the other subgroups, but amounts of minerals show some differences especially in case of pyroxenes. The subgroup has 5-6% of quartz, 7-8% of amphiboles, 5% of biotites, 2% of pyroxenes, and 3% of grog material. Moreover, this group has very diffuse mineral boundaries and muddy matrix rather than others, so it is very hard to determine some minerals. Therefore, the total amount of some mineral inclusions, like pyroxenes, could not be identified correctly.

5.1.2.5 Subgroup – WSII-E

Subgroup WSII-E contains eight samples, WSII- 3, WSII-8, WSII-15, WSII-16, WSII-20, and WSII-21 (Table 5.1). Although, the four members of the subgroup, WSII-A, WSII-B, WSII-C and WSII-D, have similar petrographic properties, the subgroup WSII-E has clear differences than others (Figure 5.9). This subgroup WSII-E has a total amount of 30-35% temper material grogs and inclusions. Paste features of the WSII-E appear not to be oriented and some of grains are not concordant with the matrix. Grain size distribution is moderately sorted, changing from fine to medium grain size (Figure 5.9). Inclusions are mainly made of plagioclase in apx. 10-15%, quartz in apx. 6-8% and minor amount of biotite and hornblende in apx. 1-2%, and also Fe-Mg rich opaque minerals in apx. 6%. Additionally, there is a high amount of grog material, which is not clearly recognizable, in apx. 5%. Most of grain have very diffuse boundary. Plagioclase inclusions show two type of distribution, monocrystalline and polycrystalline. Monocrystalline plagioclases appear to have grain from fine to small sizes (Figure 5.10), whereas polycrystalline plagioclases are made of small to medium grain size. This polycrystalline plagioclases, which show cumulo porphric in texture, are rock fragments, most probably of andesitic rocks. They are mostly rounded and some of large-sized plagioclases have broken edges, which can be due to the grinding processes during the sample preparation. They also show characteristic optical properties like elongated shapes, low relief and low birefringence color and polysynthetic twinning. Monocrystalline quartz minerals, which have mostly fine grain size, sub-rounded shape and well-sorted distribution in the paste. Other mineral inclusions in small quantities are hardly recognizable, where I managed to identify some hornblende and biotite minerals. Matrix types of this subgroup represent non-calcareous silty clay matrix. In addition, paste color is homogenous-looking brownish gray.

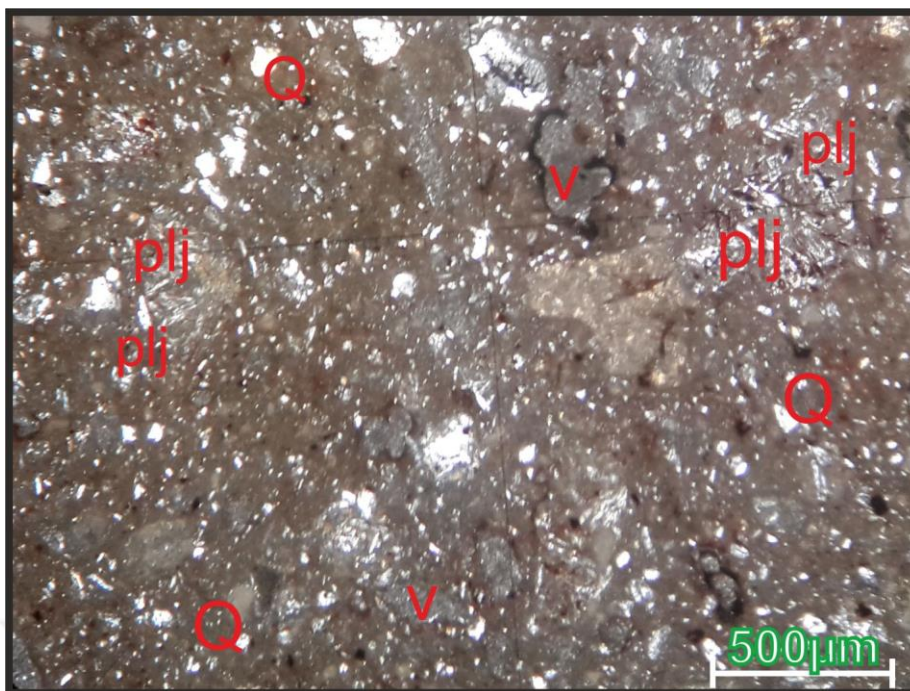


Figure 1.9: General petrographic thin-sections view of the subgroup 5 of White Slip II from polarized light microscope. Q: quartz, plj: plagioclase, v: void.

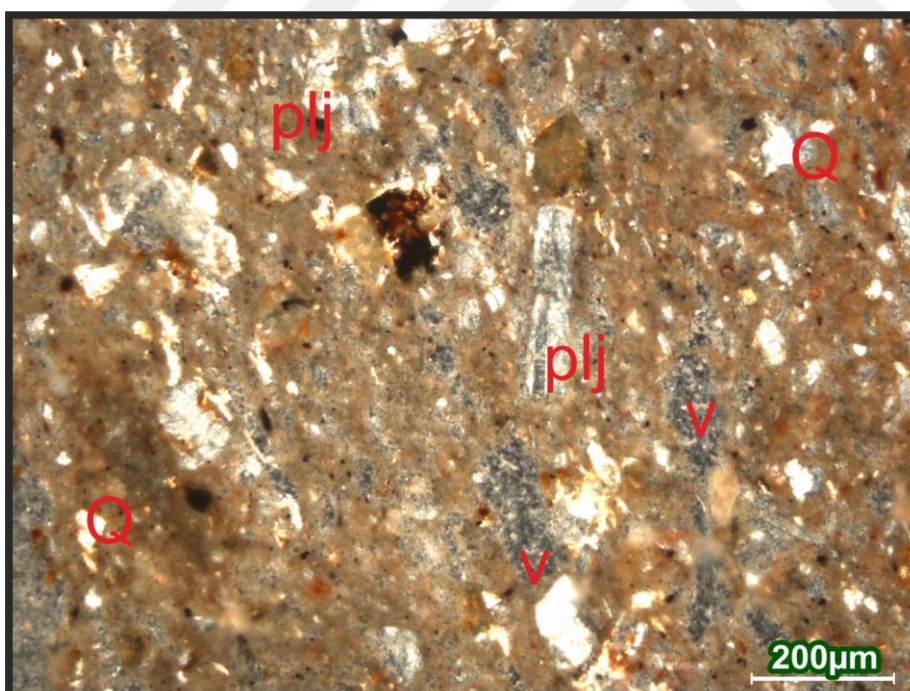


Figure 1.10: Photomicrograph of WS II from polarized light microscope (sp: WSII-15). It is seen altered fabric, non-defuse inclusion boundary and mineral inclusions; plj: plagioclase, Q: quartz and v: voids.

Void types are made of both very tiny elongated and small size shapeless pores in amount of about 15%. Other type of voids generally have irregular shapes that are covered by iron rich minerals, and changes from small to medium size. These voids probably related with burned organic component and/or altered minerals, because of the high temperature firing process.

According to the thin-sections analyses, White Slip II ware classified into five petrographic subgroup. The four of them (WSII-A, WSII-B, WSII-C, WSII-D) show very similar petrographic properties and there are only minor differences between them. On the other hand, the subgroup WSII-E shows differences than others and these are actually look like second group (WSI-B) of White Slip I ware because of containing high amount plagioclase inclusions.

5.1.3 Monochrome Ware

Monochrome ware have 18 thin-sections samples and they show similar petrographic properties (Table 5.1). Paste feature of sherds consists of red, reddish brown silty clay matrix, and mineral inclusions (pieces of mudstone -clay nodules-, pieces of sandstone, quartz, and Fe-rich opaque minerals) and voids (Figure 5.11). Mineral inclusions of the MON mainly have an average of 3-5% weight in the total amount, and they are made of 2% for mudstone, 1% for sandstone fragments, 1-2% quartz inclusions. Grain distributions are mostly well sorted and concordant with matrix. In pieces of mudstones, fragments appear to be well rounded and are surrounded by pores (Figure 5.12). Moreover, mudstone grains show fractures (Figure 5.12). According to Riederer's grain size classification, mudstones fragments has small grained and medium grain size (2004). The optical features of mudstone show high relief and reddish brown color in plane and cross polarized light. Another inclusion is made of sandstone fragments that are characterized by rounded grain and concordant with matrix (Figure 5.13). Grains show diffuse to clear boundary and grains are mostly medium sized (1-3.3mm). Optical features of sandstone fragments show high relief and low interference color on plane and cross polarized light. Quartz is another mineral inclusion, which is mostly characterized by fine (0,1-0,33mm) and small (0,33-1mm) grain size. Moreover, these quartz grains are well sorted, sub-rounded and have diffuse

boundary. Moreover, they appear monocrystalline and well distributed in paste. In plane and cross polarized light, quartz minerals are observed to have low interference color and low to medium relief.

As a whole, grain distribution of Monochrome ware is well sorted. All Monochrome ware shows same paste color, but there is a little variation, changing from brown, reddish brown to orange reddish brown, between samples. Monochrome ware also shows porosity of about 15-20% by volume. Some of them have big elongated and oriented structure. Other pores show fine grained size and well sorted structure. In addition, there are secondary pore structures, which are covered around grains. They may be formed during the firing through the shrinkage of the clay as water is released, and this condition creates pores around large temper material.

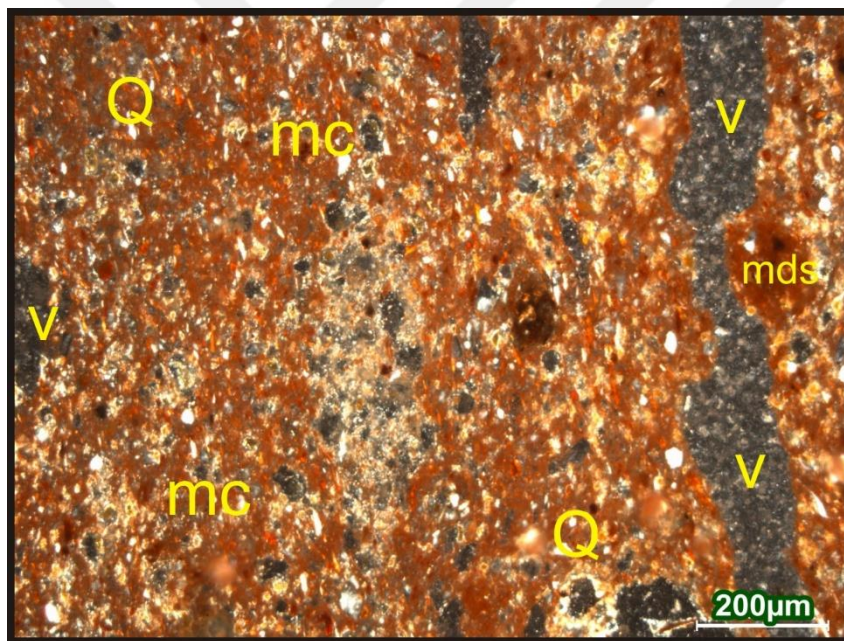


Figure 1.11: General petrographic thin-sections view of the Monochrome from polarizan microscope (sp: MN- 1). Q: quartz, mds: mudstone fragment, mc: white mica, v: void (pores)

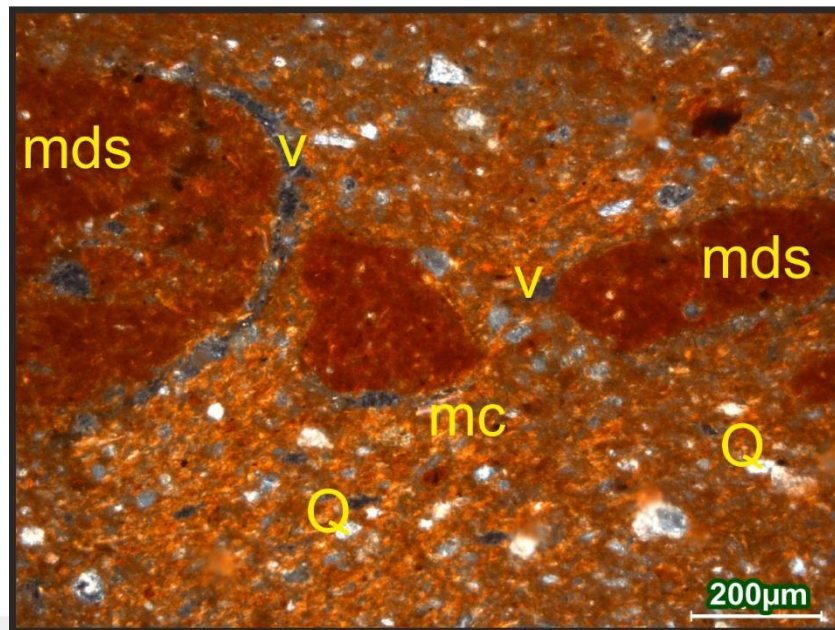


Figure 1.12: Photomicrograph of Monochrome from polarized light microscope (sp: MN-5). It is seen mainly mineral inclusions; mds: mudstone, Q: quartz and mc: mica (white mica). There are also secondary pore structure (v) which cover around the grains.

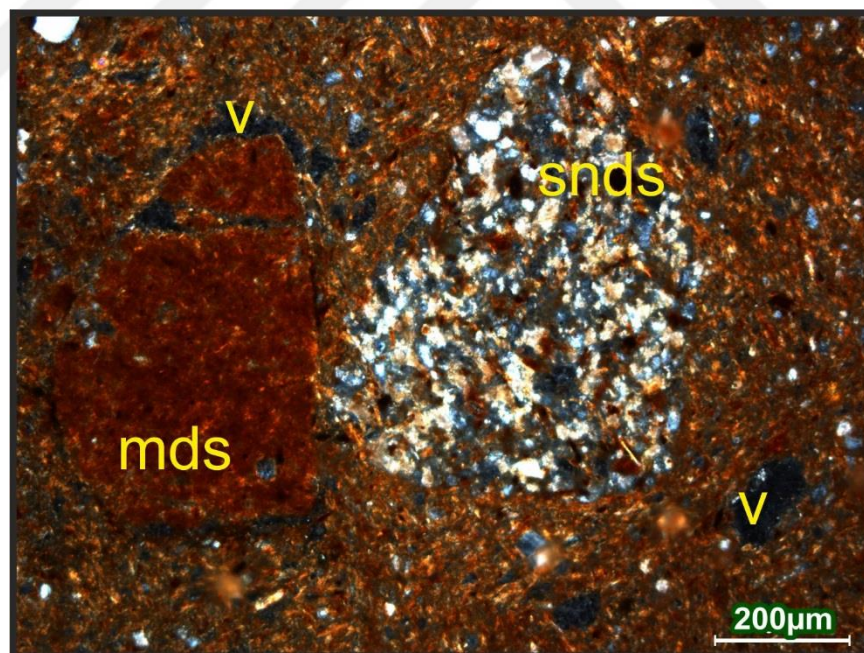


Figure 1.13: Photomicrograph of Monochrome ware from polarized light microscope (sp: MN-3). It can be seen clearly rock fragments inclusions; snds: sandstone, mds: mudstone and void structures (v).

5.1.4 Observation of the Production Techniques for WS I, WS II and MN Ware

From the point of the production technology, it can be interpreted that the grinding process was not focuses due to the high content of temper material, of about 30-35%, in WSI pottery. Moreover, grogs and pore structures show that they were used to increase the resistance of pottery. Diffuse grain boundaries and color difference of ceramic edge can be result of the firing process.

For the production technique of the White Slip II samples, there is not standard measurements, so it can be prepared in unsteady conditions. Therefore, there are some differences in the production process. For example, in the previous studies, it is known that White Slip ware was fired in high temperature. However, the differences of paste color of the samples shows that the firing temperature and/or firing duration is not clear. Another example, clay material of the samples was not grinded in same proportions and was mixed during the clay processing steps. Actually, the reason can be that the White Slip wares was popular pottery type and had been used for a long time, therefore the production technique of WSII potteries can be in the development stage in these long years.

In terms of the production technology of Monochrome ware, it can be said that all Monochrome samples are products of the same production techniques such as firing temperature and preparation process. On the other hand, there are some lumps or nodules of clays, resulting from probably less afford during grinding, sieving or mixing of the clay. Moreover, some samples have two paste color despite usually homogenous in the paste, this can result from inadequate mixing clay process during preparation or different degree of temperature during firing process.

5.2 Chemical Analysis

5.2.1. Chemical Characteristic of Potteries from Tell Atchana

A total of 56 samples of the potsherds, that are from the samples White Slip I (n= 6), White slip II (n= 30), and Monochrome wares (n= 20) of Tell Atchana, were prepared for geochemical analysis. I present the most characteristic features of the White Slip I, White Slip II, and Monochrome ware by interpreting these geochemical analyses.

5.2.1.1 Chemical Characteristic of White Slip I Ware (From Tell Atchana)

XRF and ICP-MS results point out that the White Slip I ware are characterized by low CaO (1,39-4,4 wt.%), $\text{Na}_2\text{O}+\text{K}_2\text{O}$ ([0,62-1,77]+[0,55-1,08] wt.%), low to middle MgO (2,11-7,75 wt.%) and middle SiO_2 (53,03-61,42 wt.%) and high Al_2O_3 (16,89-20,72 wt.%), Fe_2O_3 (8,89-12,26 wt.%) (Table 5.2 and 5.3).

After the evaluation of data shows that a geochemical grouping between the samples of WSI-1, WSI-4, WSI-5, WSI-6 (WS-IA) and WSI-2, WSI-3 (WS-IB). For example, the first group WS-IA shows lower SiO_2 , Na_2O and higher MgO, CaO, Al_2O_3 than the WS-IB. The differences between two subgroups appear on diagrams such as; Fe_2O_3 - Na_2O -CaO and MgO-CaO-($\text{Na}_2\text{O}+\text{K}_2\text{O}$) ternary diagrams in Figure 5.14. Grouping also appear on binary diagrams on SiO_2 , MgO, CaO and Fe_2O_3 elements that are plotted versus Al_2O_3 (Figure 5.15). Moreover, the samples of subgroup WS-IB show a constant distribution pattern, while samples of subgroup WS-IA show an increasing pattern in Al_2O_3 vs. SiO_2 and decreasing pattern in Al_2O_3 vs. MgO and Al_2O_3 vs. Fe_2O_3 diagrams (Figure 5.15).

Table 1.2: Bulk major (in wt %) and trace (ppm) element concentrations of the While Slip I and White Slip II ware from Tell Atchana.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	Cr2O3	P2O5	MnO	LOI	Total	Li	Be	Co	Ni	Cu	Zn	Ga	As	Rb
WS1-1	56	21	8,9	6,8	4,4	1,6	0,6	0,5	0,0	0,0	0,1	0,7	100	25	1,0	31	95	28	79	21	39	9
WS1-2	61	17	12,0	2,7	2,0	1,7	0,9	1,1	0,0	0,1	0,1	1,0	100	25	1,4	24	33	269	116	26	43	14
WS1-3	61	19	11,9	2,1	1,4	1,8	1,1	1,0	0,0	0,0	0,2	0,6	100	25	1,0	24	34	314	128	23	41	17
WS1-4	53	20	11,2	7,8	3,7	0,7	0,6	0,9	0,0	0,0	0,1	1,9	100	35	1,2	39	86	82	55	20	38	10
WS1-5	57	21	10,5	5,1	3,6	1,3	0,7	1,0	0,0	0,0	0,1	0,0	100	29	1,3	29	73	41	66	21	38	14
WS1-6	55	20	12,3	5,9	4,0	0,6	0,8	1,1	0,0	0,0	0,2	0,1	100	35	1,5	43	96	75	64	27	43	19
WS2-1	56	19	10,1	6,7	4,7	0,9	0,8	0,7	0,0	0,0	0,1	1,1	100	37	0,9	36	87	33	48	21	40	13
WS2-2	55	20	8,8	8,2	4,9	1,0	0,8	0,7	0,1	0,0	0,1	0,3	100	42	1,6	45	114	30	65	24	48	14
WS2-3	57	17	10,9	6,0	4,2	2,6	0,6	0,7	0,0	0,0	0,2	0,5	100	23	1,2	36	75	96	158	26	42	7
WS2-4	54	20	8,7	7,9	5,5	0,9	0,7	0,5	0,1	0,0	0,1	0,8	100	28	1,0	34	105	29	43	18	40	11
WS2-5	56	19	9,8	7,2	4,9	1,0	0,8	0,6	0,0	0,0	0,1	0,5	100	37	1,6	43	121	19	59	25	40	19
WS2-6	51	20	11,5	7,6	5,0	1,2	0,6	0,4	1,9	0,0	0,2	0,7	100	14	0,9	35	107	25	78	21	44	10
WS2-7	56	19	9,8	7,7	4,5	1,3	0,8	0,6	0,1	0,0	0,1	0,1	100	21	0,7	42	116	17	62	23	50	17
WS2-8	58	18	11,6	5,7	2,8	2,8	0,4	0,7	0,1	0,0	0,2	0,0	100	15	0,4	39	132	214	158	19	48	5
WS2-9	56	19	9,6	7,1	4,8	1,2	0,8	0,6	0,0	0,1	0,1	0,5	100	52	7,2	55	118	83	310	77	68	23
WS2-10	54	20	9,3	6,5	5,5	1,2	0,7	0,5	0,0	0,1	0,1	1,9	100	14	0,6	26	65	31	38	15	38	7
WS2-11	52	19	11,6	8,1	4,1	2,1	0,7	0,7	1,2	0,0	0,1	0,1	100	15	0,8	34	95	37	38	16	39	7
WS2-12	55	20	8,2	7,1	4,6	1,3	0,9	0,6	0,1	0,1	0,1	1,9	100	16	0,6	29	87	47	62	21	46	9
WS2-13	51	20	9,7	9,1	5,3	0,9	0,7	0,5	1,2	0,2	0,1	1,1	100	16	0,5	38	138	21	55	16	14	10
WS2-14	55	20	8,5	7,9	5,3	0,9	0,6	0,5	0,1	0,0	0,1	0,8	100	12	0,8	28	85	19	34	12	24	8
WS2-15	57	18	12,5	3,8	2,6	2,1	0,9	0,9	0,0	0,2	0,2	1,1	100	25	0,7	26	36	178	109	24	40	12
WS2-16	44	12	7,1	3,5	18,5	1,3	2,1	0,7	0,1	0,2	0,1	9,6	99	31	1,5	15	82	26	71	23	40	36
WS2-17	57	17	8,7	7,4	4,8	1,7	0,9	0,6	0,1	0,0	0,1	1,0	100	14	0,8	27	98	17	34	12	29	10

Table 1.3: Trace (ppm) element concentrations of the While Slip I and White Slip II ware from Tell Atchana.

Sample	Sr	Ag	Cs	Ba	Tl	Pb	U	Sc	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th
WS1-1	101	4,0	2,7	104	0,0	45	1,3	208	15	10	20	2,5	10	2,4	0,7	3,1	0,5	2,9	0,6	1,9	0,3	1,8	0,3	3,6
WS1-2	102	3,0	2,8	113	0,1	26	1,0	225	24	12	25	3,2	14	3,4	1,1	4,5	0,7	4,4	1,0	2,9	0,4	2,8	0,5	3,9
WS1-3	84	2,0	2,7	108	0,1	32	1,5	262	28	18	39	4,9	20	4,8	1,4	6,1	0,9	5,6	1,2	3,5	0,5	3,2	0,5	5,9
WS1-4	100	1,9	2,9	38	0,0	21	1,0	287	32	16	29	4,2	18	4,6	1,4	6,1	1,0	6,1	1,3	3,9	0,6	3,6	0,6	4,9
WS1-5	68	3,0	2,8	88	0,1	30	1,6	225	26	24	50	5,8	23	4,9	1,3	6,1	0,8	5,1	1,1	3,2	0,5	2,9	0,5	6,8
WS1-6	80	2,7	3,5	100	0,1	33	2,0	308	37	25	52	6,8	28	6,4	1,8	8,1	1,2	7,3	1,5	4,6	0,7	4,2	0,7	7,9
WS2-1	80	1,7	2,6	88	0,0	23	1,0	157	17	12	25	3,1	12	2,8	0,8	3,5	0,5	3,3	0,7	2,1	0,3	2,1	0,3	4,2
WS2-2	100	2,6	3,4	100	0,5	32	2,2	211	22	14	27	3,5	14	3,4	0,9	4,4	0,7	4,3	0,9	2,8	0,4	2,6	0,4	4,5
WS2-3	161	3,3	2,8	156	0,0	45	1,2	207	23	10	20	2,7	12	3,0	1,0	4,1	0,7	4,5	1,0	3,0	0,5	2,9	0,5	3,6
WS2-4	107	2,3	2,7	66	0,0	22	1,0	216	16	12	23	3,0	12	2,7	0,8	3,4	0,5	3,2	0,7	2,1	0,3	2,0	0,3	4,2
WS2-5	113	2,9	3,6	131	0,1	24	1,6	252	23	21	45	5,3	21	4,5	1,2	5,4	0,8	4,7	1,0	3,0	0,4	2,8	0,5	7,6
WS2-6	68	0,0	0,5	95	0,0	27	1,1	212	19	10	20	2,7	11	2,8	0,9	3,6	0,6	3,7	0,8	2,4	0,3	2,2	0,3	3,8
WS2-7	67	0,1	0,9	102	0,1	17	0,7	175	18	14	31	3,6	14	3,3	0,9	4,0	0,6	3,6	0,8	2,2	0,3	2,1	0,3	4,6
WS2-8	76	0,7	0,2	68	0,0	14	0,3	135	16	6	12	1,6	7	2,1	0,7	2,9	0,5	3,2	0,7	2,1	0,3	2,0	0,3	2,0
WS2-9	136	0,0	2,6	866	0,1	318	1,0	123	13	10	22	2,5	10	2,3	0,6	2,8	0,4	2,6	0,5	1,6	0,2	1,5	0,2	3,2
WS2-10	93	0,0	0,3	54	0,0	13	0,4	145	16	7	14	2,0	9	2,3	0,8	3,1	0,5	3,3	0,7	2,1	0,3	2,0	0,3	2,8
WS2-11	71	0,5	0,2	50	0,0	13	0,3	157	24	6	12	1,9	9	2,8	0,9	4,0	0,7	4,5	1,0	2,9	0,4	2,6	0,4	2,0
WS2-12	116	0,3	0,4	147	0,0	26	1,4	181	20	8	16	2,1	9	2,5	0,8	3,4	0,6	3,6	0,8	2,4	0,4	2,2	0,3	2,7
WS2-13	99	4,8	0,6	60	0,1	5	0,4	112	14	6	12	1,5	6	1,7	0,5	2,4	0,4	2,6	0,6	1,7	0,2	1,6	0,2	2,1
WS2-14	56	0,0	0,3	56	0,0	14	0,3	150	14	7	15	1,9	8	2,0	0,7	2,7	0,4	2,7	0,6	1,7	0,2	1,6	0,2	2,4
WS2-15	102	0,2	0,5	180	0,0	19	1,0	161	24	9	17	2,6	12	3,4	1,1	4,4	0,7	4,6	1,0	3,0	0,4	2,7	0,4	2,8
WS2-16	293	0,0	2,2	254	0,1	29	2,6	100	24	26	49	6,2	25	5,3	1,4	6,1	0,8	4,6	0,9	2,6	0,4	2,2	0,3	8,5
WS2-17	51	0,0	0,5	61	0,0	26	0,4	163	17	10	22	2,7	11	2,7	0,8	3,4	0,5	3,4	0,7	2,1	0,3	1,9	0,3	4,2

Table 1.4: Bulk major (in wt %) and trace (ppm) element concentrations of the While Slip I and White Slip II ware from Tell Atchana.

Sample	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	Cr ₂ O ₃	P ₂ O ₅	MnO	LOI	Total	Li	Be	Co	Ni	Cu	Zn	Ga	As	Rb
WS2-18	55	20	9,4	7,4	4,4	1,2	0,7	0,5	0,0	0,0	0,1	1,0	100	19	0,8	29	73	30	42	13	29	8
WS2-19	57	19	10,3	5,0	3,9	1,9	0,5	0,8	0,0	0,1	0,1	0,7	100	10	0,8	23	38	47	32	16	31	8
WS2-20	57	18	11,5	5,1	3,7	2,3	0,9	0,8	0,1	0,0	0,1	0,7	100	18	0,9	34	63	71	46	17	31	12
WS2-21	59	18	10,4	5,6	4,1	3,0	0,7	1,1	0,0	0,2	0,1	0,9	100	14	0,7	30	66	55	35	16	31	7
WS2-22	56	19	10,1	7,7	4,2	2,1	0,6	0,6	0,0	0,0	0,1	0,0	100	11	0,4	36	103	15	495	16	37	6
WS2-23	51	20	11,9	5,0	3,3	1,1	1,0	0,9	0,0	0,0	0,1	0,0	0	47	4,5	51	83	59	246	62	58	19
WS2-24	56	19	9,9	7,1	4,5	1,0	0,8	0,6	0,0	0,0	0,1	0,4	100	41	4,3	56	146	62	227	57	58	23
WS2-25	57	19	10,0	7,4	4,7	1,1	0,8	0,6	0,1	0,0	0,1	0,4	100	28	1,6	49	137	39	116	30	37	18
WS2-26	56	19	9,3	7,5	4,7	1,1	0,7	0,6	0,1	0,0	0,1	0,9	100	27	2,4	39	103	34	114	32	40	14
WS2-27	58	18	11,4	5,7	2,4	2,2	0,7	0,9	0,0	0,1	0,3	0,4	100	19	1,5	38	65	243	318	25	42	7
WS2-28	55	20	10,1	7,1	4,1	1,0	0,9	0,6	0,0	0,0	0,1	0,3	100	49	0,9	44	111	29	53	25	40	12
WS2-29	57	18	11,3	5,6	3,5	1,7	0,8	0,6	0,0	0,0	0,2	0,3	100	32	3,5	54	97	96	248	51	58	13
WS2-30	51	14	8,5	4,2	13,0	1,3	2,5	0,9	0,1	0,0	0,2	3,5	100	36	1,3	24	133	38	94	41	41	54

Table 1.5: Trace (ppm) element concentrations of the While Slip I and White Slip II ware from Tell Atchana.

SAMPLE	Sr	Ag	Cs	Ba	Tl	Pb	U	Sc	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th
WS2-18	51	0,0	0,4	68	0,0	16	0,6	147	13	7	14	1,8	8	1,8	0,6	2,4	0,4	2,4	0,5	1,5	0,2	1,5	0,2	2,3
WS2-19	64	0,0	0,4	97	0,0	19	1,0	146	18	8	17	2,2	10	2,5	0,8	3,2	0,5	3,2	0,7	2,0	0,3	1,8	0,3	2,6
WS2-20	72	0,0	0,5	82	0,0	21	0,8	148	21	10	22	2,8	12	3,1	1,0	4,1	0,6	4,0	0,9	2,5	0,4	2,3	0,4	3,2
WS2-21	64	0,0	0,3	64	0,0	15	0,4	156	27	9	18	2,5	12	3,3	1,1	4,5	0,8	5,1	1,1	3,2	0,5	2,9	0,4	2,6
WS2-22	75	3,0	0,4	37	0,0	69	0,3	161	21	5	10	1,5	7	2,3	0,8	3,4	0,6	3,8	0,8	2,5	0,4	2,3	0,4	1,5
WS2-23	125	1,2	1,9	577	0,1	177	1,1	136	19	8	17	2,2	10	2,5	0,8	3,4	0,6	3,5	0,8	2,2	0,3	2,0	0,3	3,0
WS2-24	119	1,0	2,2	560	0,1	163	1,1	170	15	11	25	2,8	11	2,6	0,7	3,2	0,5	2,9	0,6	1,8	0,3	1,6	0,3	4,0
WS2-25	121	0,7	1,1	224	0,1	54	0,8	151	13	10	22	2,5	10	2,3	0,6	2,9	0,4	2,5	0,5	1,6	0,2	1,4	0,2	3,9
WS2-26	84	0,5	1,1	277	0,1	77	0,8	180	15	9	18	2,2	9	2,2	0,7	2,8	0,4	2,7	0,6	1,8	0,3	1,6	0,3	2,8
WS2-27	97	1,0	0,5	144	0,1	36	3,3	182	26	6	14	1,9	9	2,7	0,9	3,9	0,7	4,4	1,0	2,9	0,4	2,6	0,4	2,4
WS2-28	75	0,8	0,7	140	0,0	32	3,1	165	15	7	14	1,8	8	2,0	0,6	2,7	0,4	2,6	0,6	1,7	0,2	1,6	0,2	2,2
WS2-29	135	0,8	1,4	438	0,1	131	0,9	145	16	5	11	1,5	7	1,9	0,6	2,6	0,4	2,9	0,6	1,9	0,3	1,8	0,3	1,8
WS2-30	263	1,0	3,1	429	0,0	15	2,3	149	31	33	65	8,0	32	6,9	1,9	7,8	1,0	5,8	1,2	3,4	0,4	2,8	0,4	11,0

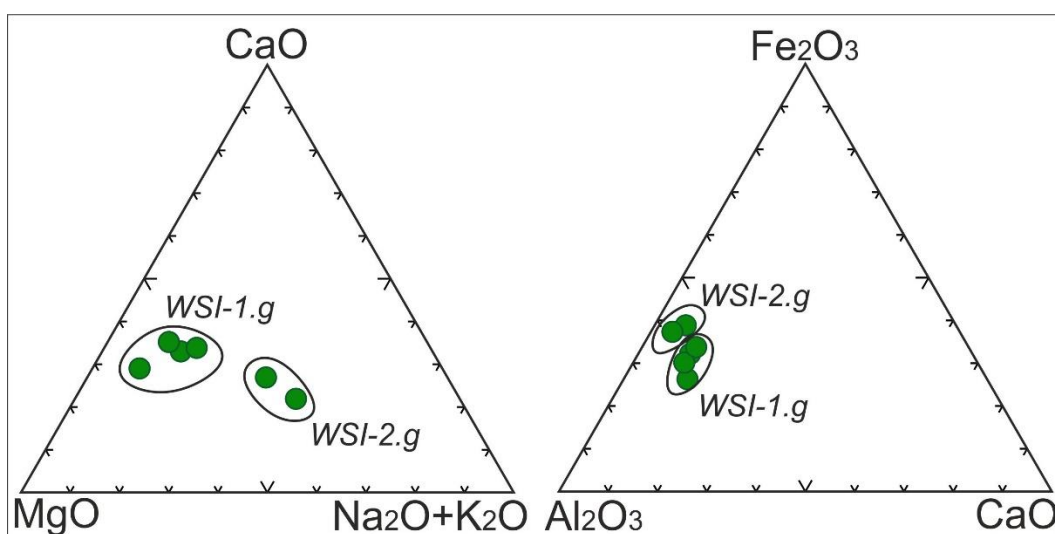


Figure 1.14: Ternary plot of MgO-CaO-(Na₂O+K₂O) and Al₂O₃-Fe₂O₃-CaO (all in wt.%) showing subgroups of White Slip I ware. (WSI.1.g: the first group of White Slip I, WSI.2.g: the second group of White Slip I.)

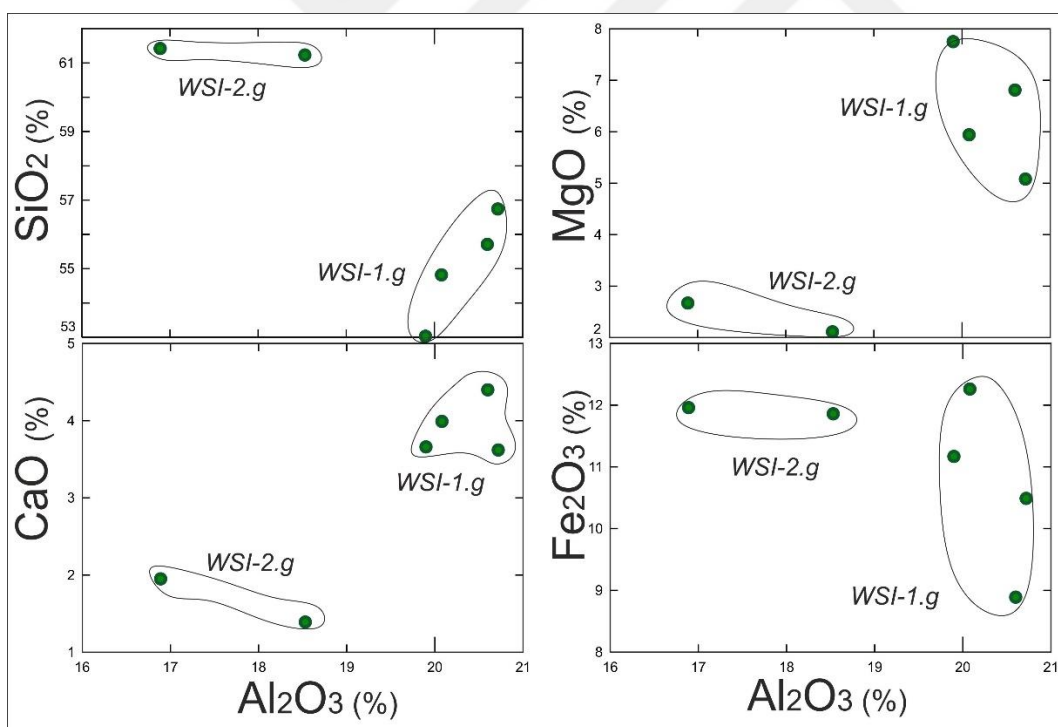


Figure 1.15: Binary plot of major elements CaO, Fe₂O₃, MgO, SiO₂ versus Al₂O₃ (all in wt.%) showing subgroup of White Slip I ware. (WSI.1.g: the first group of White Slip I, WSI.2.g: the second group of White Slip I.)

However, some trace elements, like Li, Co, Zn, show slightly different values between the first and second group. For instance, it can be seen Co, Zn and Li versus Al_2O_3 diagram, two group show different distribution patterns (Figure 5.16). In order to understand the characteristics of WSI, I used the trace elements normalized diagram against Post Archean Shale (PAAS) that are most commonly used in normalizing values for sedimentary rocks using the factors of Taylor and McLennan (1985). According to PAAS spider diagram (normalizing), the composition of WSI are quite similar to the reference composition and all White Slip I samples show similar behavior, displaying depletion pattern on some REE elements including La, Ce, Pr, Nd, Sm and Eu (Figure 5.17).

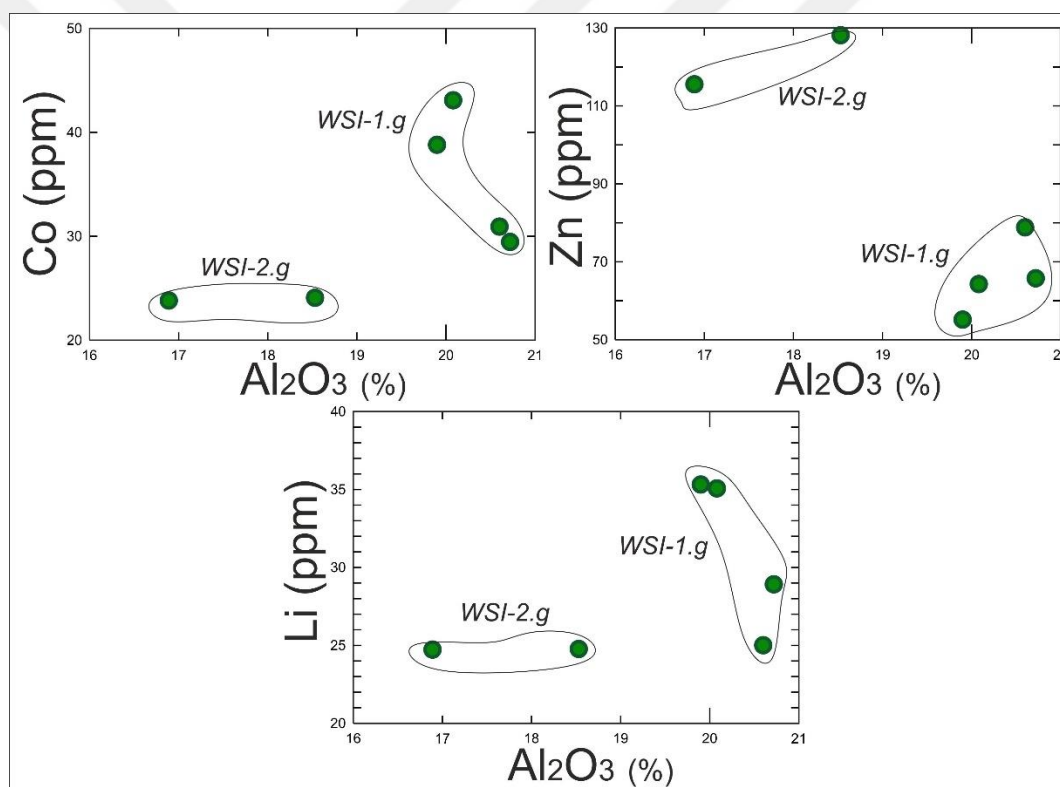


Figure 1.16: Binary plot of trace elements Zn, Co and Li (in ppm) versus Al_2O_3 (in wt.%) showing subgroup of White Slip I ware. (WSI.1.g: the first group of White Slip I, WSI.2.g: the second group of White Slip I).

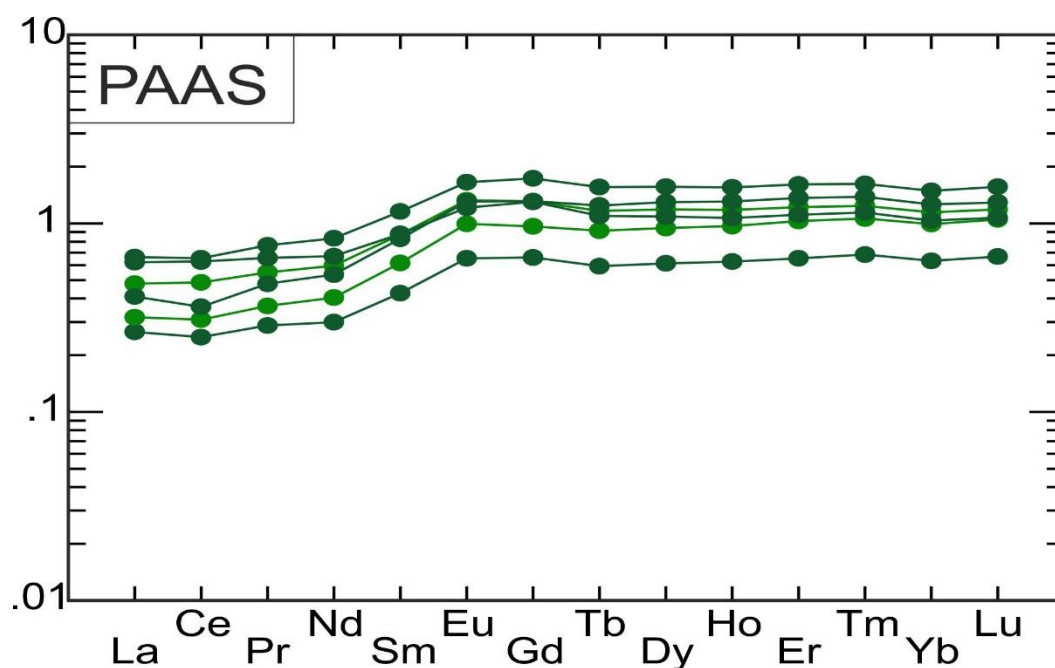


Figure 1.17: Post Archean Australian Shale (PAAS) normalized REE-s element diagrams of the White Slip I wares. PAAS values: Taylor and McLennan, 1985.

5.2.1.2 Chemical Characteristic of White Slip II Ware (From Tell Atchana)

According to the results of XRF and ICP-MS analysis, major and trace element concentrations of White Slip II samples show variations among each other (Table 5.2, 5.3, 5.4, 5.5). Consider as a whole, the major elements of WSII samples are characterized by low SiO_2 (50,94-58,81 wt.%), low Al_2O_3 (17,27 to 20,48 wt.%) and low CaO (2,83 to 5,30 wt.%) and middle to high MgO (3,51 to 9,11 wt.%), high Fe_2O_3 (7,12-11,67 wt.%) and also low $\text{Na}_2\text{O}+\text{K}_2\text{O}$ ([0,87-2,99]+[0,38-0,98] wt.%). The major element distribution can be seen on Al_2O_3 - MgO - CaO and MgO - CaO -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) ternary diagrams on Figure 5.20. On the other hand, one exceptional sample (WSII-16) shows very different ratios than others such as very low Al_2O_3 (12,48 wt.%) and SiO_2 (43,77 wt.%) content and very high CaO (18,49 wt.%).

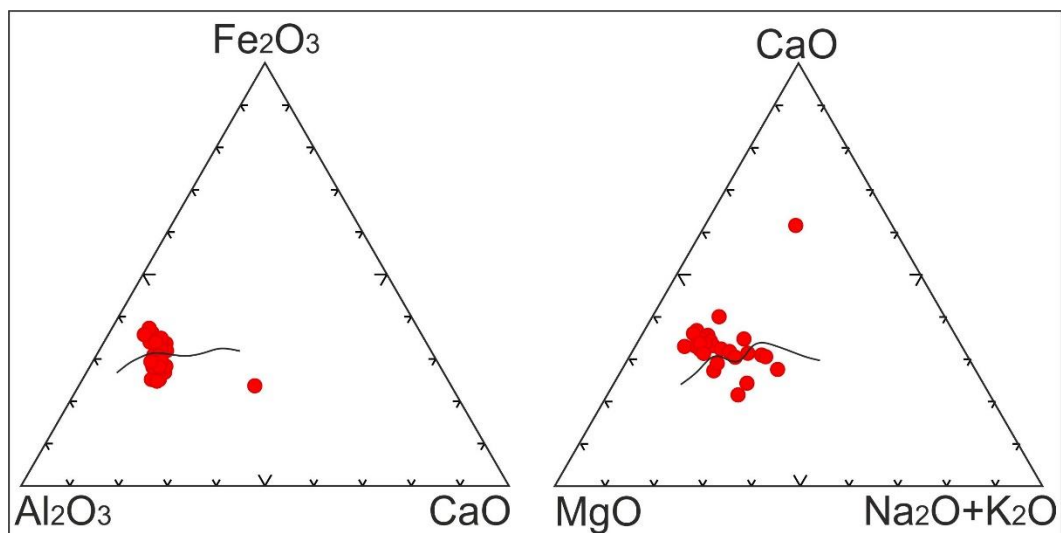


Figure 1.18: Ternary plot of Al_2O_3 - Fe_2O_3 - CaO and MgO - CaO -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) diagrams, showing major element distribution of White Slip II ware.

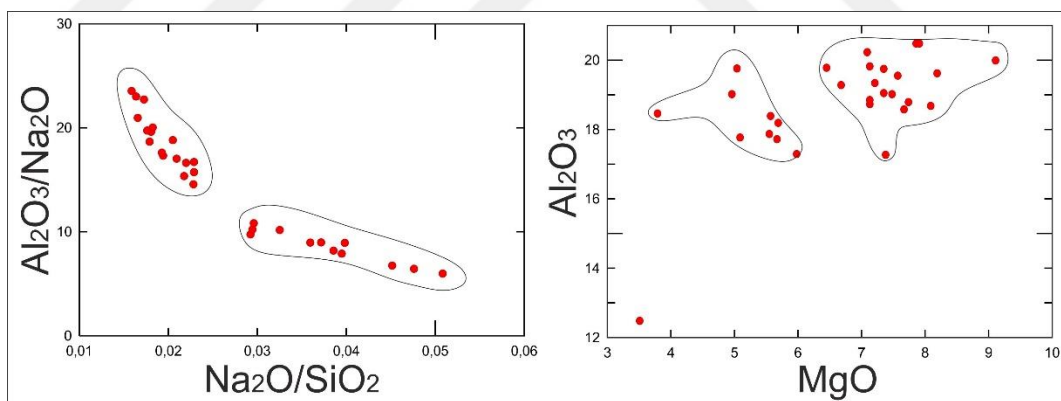


Figure 1.19: Binary plot of major elements $\text{Al}_2\text{O}_3/\text{Na}_2\text{O}$ versus $\text{Na}_2\text{O}/\text{SiO}_2$ (in wt.%) and Al_2O_3 versus MgO (in wt.%) showing subgroups of White Slip II ware.

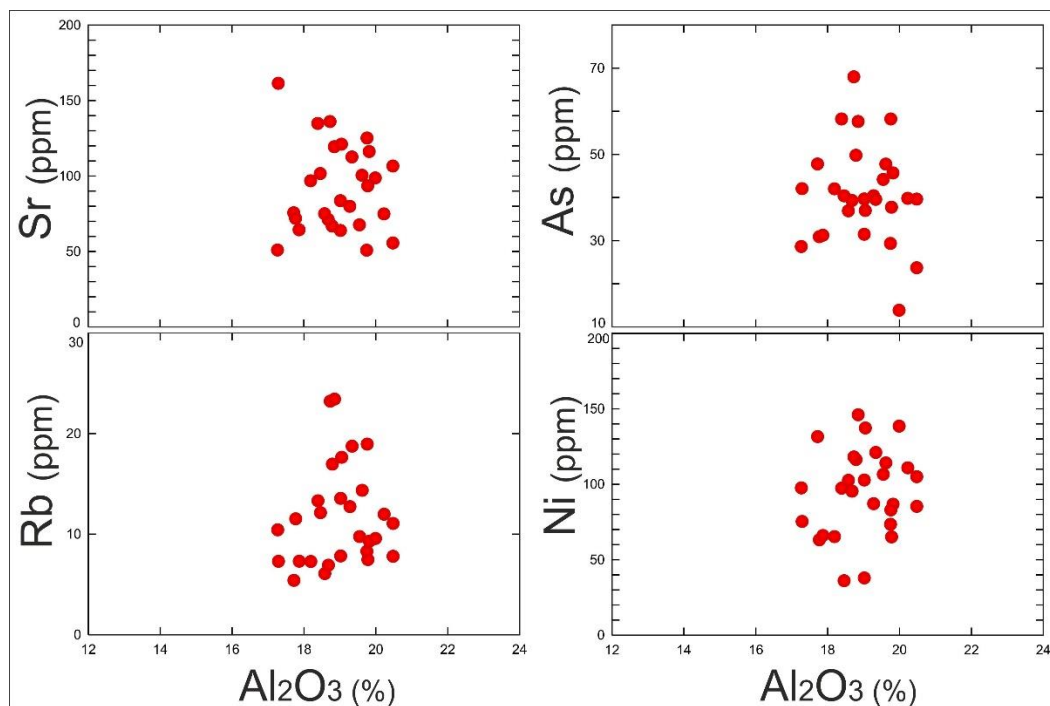


Figure 1.20: Binary plot of trace element distribution of the White Slip II samples for Sr, Rb, As, and Ni (in ppm) versus Al₂O₃ (in wt.%) diagrams.

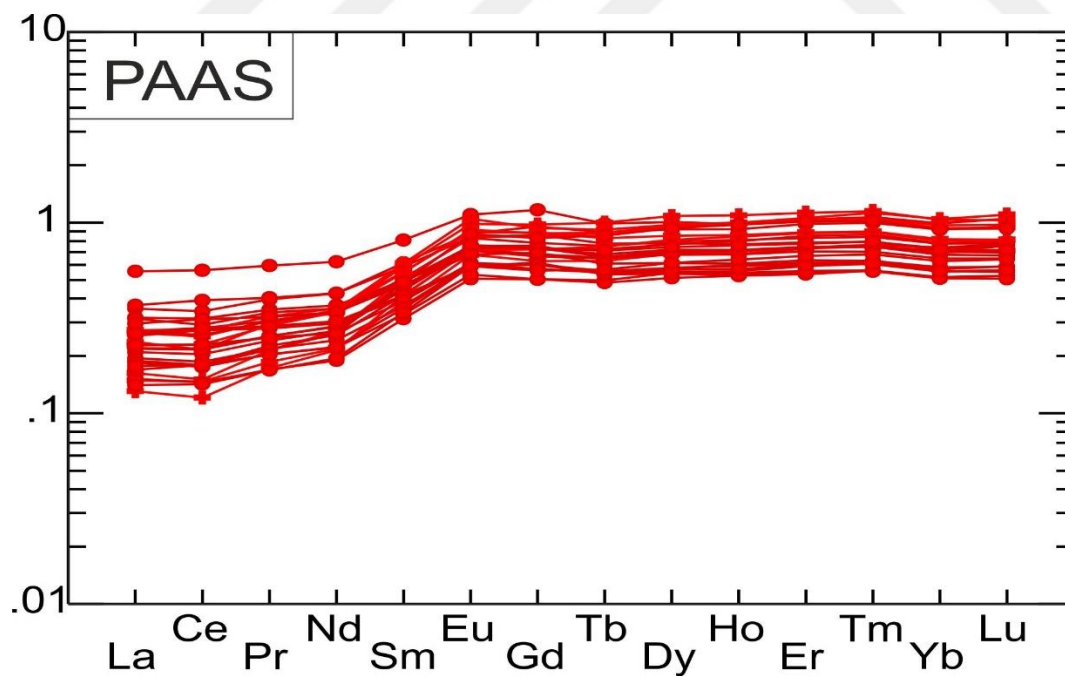


Figure 1.21: Post Archean Australian Shale (PAAS) normalized REE-s element diagrams of the White Slip II wares. PAAS values: Taylor and McLennan, 1985.

The trace elements composition of the White Slip II has high value of Co (23,3-56 ppm), Ni (36,1-146 ppm), As (13-67) ppm and Sc (111-251 ppm). Incompatible element composition of LILE of WSII ware has lower value than average value like Rb (5-23 ppm), Sr (50-136 ppm), Ba (37-867 ppm) and Cs (0,2-3,6 ppm) but just Ba values shows variation inside.

As in WS I, subgrouping was also seen in WS II samples. This grouping is observed for samples between WSII-(1, 2, 4, 5, 6, 7, 9, 10, 12, 13, 14, 18, 23, 24, 25, 26, 28) in subgroup WS-IIA and WSII-(3, 8, 11, 15, 16, 17, 19, 20, 21, 22, 27, 29, 30) in subgroup WS-IIB. Major elements represent grouping clearly like on Na_2O , Al_2O_3 , MgO , and Fe_2O_3 . For example, grouping structure can be seen on $\text{Al}_2\text{O}_3/\text{Na}_2\text{O}$ versus $\text{Na}_2\text{O}/\text{Si}_2\text{O}_3$ and on MgO versus Al_2O_3 diagrams (Figure 5.19). Especially, Na_2O values clearly show this grouping (Figure 5.19). This probably is because of the high plagioclase content of the WS-IIB samples. Likewise, trace elements distribution of the White Slip II wares is presented in Table 5.2, 5.3, 5.4, 5.5.

According to the trace element distribution, all WS II values show variations among each other, but mostly seen compatible with related major oxides. In addition, grouping in WS-IIA and WSII-B can be followed in trace elements in spite of not showing distinct grouping. However, subgroup WS-IIA and WS-IIB have similar geochemical properties each other. These are shown on Al_2O_3 versus Sr, As, Rb, Ni binary diagram (Figure 5.20). According to PAAS spider diagram (normalizing), the composition of WSII are quite similar to the reference composition and to all White Slip II samples, but some elements including La, Ce, Pr, Nd, Sm and Eu show little bit depletion pattern (Figure 5.21).

5.2.1.3 Chemical Characteristic of Monochrome Ware (From Tell Atchana)

The result of the XRF and ICP-MS analyses, all samples of the Monochrome ware show very similar geochemical composition between each other (Table 5.6 and 5.7). As a whole, the major elements of WSII samples are characterized by low SiO_2 , ranging from 53,61 to 59,05 wt.% and low Al_2O_3 , changing from 14,03 to 16,81 wt.%. Rates of CaO and MgO are moderate, which changes from 3,33 to 9,16 wt.% and from 3,64 to 4,88 wt.%, respectively. Moreover, Fe_2O_3 shows high content from 6,82 to

7,85 wt.%. Major element contribution of the Monochrome ware can be seen on Al_2O_3 - CaO -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) and Al_2O_3 - Fe_2O_3 -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) ternary diagrams (Figure 5.22). Samples mostly plot in the same specific area due to the closely spaced similar values. However, for CaO contents, samples show little variations between each other and against other oxides (Figure 5.24). Moreover, MN wares represent straight positive and negative correlation on the bivariate diagram. For example; Fe_2O_3 , MgO and SiO_2 values show positive correlation, while Al_2O_3 values increase. On the other hand, CaO , Na_2O and K_2O values show negative correlation (decreasing pattern), while Al_2O_3 values are increasing (Figure 5.25).

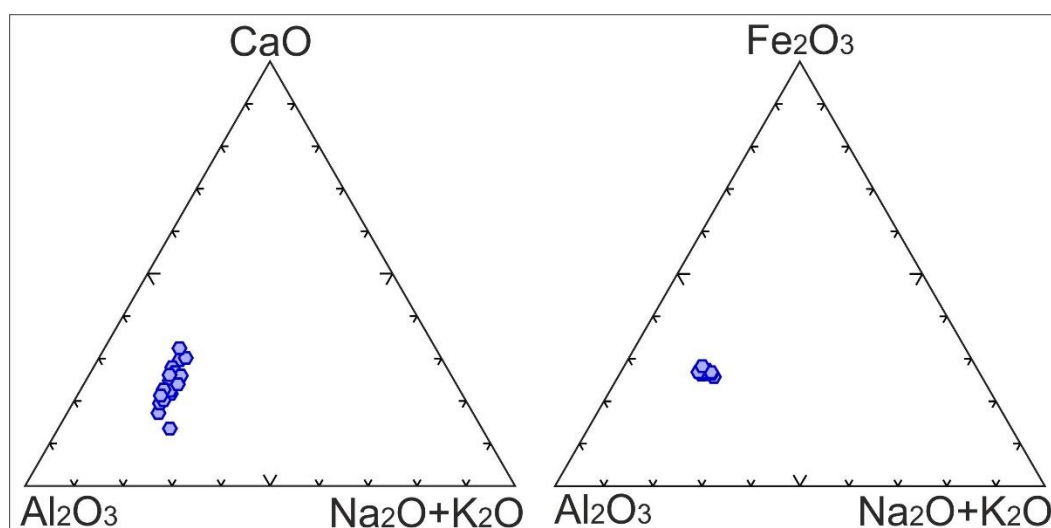


Figure 1.22: Ternary plot of major element distribution of Monochrome ware for Al_2O_3 - CaO -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) and Al_2O_3 - Fe_2O_3 -($\text{Na}_2\text{O}+\text{K}_2\text{O}$) (all in wt.) diagrams.

Table 5.6: Major (wt %) and trace (ppm) element concentrations of the Monochrome ware from Tell Atchana.

Sample	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	Cr ₂ O ₃	P ₂ O ₅	MnO	LOI	Total	Li	Be	Co	Ni	Cu	Zn	Ga	As	Rb
MN-1	54	15	7,4	4,2	8,3	1,3	3,4	0,9	0,0	0,4	0,2	4,3	100	99	2,9	28	159	58	204	52	60	132
MN-2	58	17	7,9	4,8	4,5	1,4	3,5	0,9	0,0	0,4	0,2	1,6	100	71	3,0	27	140	72	144	44	52	129
MN-3	54	16	7,2	3,7	6,7	1,2	3,4	0,9	0,0	0,5	0,1	6,0	100	64	3,0	24	127	84	154	60	55	115
MN-4	57	15	7,6	4,1	5,5	1,3	3,3	0,9	0,0	0,4	0,2	4,0	99	88	4,0	30	168	152	185	60	63	121
MN-5	54	15	7,4	4,2	7,6	1,0	3,3	0,8	0,0	0,4	0,1	5,8	100	72	2,5	23	138	113	135	52	51	120
MN-6	57	15	7,6	4,3	5,6	1,3	3,6	0,9	0,0	0,4	0,2	2,9	99	66	3,0	25	147	69	165	63	56	107
MN-7	57	15	7,5	4,2	5,8	1,2	3,6	0,9	0,0	0,4	0,2	3,7	100	82	3,0	30	161	70	126	52	47	129
MN-8	55	15	7,0	4,3	6,8	1,3	3,5	0,8	0,0	0,5	0,2	5,3	100	65	2,6	23	136	54	115	35	43	106
MN-9	54	14	6,8	4,1	8,1	1,5	3,3	0,8	0,0	0,4	0,1	6,5	99	74	2,4	23	140	54	121	43	42	120
MN-10	55	15	6,9	3,9	9,2	1,2	3,2	0,8	0,0	0,2	0,1	4,6	100	85	4,5	29	147	77	214	62	51	115
MN-11	59	16	7,4	3,6	3,3	1,7	3,9	0,9	0,0	0,3	0,1	3,8	99	63	2,9	22	128	59	111	56	41	119
MN-12	58	16	7,6	4,5	6,1	1,0	3,5	0,9	0,0	0,2	0,1	1,8	100	73	2,9	22	123	60	106	39	38	118
MN-13	57	16	7,6	4,9	7,5	1,4	3,5	0,9	0,0	0,1	0,2	1,3	100	80	2,9	27	157	74	123	47	37	137
MN-14	59	16	7,7	4,7	4,9	1,1	3,4	0,9	0,0	0,2	0,2	1,6	99	89	3,0	32	187	94	156	99	40	139
MN-15	58	16	7,6	4,3	5,2	1,1	3,6	0,9	0,0	0,2	0,2	2,9	100	69	3,0	24	130	63	118	43	34	105
MN-16	54	14	6,9	3,7	6,7	1,4	3,5	0,8	0,0	0,2	0,2	7,7	99	39	1,8	15	88	36	77	29	31	69
MN-17	58	17	7,9	4,3	5,8	1,3	3,4	0,9	0,0	0,2	0,2	1,5	100	175	2,3	26	139	80	125	49	35	126
MN-18	57	15	7,5	4,4	6,5	1,7	3,5	0,9	0,0	0,3	0,2	2,3	99	104	2,4	23	126	70	116	41	40	115
MN-19	55	15	7,8	4,0	7,0	1,3	3,1	0,8	0,0	0,2	0,2	4,4	100	59	3,0	22	143	68	117	32	16	103

Table 5.7: Trace (ppm) element concentrations of the Monochrome ware from Tell Atchana.

Sample	Sr	Ag	Cs	Ba	Tl	Pb	U	Sc	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
MN-1	296	1,0	7,3	451	0,3	25	1,0	88	19	36	88	9	35	6,6	1,5	6,9	0,8	4,3	0,8	2,1	0,3	1,8
MN-2	170	1,4	7,1	350	0,4	22	1,7	116	26	47	116	11	45	8,5	1,9	9,4	1,1	5,5	1,0	2,8	0,4	2,3
MN-3	287	0,9	6,0	602	0,5	26	1,5	78	19	34	83	8	32	6,2	1,4	6,4	0,8	4,1	0,7	2,1	0,3	1,9
MN-4	241	1,0	7,4	597	0,7	59	1,9	107	23	41	101	10	39	7,5	1,7	7,8	0,9	4,9	0,9	2,7	0,3	2,2
MN-5	225	1,6	6,9	497	0,4	34	1,5	112	22	39	96	9	36	7,2	1,7	7,5	0,9	4,8	0,9	2,5	0,3	2,1
MN-6	270	1,8	6,3	692	0,5	54	1,4	108	23	44	103	10	41	7,9	1,8	8,2	1,0	4,9	0,9	2,5	0,3	2,0
MN-7	249	1,5	7,4	510	0,5	27	1,2	102	22	41	87	10	37	7,5	1,7	7,7	0,9	4,8	0,9	2,4	0,3	2,0
MN-8	230	0,9	5,9	294	0,5	22	1,3	116	23	41	86	10	37	7,3	1,6	7,6	0,9	5,0	0,9	2,6	0,3	2,1
MN-9	329	0,9	6,8	359	0,5	24	1,1	67	21	40	83	9	36	7,3	1,6	7,3	0,9	4,7	0,9	2,4	0,3	1,9
MN-10	346	0,9	7,1	623	0,4	101	0,9	100	24	41	85	10	37	7,3	1,6	7,5	0,9	4,9	0,9	2,5	0,3	2,1
MN-11	204	1,2	6,1	574	0,5	25	2,1	87	22	40	85	9	36	7,3	1,7	7,2	0,9	4,7	0,9	2,4	0,3	2,0
MN-12	204	1,2	6,8	334	0,2	21	2,0	66	17	33	69	8	30	6,0	1,3	6,0	0,7	3,8	0,7	1,9	0,2	1,5
MN-13	252	1,0	7,7	389	0,0	20	2,1	106	23	45	92	10	40	8,0	1,8	8,3	1,0	5,1	0,9	2,6	0,3	2,0
MN-14	257	1,3	8,2	1189	0,4	29	2,5	94	21	38	79	9	34	7,0	1,8	6,8	0,8	4,4	0,8	2,2	0,3	1,8
MN-15	193	0,9	6,3	390	0,5	36	1,5	58	18	29	63	7	26	5,3	1,2	5,5	0,7	3,4	0,6	1,8	0,2	1,4
MN-16	138	0,8	3,5	278	0,3	14	1,3	73	20	33	70	8	30	6,1	1,4	6,2	0,7	4,0	0,8	2,1	0,3	1,7
MN-17	216	1,3	7,3	434	0,2	22	1,8	58	20	39	82	9	35	7,0	1,6	6,8	0,8	4,4	0,8	2,2	0,3	1,7
MN-18	193	0,8	6,4	337	0,2	20	1,8	103	24	47	98	11	42	8,5	1,9	8,4	1,0	5,3	1,0	2,7	0,3	2,1
MN-19	257	1,7	6,4	421	0,6	24	2,1	106	30	45	96	10	40	8,3	1,9	8,5	1,1	5,8	1,1	3,1	0,4	2,7

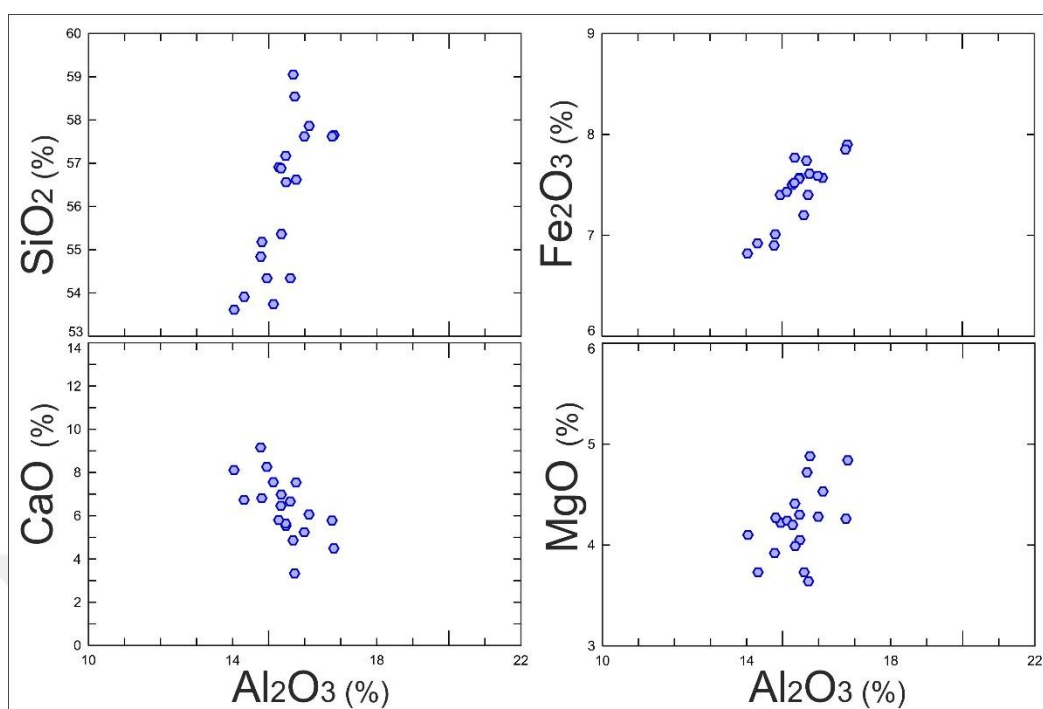


Figure 1.23: Binary plot of major elements SiO₂, CaO, Fe₂O₃, MgO versus Al₂O₃ (in wt.%) of Monochrome ware.

Like major elements, the trace element composition of Monochrome wares mostly has similar chemical behavior, but also there are variations in some elements. For example; trace elements distribution generally has high value like Co: (22-30 ppm), Ni (123-187 ppm), and As (36-60 ppm) and Sc (57-116 ppm). Incompatible elements of LILE like Rb (103-138 ppm), Sr (170-346 ppm), Ce (62-116 ppm) and Ba (239-1188 ppm) indicate mostly close to the average value. However, Ba remarkably has variable values, Sr has some low values, and Ce has high values. Gd (5,52-9,41 ppm), Th (9,09-14,49 ppm), Tb (0,06-1,06 ppm) of Rare Earth Elements has average composition but Th and also Eu (1,1-1,9 ppm) has some high values. According to the Post Archaean Shale PAAS, REE elements are plotted on the spider diagram, where the La, Ce, Pr, Nd show similar values, but some Ce samples shows a positive anomaly. In addition, Ho, Er, Tm, Yb, Lu show depletion against average value and also Eu, Sm, Gd show enrichment against average value on the PAAS diagram in Figure 5.24.

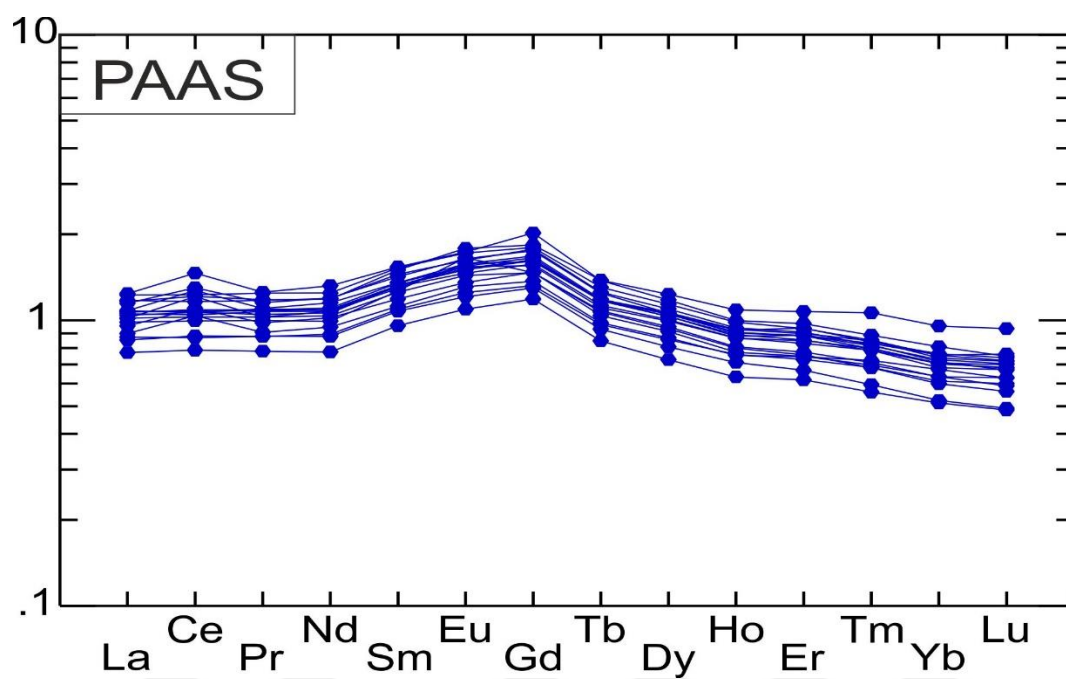


Figure 1.24: Post Archean Australian Shale (PAAS) normalized REE-s element diagrams of the Monochrome wares. PAAS values: Taylor and McLennan, 1985.

2. DISCUSSION

6.1 The Provenance of the Potteries

6.1.1. The provenance of the White Slip I and White Slip II ware

In order to understand provenance of the archaeological ceramics, geochemical and petrographic analyses provide great help. Using such analyses, we can interpret and define the source area of the raw material of the potteries.

The White Slip I (WS I) and the White Slip II (WS II) wares found in Alalakh, show very similar petrographic and geochemical characteristics. As a general, petrographic-mineralogical analyses indicate that main mineral inclusions in the White Slip wares are magmatic minerals rather than metamorphic or sedimentary. For example, main mineral inclusions in the White Slip ware are pyroxenes, hornblende, plagioclases, bitotite and quartz. This mineral paragenesis allow us to infer that raw material (clay source) of the White Slip ware is probably derived from igneous rocks. In addition, especially existence of orthopyroxene and clinopyroxene reveal mafic magmatic source area. Because orthopyroxene is one of the first crystalized minerals in the magma evolution and are typically observed in ultramafic rocks. Furthermore, the occurrence of the low amount of quartz and absence of K-feldspar in the potteries are other supporting facts of this idea about the origin. On the other hand, some subgroups of the White Slip wares contain higher amount of plagioclases and some rock fragments (probably andesitic origin). Therefore, it can be thought that clay material of the White Slip samples show variation to each other. Contribution of the andesitic rock fragments as inclusions also indicates intermediate rock source for the clay material. This is probably as a result of local variation in the catchment area.

Similar to petrographic results, geochemical analyses also support the idea about the origin of the WS I and WS II wares' clays. The major element amounts exhibit mafic characteristic rather than felsic and calcareous, because of the low K_2O (0.74 wt.%), Na_2O (1.47 wt.%) and low CaO (4.12 wt.%) and high Fe_2O_3 (10.33 wt.%) and MgO (6.48 wt.%) amounts (exp. Al_2O_3 vs. Fe_2O_3 and Al_2O_3 vs. CaO diagram in Figure 6.1).

Trace element compositions of the WS potteries also indicate mafic source area. For example; like Ni (90.65 ppm), As (40.70 ppm), Co (36.60 ppm) etc. elements which show calcophilic and siderophilic affinity are common in the Earth's core (exp. Ni/Co diagram in Figure 6.1). The concentration of these elements decrease when the rock acidity increases. According to WBR (World Reference Base for Soil Resources, 2006), The WS I and WS II ware include high amount of these elements and their amounts are in a range of typical mafic rock class (Kabata Pendias, A., 2011). Other trace elements like Rb (12.20 ppm), Li (25.58 ppm), Sr (91.52 ppm), Ce (22.08 ppm) have alkalinity property having similar behavior with K, Ca elements and they are mostly enriched in the lithosphere (exp. Rb/Sr diagram in Figure 6.1). Therefore, the low amount of these elements, basically, refers to a mafic chemical affinity of the parent rock. In addition, the Rare Earth Element (REE) behavior of the samples points mafic parent rock as it is seen in major and trace elements mentioned. For example; Light Rare Elements (LREs), La, Ce, Pr, Nd, Sm, Eu and Gd, display depleted pattern for the WS I and II wares in the spider diagram (Chapter 5, Figure 19 and 21), whereas Heavy Rare Earth elements (HREs), Tb, Dy, Ho, Er, Tm, Yb and Lu, display enriched pattern. The LRE elements mostly are found in felsic rocks like granite while HRE elements are found in mafic rocks like gabbro and basalt etc. Thus, the enrichment in the HRE indicates that the raw material of the White Slip potteries derived mainly from the mafic sources.

Although WS I and WS II wares have similar petrography and geochemical characteristics indicating most probably the same provenance, there are some internal local variations. This variation can be seen on binary diagrams like La/Lu, La/Sc, Th/Co, Th/Sc (see Figure 6.2). These trace element ratios are good indicators for the sediments and widely used for determination of the provenance (Rollinson, 1993).

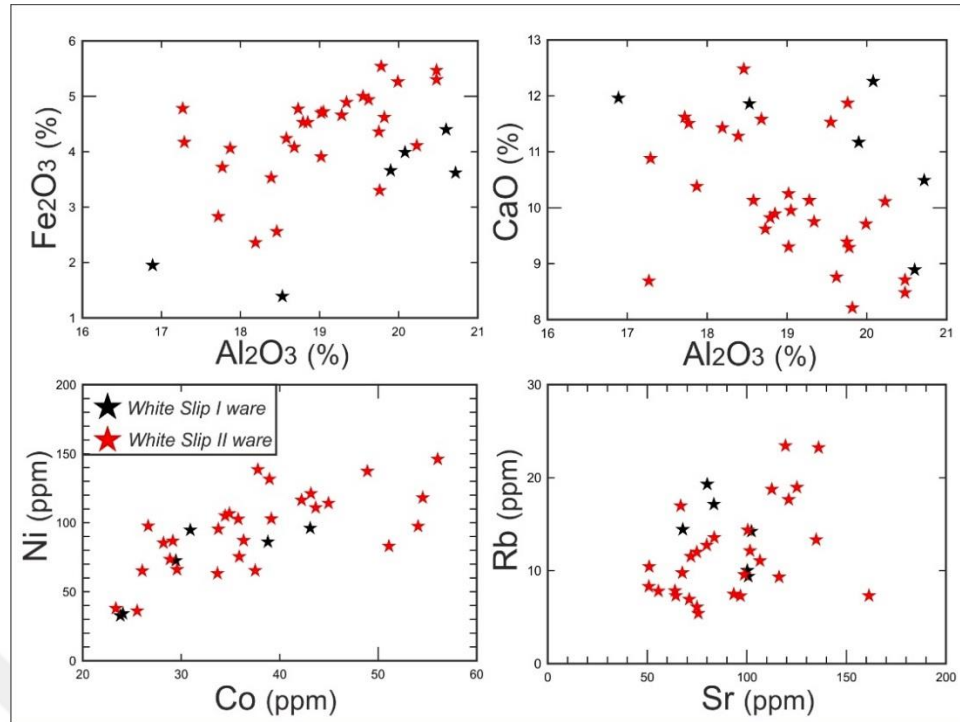


Figure 2.1: Binary plot of major and trace element distributions of the White Slip I and White Slip II samples for Al₂O₃ vs. Fe₂O₃ and CaO (wt.%), Co-Ni, Sr-Rb (in ppm) diagrams.

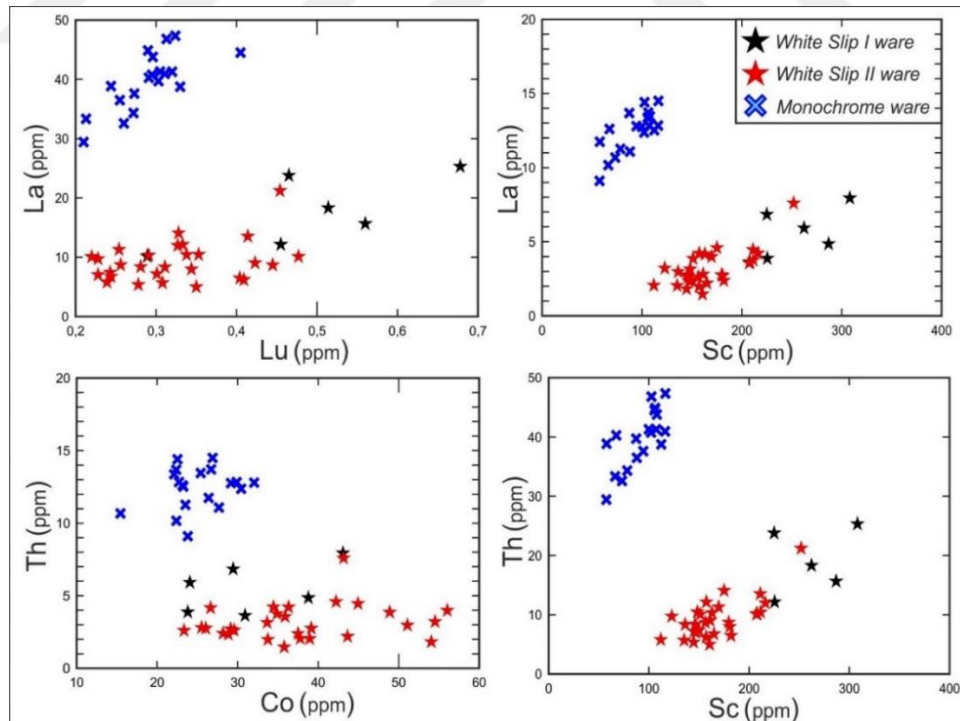


Figure 2.2: Binary plot of trace element distributions of the White Slip I, White Slip II and Monochrome samples for La-Lu, La-Sc, Th-Co, Th-Sc (in ppm) diagrams.

6.1.2 The Provenance of the Monochrome ware

All Monochrome (MN) sample from the Tell Atchana show very similar petrographic-mineralogical and geochemical features. In petrographic studies it is observed that the samples of the Monochrome ware do not contain much mineral inclusions, which cannot allow to determine their provenance. Inclusions contain average 5% of total amount in the samples and main mineral inclusions are fragments of sandstone and mudstone and also quartz minerals. Additionally, the MN wares include minor amount of very fine grained plagioclase and white mica minerals in the paste. These micas are serisitic. At least these features point out that the raw material of the MN ware associate with clastic sedimentary rock (no calcite) or metapelite? provenance.

The geochemical results of major element contents of the MN samples do not give a direct and a precise provenance because geochemistry of the sedimentary originated raw materials do show very variable results, and geochemistry of the major elements alone cannot be used for provenance studies. The samples of the MN have low amount of Na_2O (1.30 wt.%) and Al_2O_3 (15.44 wt.%), moderate CaO (6.37 wt.%) and MgO (4.23 wt.%), moderate to high Fe_2O_3 (7.43 wt.%) and also relatively high amount of K_2O (3.44 wt.%). The very low amount of CaO contents show that the clay source of the samples is not related to any calcareous sedimentary rock like limestone and dolomite. Therefore, the source of the raw material probably related to terrigenous clastic sedimentary rock.

The trace elements of the MN ware represent similar values with argillaceous sedimentary rock value when compared to WRB (World Reference Base for Soil Resources, 2006). For example; Rb (117.05 ppm), Sr (239.91 ppm), Li (79.94 ppm), Be (2.90 ppm), Cs (6.68 ppm) elements amount of the MN ware clearly correspond to sedimentary rock values but Sr has little bit lower value. Low Sr value is a result of depletion of the CaO in the samples because these two elements behave as same manner. The REE show enrichment for the LRE elements in the PAAS normalized diagram while depletion pattern for the HRE elements (chapter 5-figure 26), which point probably out clastic sedimentary (or metapelitic) source for the MN potteries. On the other hand, some elements like Sc (91.97 ppm), Ni (141.21 ppm) and Co (25.05 ppm) show higher values compared to average of the sedimentary rock values (FAO/UN, 2006).

6.2. Comparison of the Monochrome ware with the White Slip wares

Some authors suggested that the WS and the MN wares has the same/similar petrographic features and their clay sources are also same indicating same provenance (Todd and Hadjicosti, 1991). Moreover, according to isotope analysis ($^{207}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$) the Monochrome and the White Slip wares found in the Sanidha site show fairly similar clay source characteristics (Renson, 2013). On the other hand, Knapp and Cherry (1994) claimed that these two wares are different from each other and they associated the Monochrome ware with different Cyprus pottery group. Therefore, we also would like to compare the MN and WS potteries to be able to compare them with the other regions and studies. When we compared MN ware with the WS I and WS II ware, it seen clearly that there are obvious differences between them. For example, according to mineralogical and petrographic characterization, WS potteries contain clinopyroxene, orthopyroxene, hornblende, white mica, plagioclase, quartz minerals, while MN potteries contain mudstone and sandstone rock fragments, minor amount of plagioclase and muscovite. Another example, according to geochemical characterization, the MN wares show negative correlation in Al_2O_3 against CaO diagram while WSI and WSII ware show positive correlation. These differences can also be seen in Al_2O_3 against K_2O diagram which is a good indicator for provenance. Besides, K_2O content of MN ware are higher than the WS I and II wares (Figure 6.3). Similar differences are also seen in trace element contents such as Ni, Cs, Li, Ce, Sr, Th, Rb and REEs. For instance, both in Ni vs. Co and Rb vs. Sr diagrams, differences between Monochrome and the White Slip wares are clear, even though those elements represent different chemical characteristics such as, siderophile and lithophile, respectively (Figure 6.4). In addition, when we compared WS I –WS II with MN ware on spider diagram (Figure 6.5 and 6.6), having different provenance can be seen between WS and MN samples. According to spider diagrams which represent upper and lower continental crust values (Taylor and McLennnon, 1985; Rudnick and Fountain, 1995), the trace elements of WS I and WS II samples are close with Lower continental crust values despite Ba, U, Sr anomaly (Figure 6.5). On the other hand, trace elements of the MN samples are close with Upper continental crust values despite U, Sr, Co, Ni anomaly (Figure 6.6).

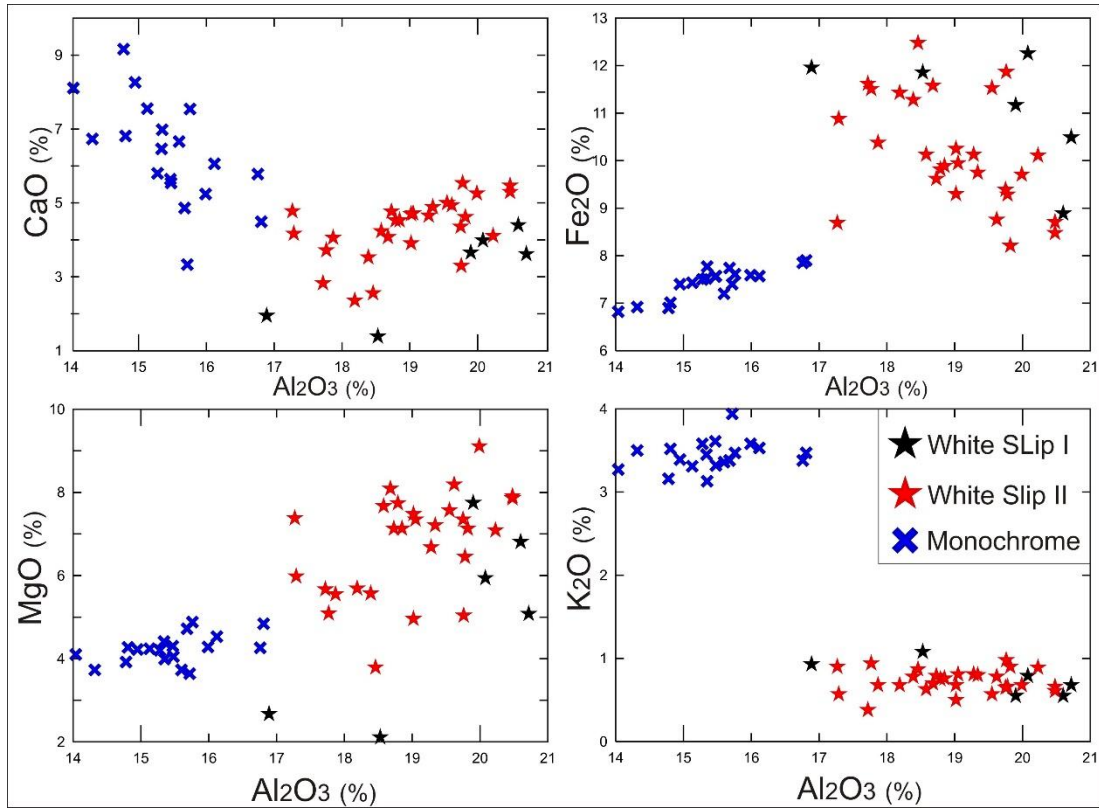


Figure 2.3: Binary plot of major element distribution of the White Slip I, White Slip II and Monochrome samples in Al₂O₃ (wt.%) versus CaO, Fe₂O₃, MgO, K₂O (wt.%) diagram.

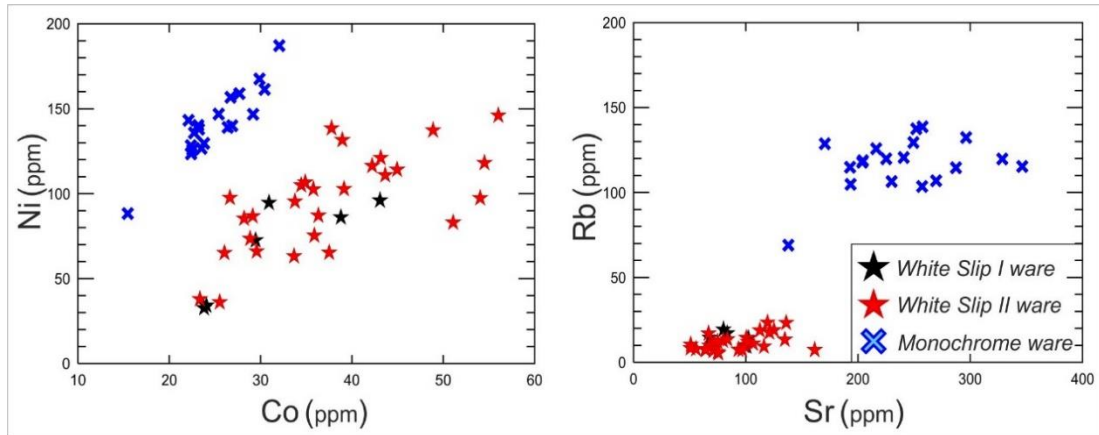


Figure 2.4: Binary plot of trace element distribution of the White Slip I, White Slip II and Monochrome samples for Ni versus Co and Rb versus Sr (in ppm).

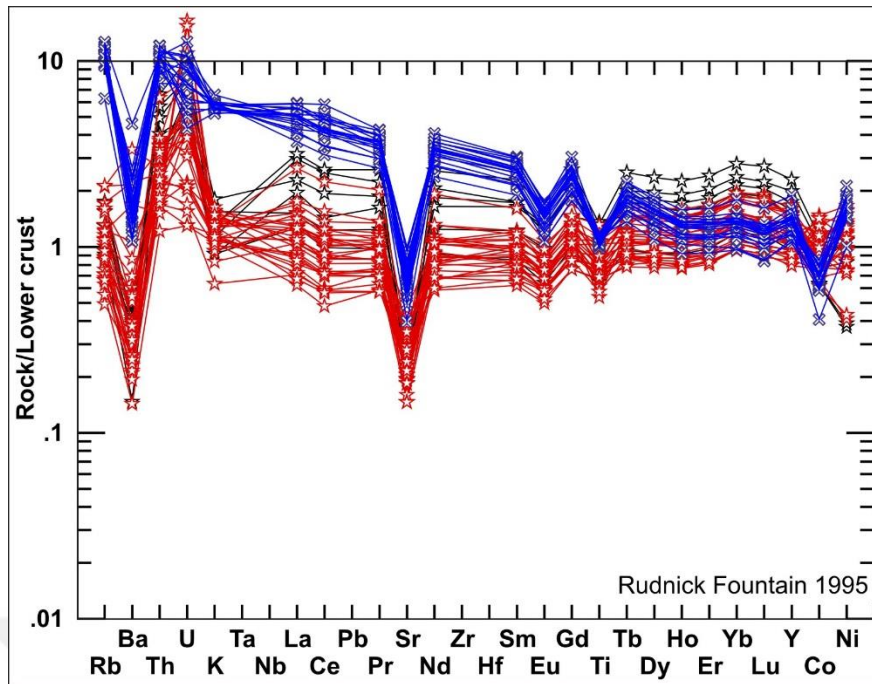


Figure 2.5: Lower Continental Crust-normalized diagrams for trace elements of the WS I, WSII and MN potteries. Lower crust values: Rudnick and Fountain, 1995.

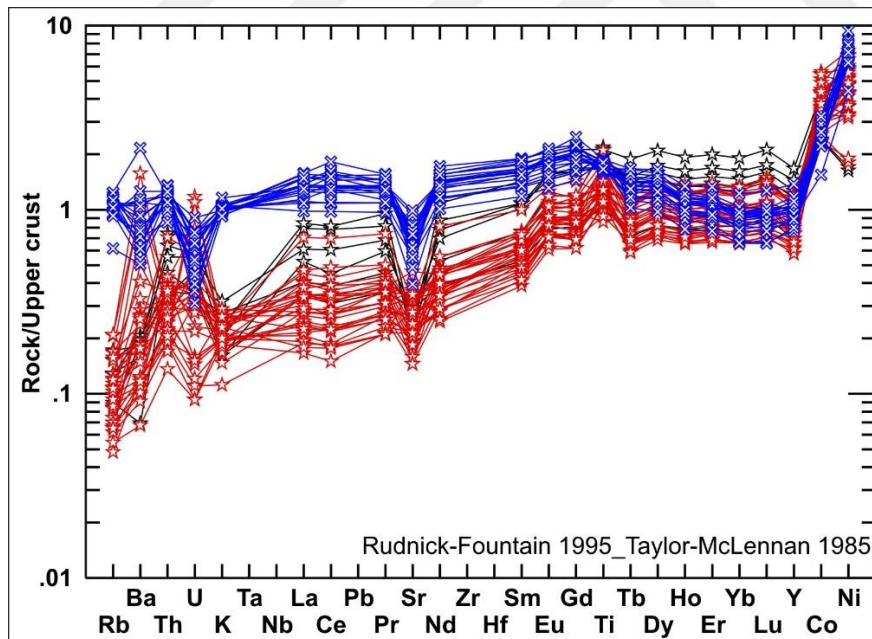


Figure 2.6: Upper Continental Crust-normalized diagrams for trace elements of the WS I, WSII and MN potteries. Upper crust values: Taylor and McLennan, 1985; Rudnick and Fountain, 1995.

6.4. Comparison with Previously Published Data

6.4.1. Comparison of the WS I and WS II wares with the other Cyprus White Slip wares

As mentioned in previous chapter, the White Slip ware had been very popular pottery type in the East of the Mediterranean, Anatolian and Levant sites during the late bronze age. One of the reason of this popularity is that the White Slip wares are durable, simple, suitable for storage and transport, suitable for hot and cold liquids and also slightly and fashionable. Therefore, it had been used for a long time during Late Bronze Age (Karageorgis, 1994) and they were probably transported and traded easily to various areas. According to archaeological studies, WS wares was found in Cyprus, Egypt, Israel, Syria, Turkey, and Crete. The distribution of the White Slip wares, which contain our data location and collected data location is shown in Figure 6.7.



Figure 2.7: According to archaeometric studies, the locations of our WS and MN ware and collected WS and MN ware from previous study. White Slip locations from previous studies are Ayios Jakavos, Morphou, Palaepaphos, Larnaca, Sanida, Enkomi, Hala Sultan Tekke, Minet El-Bedia, Tell Akko, Kommos. Monochrome locations from previous studies are Kalopsidha, Phlamoudhi, Tyre (see appendix A).

Because of very spread distribution of the White Slip ware, to establish its origin is a matter of debate. Furthermore, it is a good problem to solve. Therefore, we did chemical analysis on the White Slip ware to understand its production center. According to previous studies, production center of the White Slip ware is shown in southern Troodos massif and raw material of the White Slip ware is accepted as unique and they stated that it was derived mainly from mafic and ultramafic rocks (Courtois, 1970; Artzy et. al., 1976; Courtois and Velde, 1980). The reason of this inference, any other Cypriot ceramics produced in Cyprus do not have mafic or/and ultramafic material that make different raw clay of the White Slip than others (Knapp and Cherry, 1994). Similarly, Grave et al. (2014) also suggested that the WS I and WS II wares are associated with the southeastern part of the Troodos massif. According Knapp and Cherry. (1994), although there is no certain conclusion about the origin of the WS wares because of their uncertain nature of unpublished data, there could be several chemical groups and subgroups, which also lead researches to different provenance regions (see also Artzy et al., 1981). However, they generally accept that the Troodos region is the production center of the White Slip ware (Knapp and Cherry, 1994). In addition to these studies Tomlinson et al, (2010) analyzed the WS I and WS II wares 29 White Slip II wares were found in Kommos, which are thought to be import from Cyprus to Kommos (see Tomlinson et al, 2010 for references). Based on this study archaeometric analysis on the White Slip revealed that these potteries were related to Limassol area that is located in the south of Cyprus (Tomlinson et al, 2010; see also Bryan et al., 1997). On the other hand, according to another study, WS wares were taken from 3 different areas (Sanidha, Hala Sultan Tekke and Minet El-Beidha) and based on the analytic result, the production center of the White Slip ware was related to different areas; Sanidha (1) or different location in the foothills of the Troodos Ophiolite (2) or perhaps from Syria (3) (Renson et al., 2013). Briefly, although there is a common believe about the production region of the WS potteries, which is somewhere around the Troodos Massif, there is no precise location mentioned in the previous studies.

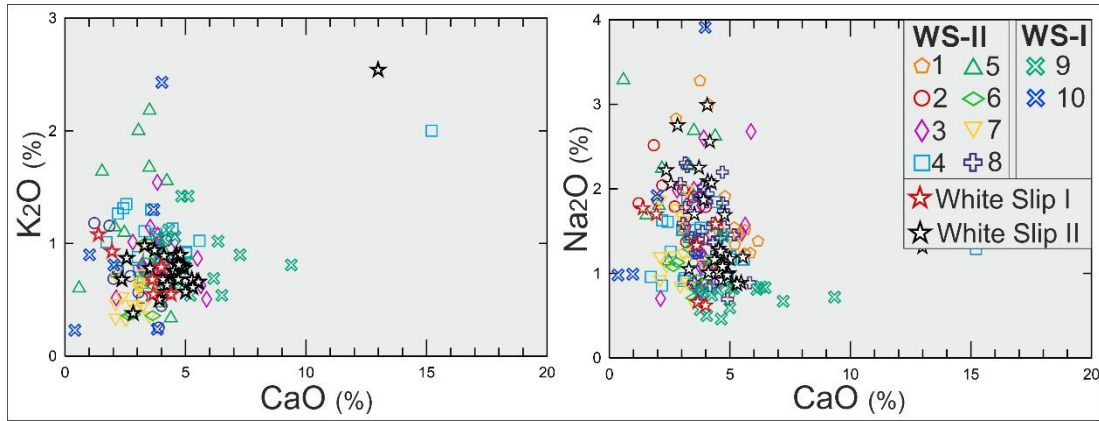


Figure 2.8: Binary plot of major element distribution of the WS I and WS II wares in CaO (wt.%) versus Na₂O and K₂O (wt.%). Besides our samples derived from the Alalakh excavation, samples from the previous studies also included for comparison. Regions are; 1: Tell Akko (), 2: Milia, 3: Larnaca, 4: Ayios Jakavos, 5: Enkomi, 6: Sanidha, 7: Hala Sultan Tekke, 8: Kommos, 9: Palaepaphos, 10: Morphou (see references in the Appendix A).

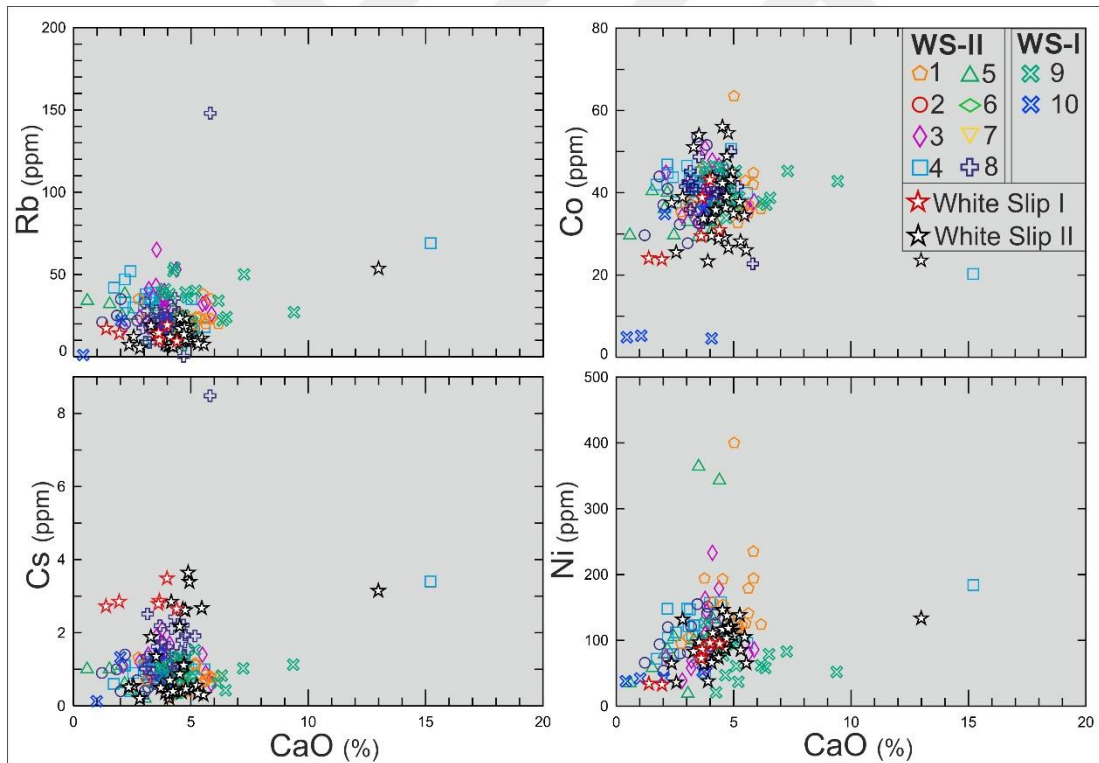


Figure 2.9: Binary plots of trace element distribution of the WS I and WS II wares. The samples are plotted in CaO (wt.%) versus Rb, Cs, Co and Ni (ppm) diagrams. Other WS I and II sample locations are; 1: Tell Akko, 2: Milia, 3: Larnaca, 4: Ayios Jakavos, 5: Enkomi, 6: Sanidha, 7: Hala Sultan Tekke, 8: Kommos, 9: Palaepaphos, 10: Morphou (see references in the Appendix A).

As far as all data, I correlated our data with other WS pottery data from previous study. Our comparison shows that in spite of some differences, all the White Slip potteries show similar geochemical characteristics. For example, all the White Slip data obtained from the other regions plotted together with the Alalakh White Slip samples on CaO against Na₂O and K₂O diagrams (Figure 6.8). Moreover, it is seen that all data show similar geochemical characterization for the trace elements such as; Ni, Rb, Co, Cs, Sm, Nd, La, Eu, (Figure 6.9 and 6.10) Ce, Th, Lu, elements (not all shown in the figures). Therefore, to sum up, the WS I and WS II ware from Tell Atchana indicate that their data correspond with the previous White Slip data's.

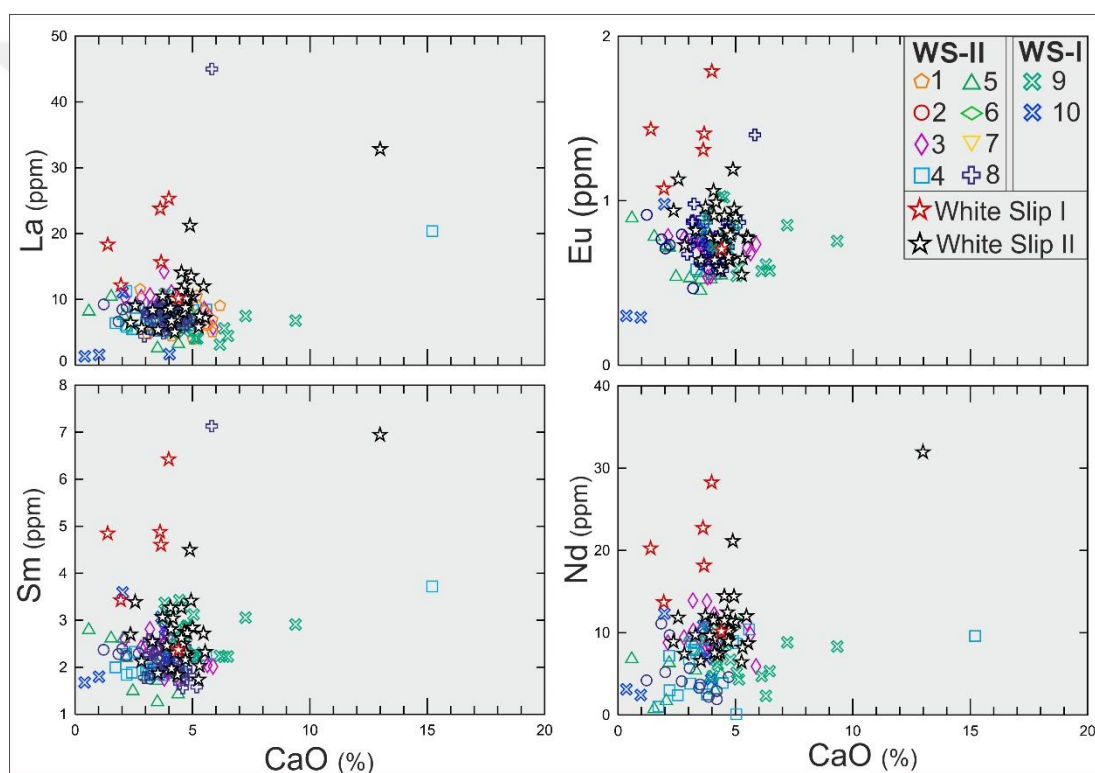


Figure 2.10: Binary plot of trace element distribution of the WS I and WS II wares. The samples are plotted in CaO (wt.%) versus La, Eu, Sm, Nd (ppm) diagrams. Other WS I and II sample locations are; 1: Tell Akko, 2: Milia, 3: Larnaca, 4: Ayios Jakavos, 5: Enkomi, 6: Sanidha, 7: Hala Sultan Tekke, 8: Kommos, 9: Palaepaphos, 10: Morphou (see reference in Appendix A)

In detail, although our data display similar geochemical behavior with other Cyprus WS ware data obtained in the previous studies, our White Slip data (both I and II) remarkably correspond to WS II sherds found in Kommos site (no WS I published). Moreover, Tomlinson, (2010) proposed that these White Slip potteries found in Kommos (import material) are related to Limassol Area located in the southwest of Cyprus (data used from Bryan et al, 1997). This distinction can clearly be seen in some diagrams. For example, our White Slip data plotted in the same area with the Kommos WS II wares, while some others (Sanidha, Hala Sultan Tekke and Minet El-Beidha) plotted in different area on the major diagrams of Al_2O_3 versus CaO and Na_2O (Figure 6.11). Therefore, as briefly stated, there is no considerable geochemical differences for all Cyprus White Slip data. However, in detail our data is more similar with the Kommos WS II wares (Limassol area).

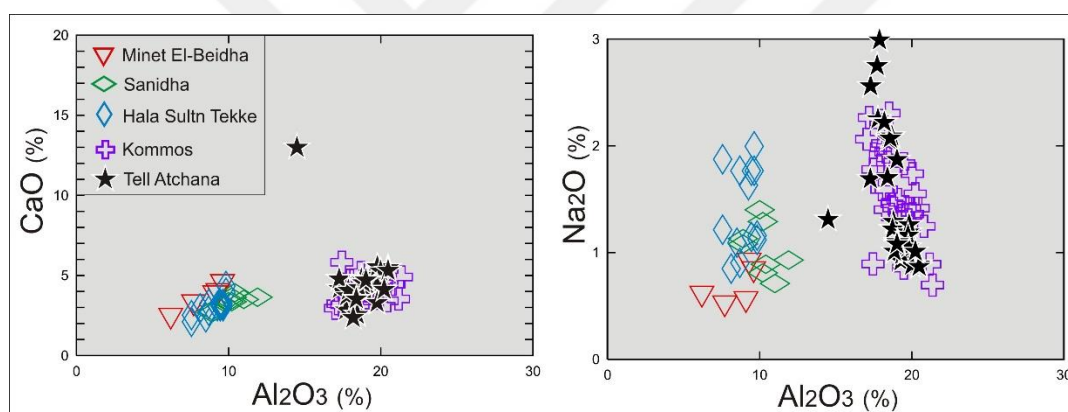


Figure 2.11: Binary plot of major element distribution of the WS II wares compiled from different regions and our own data. Diagrams are Al_2O_3 (wt.%) versus CaO and K_2O (wt.%) (for references see Appendix A).

6.4.2 Comparison of the MN wares with other Cyprus Monochrome wares

The Monochrome ware of the Late Bronze age, is the one of the Cypriot ceramic types. Although it was not as popular as the White Slip ware, it was also popular in the Mediterranean from Levant to Cyprus. However, as we discussed in previous sections, there are not enough specific archaeometrical study about the Monochrome ware. Thanks to the Knapp and Cherry (1994) source and also Lawrence Berkeley National Laboratory (2014), we could reach 21 Monochrome geochemical data that was found in several areas (appendix A). According to an isotope study (Renson et al., 2013) the MN wares reported as similar to WS wares, but any major and trace element data provided in this study and it made impossible to compare them with our geochemical data. This create a confusion about the similarities of the MN wares which are found in different regions. The MN wares found in different regions can be different in origin but to make a decision we do not have any geochemical and petrographic data published from such region.

Thus, comparable geochemical data are represented by the samples from Kalopsidha in eastern Cyprus, from Phlamoudhi in northeastern Cyprus and one sample from Tyre in Syria (Figure 6.7). First, result of the all data display several behaviors for some elements. For example; CaO and Na₂O content of our MN sample are close to the MN sample (n=14) which was taken from Kalopsidha (Figure 6.12-a). These similarity is also seen Ni, La, Th elements and its example can be shown in CaO versus Ni, La, diagrams (Figure 6.12-b). Moreover, Similarity between MN (Tell Atchana) and MN (Kalopsidha) are seen on Ba, Cs and Yb elements but not so much. On the other hand, for some elements, the MN ware from Kalopsidha show different pattern than the MN ware taken from the Alalakh. For example, it is clear in K₂O versus Rb diagram (Figure 6.13-a) and CaO versus Rb, Ce diagrams (Figure 6.12-b). Another striking point here is that, the Monochrome samples from Kalopsidha area separated into two distinct groups. In addition, after comparison all data, our MN samples display mostly similar feature with other MN samples from Kalopsidha, Phlamoudhi and Tyre. For example, they appear similar in Na₂O versus Co, Th and in Lu vs. Th diagram, while they do not appear similar in the La vs. Sc diagram (Figure 6.13).

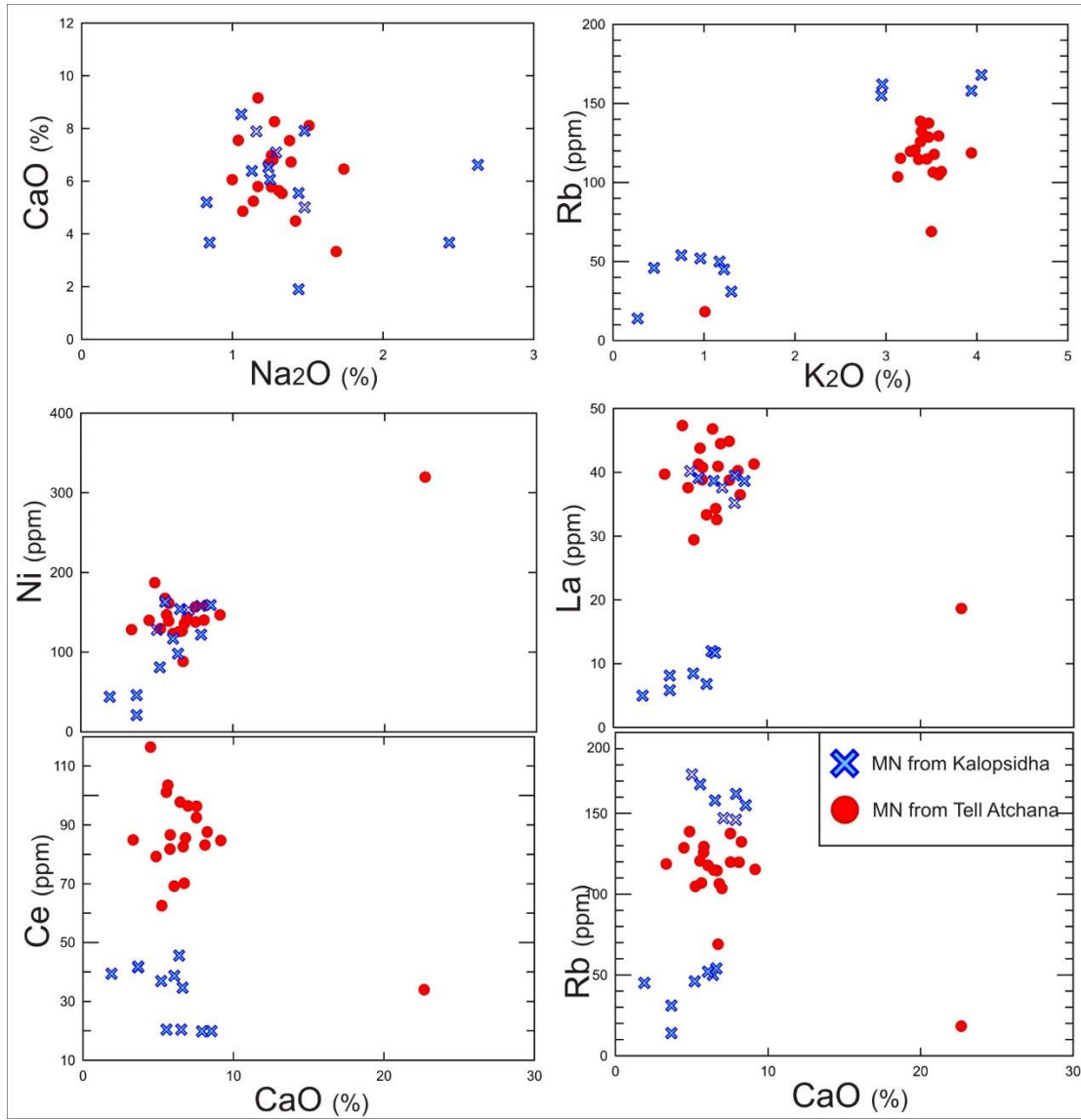


Figure 2.12: Binary plot of major and trace element distribution of the Monochrome wares compiled from different regions and our own data. Diagrams are a) in Na₂O (wt.%) vs. CaO (wt.%) and K₂O (wt.%) vs. Rb (ppm), b) CaO (in %wt.) versus Ni, La, Ce, Rb (ppm).

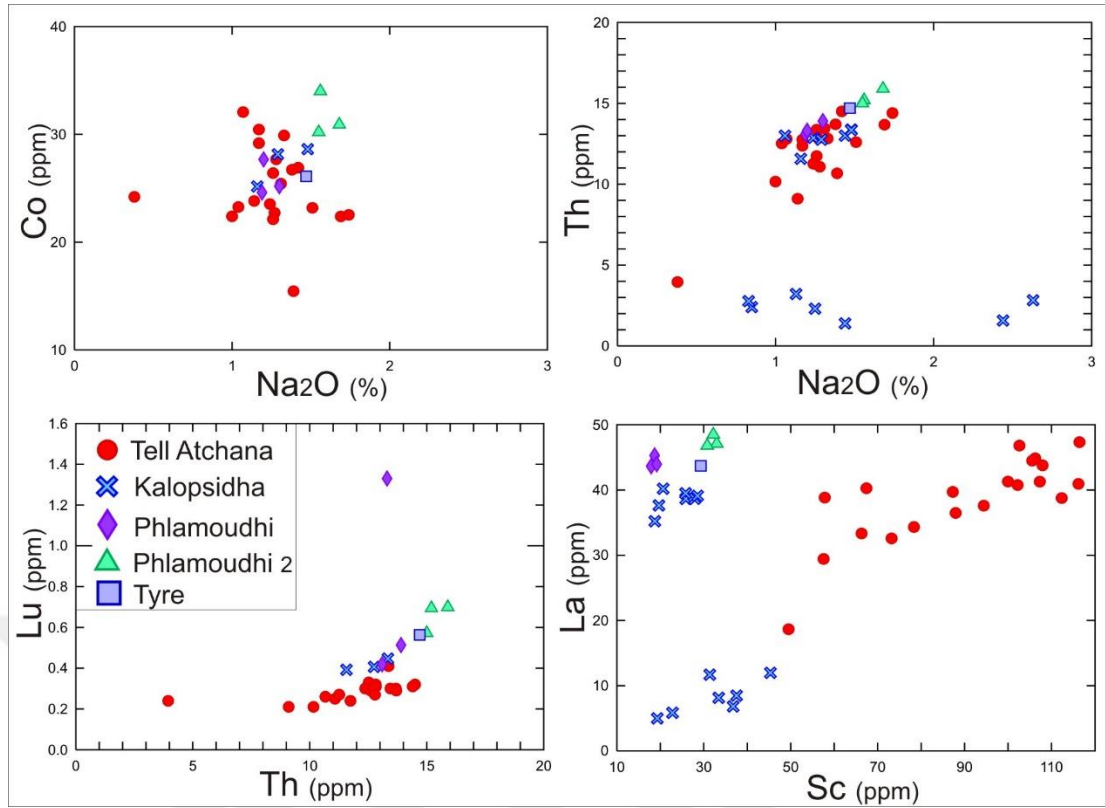


Figure 2.13: Binary plot of major and trace element distribution of the Monochrome ware in Na₂O (wt.%) versus Co and Th (ppm). Besides our samples derived from the Alalakh excavation, samples from the previous studies also included for comparison. Regions are; Kalopsidha, Phlamoudhi, Tyre (see references in the Appendix A).

6.5 Comparison of The WS I, WS II and MN Wares with The Clay Sources of the Amuq Region and The Cyprus

6.5.1. Comparison of the WS I, WS II, MN wares with the clay sources of the Amuq Valley

One of the main concern in determination of the provenance of archaeological materials is that; do they produced locally or they produced in far regions and transferred to the site where they are found. Local productions are mainly imitations of the original. Even they have same archaeological features such as color and morphology, their petrography and chemistry are different. They are transported as import goods for the purpose of commerce. Due to determine their provenance, first we should ensure that is there any relation with the Amuq region clay sources and sherds which are found in Alalakh excavation. Because there are considerable amount of the White Slip and the Monochrome sherds found in this region.

Many of the previous studies have supported the idea that White Slip ware was produced in a place where the Troodos Ophiolite exposed and altered to produce clay beds (southern Cyprus) (Courtois and Velde, 1980; Knapp, 1994, Gomez, 2002). They claimed that, the White Slip most probably was produced in Sanidha (Cyprus); however, some other WS sherds possibly was produced in another region such as; in somewhere derived from near in Troodos or near in Syria. Especially latter argument had raised the question that could there be any other different production centers for the White Slip wares. As it was mentioned in the previous sections main inclusions in the potteries are mafic-ultramafic minerals. Like the Troodos massif, the Kızıldağ ophiolite complex in Antakya region has similar rock types (see Gutsuz et. al, in prep.). These two ophiolitic complex, Kızıldağ and Troodos Massif, can produce similar alteration products of the ceramic raw material because of the including mafic and ultramafic rocks. Therefore, the raw materials of the White Slip ware may be a product of the Kızıldağ ophiolite. To better understand and to ensure, it is required to analyze representative clays in the Amuq valley and compare them with our sherds' data.

Besides, there have not been enough provenance research done for the Monochrome ware yet. Only it was reported that Monochrome ware was produced probably in Karpas, Troodos and eastern Cyprus regions (Knapp, 1994). Renson (2013) claimed that according to $^{207}\text{Pb}/^{204}\text{Pb}$ vs $^{206}\text{Pb}/^{204}\text{Pb}$ isotope analyses, the source area of the Monochrome and White Slip ware are probably the same. However, any of them have given a specific production location for the Monochrome ware.

Sixty-four clay samples was taken from all over the Amuq Valley in order to examine the character of the local clay (Gutsuz et al, in prep.). The main goal of such project conducted by Gutsuz et. al., was to perform geochemical analysis on these clay samples and to show general characteristics of clay sources and their distribution in the Amuq valley. For this purpose, they produced concentration distribution maps to display clay source differences (for the detail see Gutsuz et al., in prep).

According to this study, four compositional clay groups clustered in different parts of the Amuq valley are reported (Gutsuz et. al., in prep). These four clay groups are associated with four drainage network which run into the Amuq valley. These are Orontes, Karasu, Afrin and Kırıkhan rivers. The Orontes clay group is located in south of the Amuq Valley and very close the Tell Atchana archaeological site so this group most likely can be a source area of the raw material for the potteries excavated. Generally, potters choose an area close to production center for taking raw material, in fact the Amuq basin is not such a big area for the long distance transport. Also, valley provide very isolated area for clay deposits to potters because it was all surrounded by mountains. Therefore, we must take into consideration equally both closest and remote groups in the Amuq valley.

The first one is the Orontes clay group. There are two predominant lithology feeding the Orontes clay group; mainly limestones, marls (Jurassic-Cretaceous and Miocene-Pliocene) and basaltic rocks (late Miocene-early Pliocene) (Bridgland et al., 2012). Therefore, the Orontes clay group is characterized by very high CaO (36,2 wt.%), high Na₂O, slightly high MgO, Fe₂O₃, low SiO₂, Al₂O₃, slightly low MnO, K₂O and TiO₂ amounts (Gutsuz et. al, in prep.) The trace elements accompanying with the related major elements show similar compositional behavior. The REE elements show homogenous distribution pattern in the valley (Gutsuz et. al., in prep).

Second one is the Afrin group. The geochemistry of the Afrin group is different because deposits carried by the Afrin river and its tributaries fed by different rock types that are different from other regions. When we compare this group with others this clay group show relatively low CaO and MgO amounts but high SiO₂, Al₂O₃, MnO and TiO₂ values. Trace element compositions show similar behavior with the major elements and are easily distinguished from other clay groups. However, some samples show high MgO, Cr and Ni contents, according to Gutsuz et al (in prep.), this can be reason of basaltic rocks exposed in the south of the Afrin River.

Third group is the Karasu clay group that is located in the northern part of the Amuq Valley. This group is fed by terrigenous sedimentary rocks (Precambrian to Upper Ordovician). Element concentrations of this clay group show high value of SiO₂, Al₂O₃, TiO₂, Na₂O major oxides and high value of Ba, Rb, Zn, Th etc. trace elements and REE elements. However, CaO and MgO contents show low values especially compared to the Afrin and Orontes clay groups, and also some trace elements like Sr, Ni, Cr, Co has low values. Last one is the Kırıkhan clay group that covers small area in the Amuq valley, which is located in the southwestern part of the Amuq Valley. This clay group slightly distinguished from the other clay group, because clays are profoundly derived from mafic and ultramafic (peridotite and harzburgite) rocks belong to the Kızıldağ ophiolite. Therefore, major element concentrations are different from each other. For example; major oxide MgO and trace elements like Ni, Co, Cr show relatively very high values compared to other clay groups in the region (Gutsuz et al., in prep).

Using this clays source data, we can say that the clay sources in the Amuq Valley seems different from the raw material used for the WS I and WS II ware and the MN wares. The major element contents of the clay samples show relatively lower Al₂O₃ and little bit lower Na₂O and K₂O and higher MgO when we compare to the samples of the WS I, WS II and MN wares.

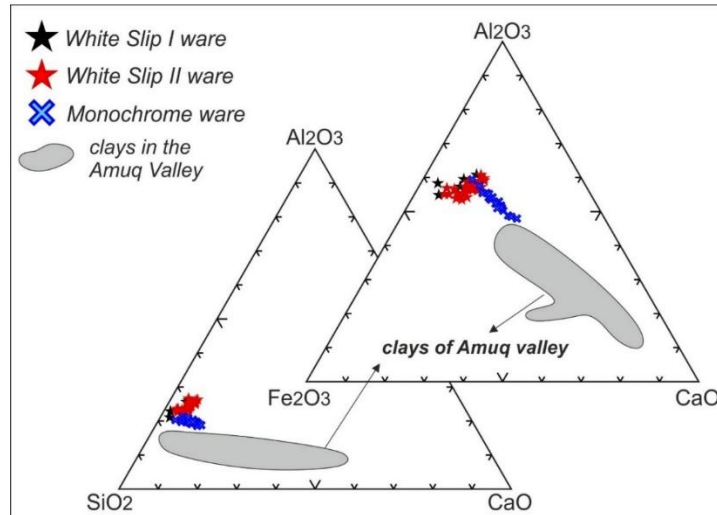


Figure 2.14: Ternary plot of SiO_2 - Al_2O_3 - CaO and Fe_2O_3 - Al_2O_3 - CaO , showing major element distribution of White Slip I, White Slip II and Monochrome wares. The gray shaded area shows major element distribution of the clay sources of the Amuq Valley (data after Gutsuz et.al, in prep).

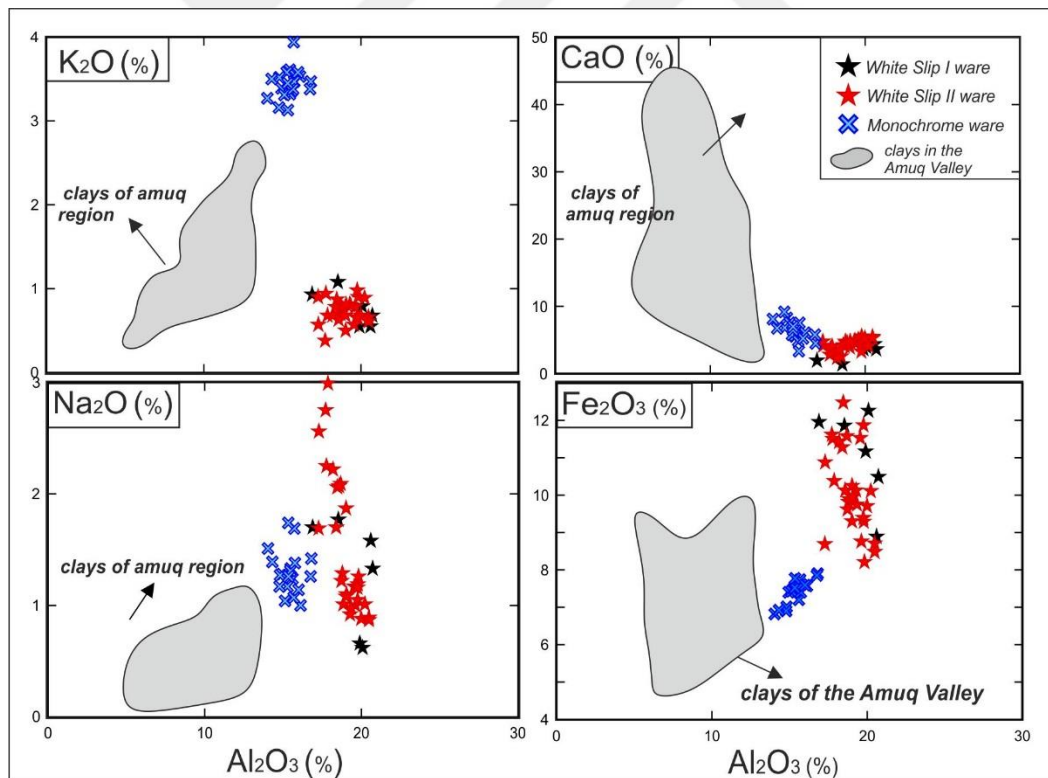


Figure 2.15: Binary plot of major element distribution of the White Slip I, White Slip II and Monochrome samples for Al_2O_3 versus K_2O , CaO , Na_2O , Fe_2O_3 (in %wt.) diagram. The gray shaded area shows major element distribution of the clay sources of the Amuq Valley (data after Gutsuz et.al, in prep).

First of all, Al_2O_3 values of the clay samples (less than 13 %) are lower than the potteries (higher than 15 %). For example, CaO contents of the clays have higher values than pottery samples and show large scatter because of different drainage networks sample different lithologies. Higher values directly related with the carbonates of the Arabian platform. Highest CaO values are obtained from south of the Amuq Valley near the Tell Atchana (Gutsuz et al, in prep). Both in ternary binary diagrams (Figure 6.14 and Figure 6.15) CaO has a large scatter and always higher values than the potteries. Another example, Fe_2O_3 and Na_2O contents of the clays have lower values than potteries, except the MN potteries have similar Fe_2O_3 values (Figure 6.15). MgO contents of the clays show high variation ranging from 3.5% to 23%. Therefore, some MgO content of clays show similar values with potteries whereas some others show higher values. Some clays have very high MgO contents, this is because of alternation and feeding of the Kızıldağ ophiolite these clay sources (Gutsuz et. al., in prep.).

Trace element behaviors of the WS wares show values are lower than clay samples such as; Rb, Sr, Ni, La and Ba (mostly). Trace elements of the MN wares show variations such as Sr and Ni amounts are lower than clay samples whereas Rb and La have higher values (Figure 6.16). In addition, Rare Earth Element values of the potteries show differences with clay source of Amuq region. For example, according to Post Archean Australian Shale normalized diagram, clay values of Amuq region plotted difference area than WS and MN values. WS samples show depleted pattern for La, Ce, Pr, Nd and Sm elements and enriched pattern for Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu by comparison with Amuq region values (Figure 6.17-a). According to PAAS diagram, MN samples show higher value than clay values of Amuq region. And MN samples show enriched pattern in La, Ce, Pr, Nd and Sm and depleted in Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu elements, whereas Amuq clays show depleted in La, Ce, Pr, Nd and Sm elements and plotted different region (Figure 6.17-b)

It is clearly seen that there are considerable geochemical differences between the potteries studied in the paper and the clays of the Amuq Valley. Therefore, the raw materials of the potteries do not match with the Amuq clays. We can clearly say that WS I, WS II and MN wares are not produced in the Tell Atchana or in a broader sense in the Amuq Valley.

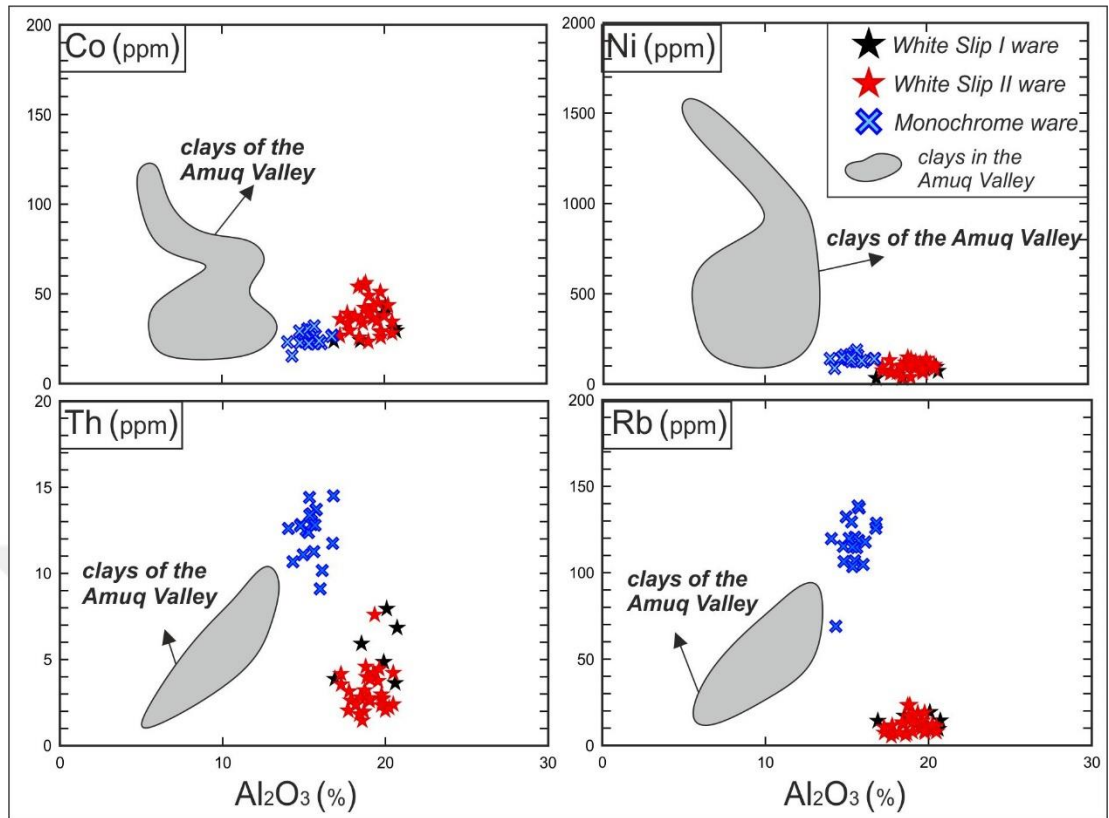


Figure 2.16: Binary plot of trace element distribution of the White Slip I, White Slip II and Monochrome samples for Al_2O_3 (in %wt.) versus Co, Ni, Th, Rb (in ppm) diagrams. The gray shaded area shows major and trace element distribution of the clay sources of the Amuq Valley (data after Gutsuz et.al, in prep).

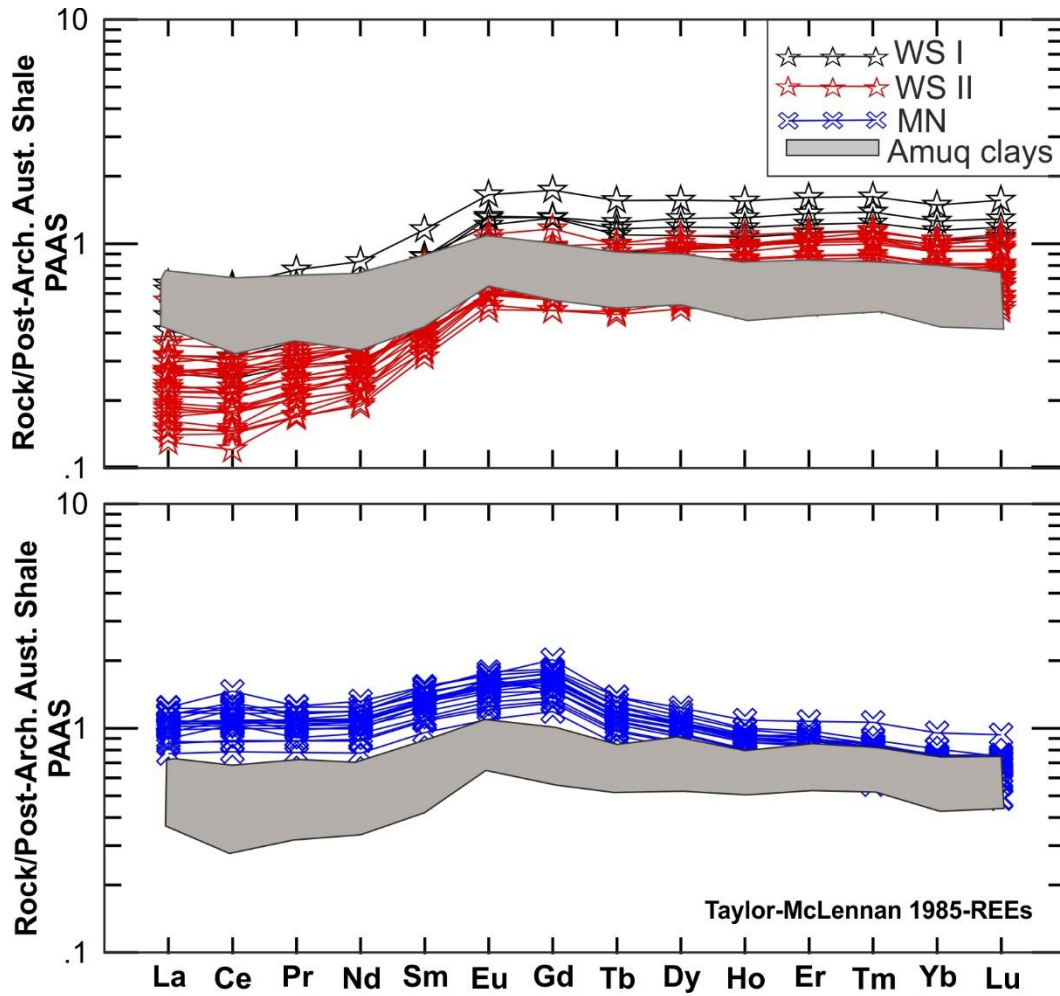


Figure 2.17: Post Archean Australian Shale (PAAS) normalized diagram for REE elements of the WS I, WSII (a) and MN (b) potteries. The gray shaded area shows clay sources of the Amuq Valley (data after Gutsuz et.al, in prep). PAAS values: Taylor and McLennan, 1985.

6.5.2 Comparison of the WS I and WS II wares with the clay sources of Cyprus

In this subchapter we compared to clay source given for Cyprus with WS I and II data that were unearthed from the Alalakh. For this comparison, we took reference clays reported by Grave et. al. (2014). According to such study, 91 clay samples was taken from several selected regions in Cyprus. Taking into account the geologic features of Cyprus, these regions are, (1) the Circum-Troodos sedimentary succession, (2) the Kyrenia Terrane, (3) the Troodos Ophiolite complex, and (4) the Mamonia Complex (Grave et. al., 2014). After multivariate analysis on clay samples, they distinguished 8 geochemical subgroups which are called as 1, 1.1, 2, 2.1, 3, 3.1, 4.2, 4.3.

Unfortunately, they gave individual analyze points generally according to geological units and their extension not according to regions. Besides, Grave et. al. (2014) did not reported individual chemistry of the samples instead they gave the average values of clays. Furthermore, the data published are the only one for geochemical characteristics of the clay beds in Cyprus so we had to use this data for comparison. In Fig. 15, it is seen that the WS I and WS II wares are very close to the group 3 that is represented by the Troodos Massif area. For example, CaO content of the group 3 (the Troodos Massif region) and the 4.2 (the Mamonia region) show lower values (less than 10%) than other groups. The CaO content of the potteries show closer values with the group 3. Also, in binary diagram (Figure 6.18), this close relation can be seen on Ce, Rb, elements. Cs and La values of the potteries are rather sparse so even they are close to the group 3 some analyzes plotted away from this group.

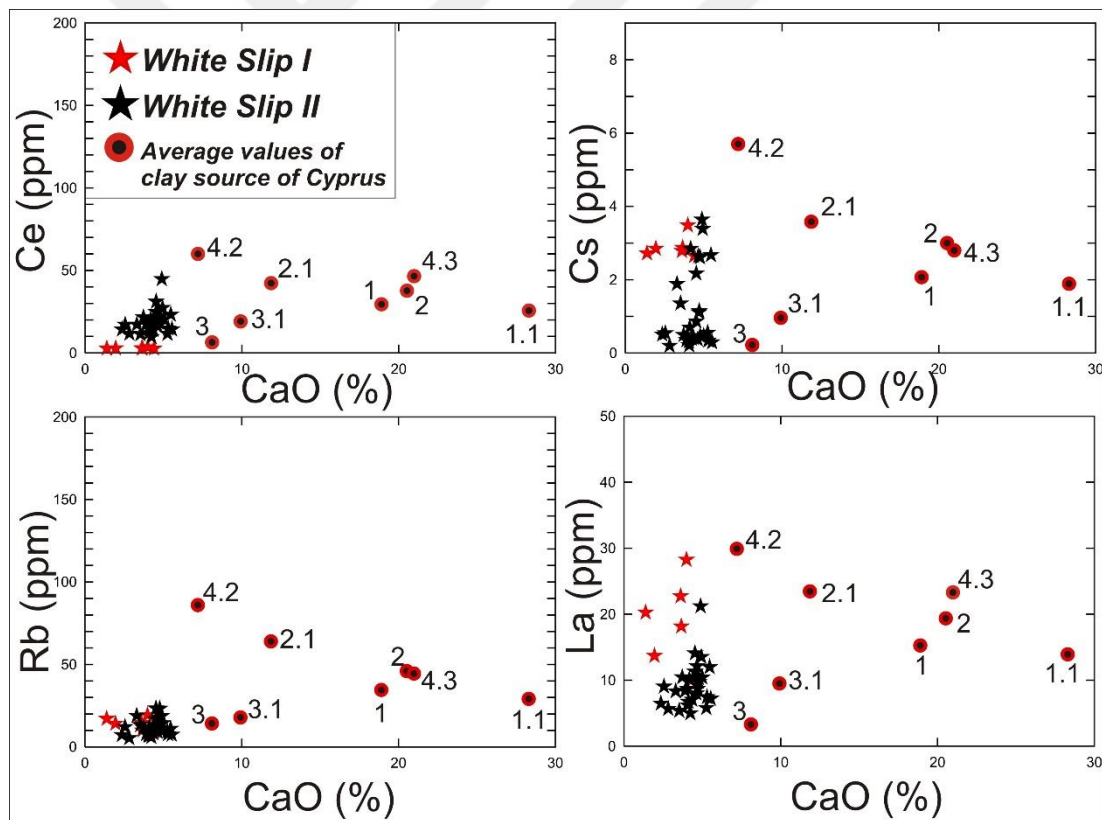


Figure 2.18: Binary plot of the CaO versus trace element (Rb, Ce, Cs, La (in ppm)) distributions of the White Slip I-II samples. The average clay source values published for Cyprus are; 1: The Circum-Troodos sedimentary succession, 2: The Kyrenia Terrane, 3: The Troodos ophiolite complex, and 4: The Mamonia complex.

According to the result, Monochrome samples plotted mostly very close to the Momonia region (area 4.2 in Figure 6.19 and 6.20). According to CaO content, the group 3 (the Troodos Massif region) and the group 4.2 (the Mamonia region) show lower values (less than 10%). Likewise, CaO content of the MN samples show lower value less than 10%. However, according to trace elements, MN values are very close to group 4.2 (the Mamonia region) rather than group 3 (the Troodos Massif region). For example, close matching can be seen on Rb, Ce elements (Figure 6.19) and on Eu, Sm, La, Nd Rare Earth elements (Figure 6.20). Exceptionally, Na₂O (not shown in the figures) content of the Monochrome wares show higher values than values of the Momonia region, so the MN ware values have equal distance to Troodos region (3) and to Momonia region (4.2) on some diagrams

Therefore, we can state that the Monochrome ware probably come from the Momonia region which is located in south-western part of the Cyprus rather than eastern part of island. The absence of the data about the MN ware do not allow us to make further consideration about them. It is required more specific research about the Monochrome ware for provenance study.

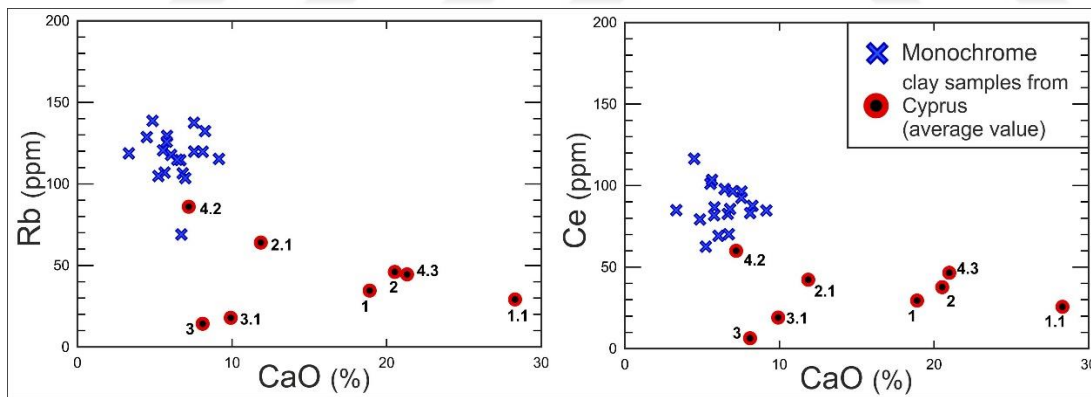


Figure 2.19: Binary plot of the major and trace elements distribution of the Monochrome samples and average clay source of the Cyprus which are represented by different geologic region for CaO (%wt.) versus Rb, Ce (in ppm) diagram. 1: Circum-Troodos sedimentary succession, 2: Kyrenia Terrane, 3: Troodos ophiolite complex, 4: Mamonia complex.

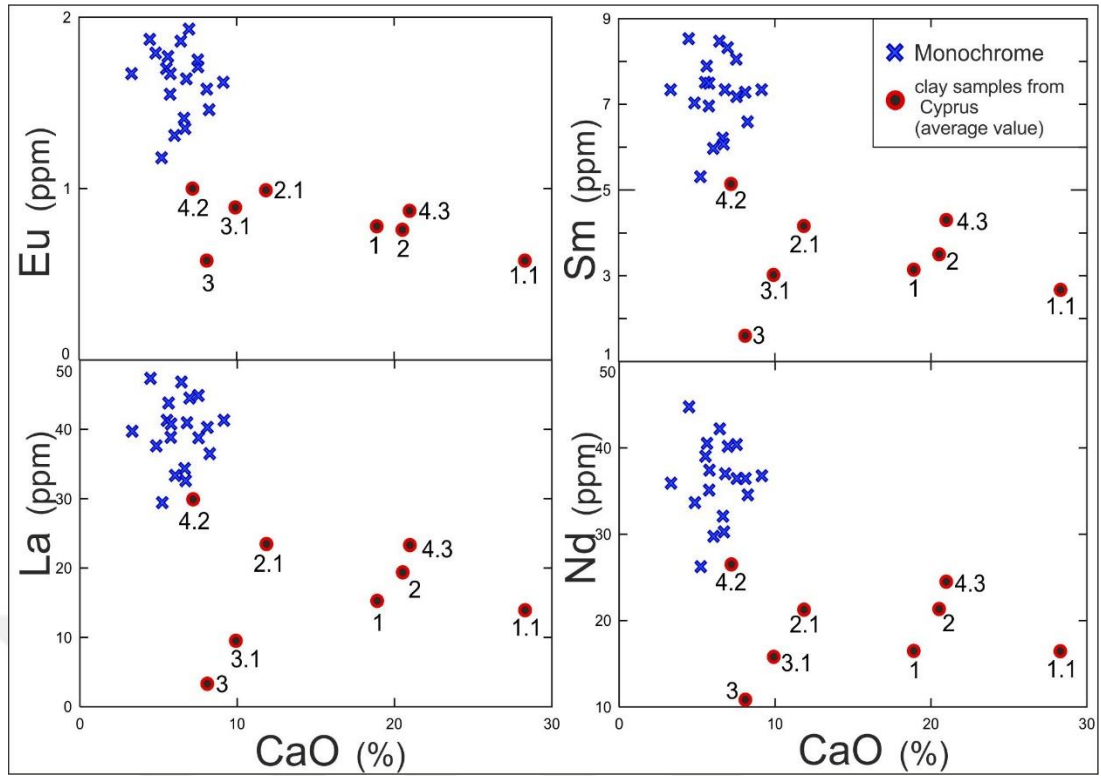


Figure 2.20: Binary plot of the major and trace elements distribution of the Monochrome samples and average clay source of the Cyprus which are represented by different geologic region for CaO (%wt.) versus La, Eu, Sm, Nd (in ppm) diagram. 1: Circum-Troodos sedimentary succession, 2: Kyrenia Terrane, 3: Troodos ophiolite complex, 4: Mamonia complex.



3. CONCLUSION

- In this study, we analyzed the White Slip I, White Slip II and Monochrome wares and put forward their geochemical properties.
- The White Slip I wares have two subgroups that can be divided with some different petrographic and geochemical features. However, the raw material of two subgroups derived from the same source area. The difference is probably as a result of local variations in the source material.
- White Slip II ware show five subgroups based on their petrographic features, whereas show only two subgroup based on geochemical features. The reason of differences between four subgroups (WSI-A, WSI-B, WSI-C and WSI-D) is probably related to production process of the potteries. However, difference of the fifth subgroup WSI-E is more probably related to local variation in the same source area.
- White Slip I and White Slip II wares show generally similar petrographic and geochemically characteristics. Despite the similarities, some differences between them most probably related to local variations of the raw materials that are used for production. The raw clay material of them derive from mafic and ultramafic rocks that can be linked to the Troodos Ophiolite complex in Cyprus.
- Sherd samples of the Monochrome ware do not show variation to each other and their raw material derived mainly from sedimentary rocks.
- According to petrographic and geochemical analysis, it can clearly be stated that the raw material of the Monochrome ware is not the same as with the White Slip wares. Therefore, the provenance of the Monochrome ware is different than White Slip wares.
- When the WSI and WSII wares are compared with clay sources of the Amuq Valley, any region where the WS potteries could have been produced are found.

- The WS and MN potteries of the Alalakh excavation are compared with the other WS and MN potteries found in different regions of surrounding Mediterranean region for the purpose of their originality. After our comparison the WS I, WS II and MN potteries are not imitation and probably imported directly from Cyprus.
- It is clear from our study that there is more than one production center for the White Slip II ware. Although general opinion accepts the production center of the WSII ware is Sanidha, our study shows that the WSII wares found in the Tell Atchana site are probably produced in different center rather than the Sanidha. Moreover, because of the great similarities between the White Slip ware from Tell Atchana and the WS II from Kommos in Crete island. Because the Kommos WS II ware was related with Limassol region (import to Kommos) which is located in southwest of Troodos ophiolite, it can be said that White Slip potteries from Tell Atchana probably associated with directly Limassol area.
- After the comparison of the Monochrome ware with the Cyprus clay sources (Grave et al., 2014), we can propose that the geochemical results of the Monochrome ware show proximity with south of the Mamonia region. However, the regional clay sources are given as average values and we are not sure the distribution of the data in the diagrams. Also absence of the error values it is not possible to certain about our statement. Therefore, the MN ware needs more and comprehensive study for determination of its provenance.

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APPENDIX

APPENDIX A : Data list from previous study

Appendix A-1: Lawrence Berkeley National Laboratory Archaeometry Archives - LBNL, University of Missouri Research Reactor Archaeometry Laboratory, Matthew T. Boulanger – 2014.

Appendix A-2: Lawrence Berkeley National Laboratory Archaeometry Archives - LBNL, University of Missouri Research Reactor Archaeometry Laboratory, Matthew T. Boulanger – 2014.

Appendix A-3: Lead isotopic analysis within a multiproxy approach to trace pottery sources. The example of White Slip II sherds from Late Bronze Age sites in Cyprus and Syria, Renson et. al., 2013.

Appendix A-4: Provenience Studies and Bronze Age Cyprus: Production, Exchange and Politico-Economic Change. A. Bernard Knapp and John F. Cherry - 1994.

Appendix A-5: Mycenaean and Cypriot Late Bronze Age Ceramic Imports to Kommos. An Investigation by Neutron Activation Analysis. Tomlinson et. al. 2010.

APPENDIX B: Sample informations from Tell Atchana

APPENDIX A

A-1: Lawrence Berkeley National Laboratory Archaeometry Archives - LBNL, University of Missouri Research Reactor Archaeometry Laboratory, Matthew T. Boulanger - 2014

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
ENK-145	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-146	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-147	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-148	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-149	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-150	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-151	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-152	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-153	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-154	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-155	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-156	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-157	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-158	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-159	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
ENK-160	Enkomi	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
JAK-1	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-2	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-3	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-4	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-5	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-6	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-7	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-8	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-9	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-10	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-11	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-12	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-13	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-14	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-15	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-16	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-17	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-18	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-19	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II
JAK-20	Ayios Jakovos	Cyprus	NAA	The Museum of Mediterranean and Near Eastern Antiquities, Stockholm		White Slip II

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
KAL-35	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-38	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-43	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-44	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-46	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-49	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-50	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-51	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-52	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-53	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-54	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-71	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-72	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
KAL-73	Kalopsidha	Cyprus	NAA	Antikmuseet, Lund	Åström, P.	Monochrome
LAR-1	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-2	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-3	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-4	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-5	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-6	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-7	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-8	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-9	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-10	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-11	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-12	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-13	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-14	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-15	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-16	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-17	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-18	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-19	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
LAR-20	Larnaca	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip II
MLA-1	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II

A-2: Lawrence Berkeley National Laboratory Archaeometry Archives - LBNL, University of Missouri Research Reactor Archaeometry Laboratory, Matthew T. Boulanger - 2014

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
MLA-2	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-3	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-4	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-5	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-6	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-7	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-8	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-9	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-10	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-11	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-12	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-13	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-14	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MLA-15	Milia	Cyprus	NAA	Museum of Mediterranean and Near Eastern Antiquities, Stockholm	Gjerstad, E.	White Slip II
MPH-1	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
MPH-2	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
MPH-3	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
MPH-4	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
MPH-5	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
MPH-6	Morphou	Cyprus	NAA	Lawrence Berkeley National Laboratory	Artzy, M.	White Slip I
PPAP-1	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-2	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-3	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-4	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-5	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-6	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-7	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-8	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-9	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-10	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-11	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-12	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-13	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-14	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-15	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-16	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-17	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-18	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-19	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I
PPAP-20	Palaepaphos	Cyprus	NAA	Department of Antiquities, Nicosia	Karageorghis, V.	White Slip I

A-3: Lead isotopic analysis within a multiproxy approach to trace pottery sources.
The example of White Slip II sherds from Late Bronze Age sites in Cyprus and Syria, Renson et. al., 2013

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
HST-4d	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-13	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-16	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-17	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-27	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-28	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-33	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-35	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-36	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-58	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-59	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-61	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-65	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-66	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-69	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
HST-70	Hala Sultan Tekke	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-16	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-18	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-20	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-23	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-24	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-27	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-28	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
SAN-29	Sanidha	Cyprus	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
MEB-2	Minet El-Beidha	Syria	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
MEB-3	Minet El-Beidha	Syria	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
MEB-4	Minet El-Beidha	Syria	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
MEB-5	Minet El-Beidha	Syria	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II
MEB-6	Minet El-Beidha	Syria	XRF	Research Foundation Flanders, Research Council of the Vrije Universiteit Brussel	Renson, V	White Slip II

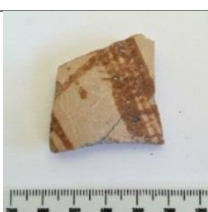
A-4: Provenience Studies and Bronze Age Cyprus: Production, Exchange and Politico-Economic Change.
A.Bernard Knapp and John F. Cherry - 1994

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
AM-01	Ambelia	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
AM-02	Ambelia	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
AM-03	Ambelia	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
ID-46	Idalion	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
ID-45	Idalion	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
GZ-43	Tel gezer	Israel	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
GZ-44	Tel gezer	Israel	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
PMBS-41	Beth Shan	Israel	NAA	Brookhaven National Laboratory	McGovern, P.E.	White Slip
PMBS-37	Beth Shan	Israel	NAA	Brookhaven National Laboratory	McGovern, P.E.	White Slip
PMBS-38	Beth Shan	Israel	NAA	Brookhaven National Laboratory	McGovern, P.E.	White Slip
PMBS-40	Beth Shan	Israel	NAA	Brookhaven National Laboratory	McGovern, P.E.	White Slip
PMBS-34	Beth Shan	Israel	NAA	Brookhaven National Laboratory	McGovern, P.E.	White Slip
TC-04	Tyre	Lebanon	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
TC-03	Tyre	Lebanon	NAA	Brookhaven National Laboratory	Bieber, A.M.	White Slip
ABSM-03	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory		Monochrome
ABSM-04	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory		Monochrome
ABSM-05	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory		Monochrome
MS05	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	Monochrome
MS04	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	Monochrome
MS03	Phlamoudhi	Cyprus	NAA	Brookhaven National Laboratory	Bieber, A.M.	Monochrome
TC02	Tyre	Lebanon	NAA	Brookhaven National Laboratory	Bieber, A.M.	Monochrome

A-5: Mycenaean and Cypriot Late Bronze Age Ceramic Imports to Kommos. An Investigation by Neutron Activation Analysis. Tomlinson et. al. 2010

Sample number	Place	Country	Analysis Type	Affiliation	Source Person	Pottery Type
C335	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C340	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C344	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C665	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C993	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C1262	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C1981	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C1982	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C2046	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C2141	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3156	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3218	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3249	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3681	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3729	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C3947	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C4127	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C4249	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C4432	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C4773	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C5122	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C5596	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C5645	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C6743	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C9567	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C9612	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C9990	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C10034	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II
C10111	Kommos	Crete	NAA	University of Manchester, Archaeometry Laboratory	Tomlinson, J.E.	White Slip II

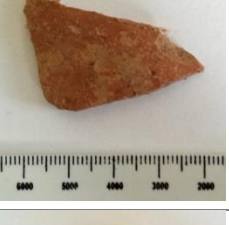
APPENDIX – B

SHERD	NO	POTTER Y TYPE	SQUAR E	CONTEX T	SHERD	NO	POTTER Y TYPE	SQUARE	CONTEX T	SHERD	NO	POTTER Y TYPE	SQUAR E	CONTEXT
	WSI-1	White Slip I	32.57	Locus 89, Lot 307		WSII-1	White Slip II	45.72	Locus 03- 3002, Pail 12		WSII-7	White Slip II	44.55	Locus 03- 2001
	WSI-2	White Slip I	32.59-60	Locus 23, Lot 103		WSII-2	White Slip II	Woolley	no info		WSII-8	White Slip II	Woolley	no info
	WSI-3	White Slip I	Woolley	no info		WSII-3	White Slip II	32.54	Locus 5, Lot 2		WSII-9	White Slip II	Woolley	no info
	WSI-4	White Slip I	Woolley	no info		WSII-4	White Slip II	Woolley	no info		WSII-10	White Slip II	Woolley	no info
	WSI-5	White Slip I	44.79	Locus 04- 2004, Pail 15		WSII-5	White Slip II	44.55	Locus 03- 2002, Pail 34		WSII-11	White Slip II	44.80	Locus 04- 2011, Lot 143
	WSI-6	White Slip I	32.57	Locus 4, Lot 25		WSII-6	White Slip II	Woolley	no info		WSII-12	White Slip II	Woolley	no info

APPENDIX B - continue

SHERD	NO	POTTERY TYPE	SQUARE	CONTEXT	SHERD	NO	POTTERY TYPE	SQUARE	CONTEXT	SHERD	NO	POTTERY TYPE	SQUARE	CONTEXT
	WSII-13	White Slip II	Woolley	no info		WSII-19	White Slip II	44.80	Locus 04-2001, Pail 45		WSII-25	White Slip II	Woolley	no info
	WSII-14	White Slip II	32.57	Locus 4, Lot 29		WSII-20	White Slip II	44.69	Locus 03-2010, Pail 23		WSII-26	White Slip II	Woolley	no info
	WSII-15	White Slip II	32.57	Locus 27, Lot 120		WSII-21	White Slip II	44.80	Locus 04-2001, Pail 1		WSII-27	White Slip II	64.82	Locus 52, Lot 171
	WSII-16	White Slip II	64.82	Locus 52, Lot 225		WSII-22	White Slip II	44.80	Locus 04-2011, Pail 93		WSII-28	White Slip II	64.72	Locus 12, Lot 47
	WSII-17	White Slip II	44.55	Locus 03-2056, Lot 60		WSII-23	White Slip II	Woolley	no info		WSII-29	White Slip II	Woolley	no info
	WSII-18	White Slip II	44.45	Locus 03-2001, Lot 16		WSII-24	White Slip II	Woolley	no info		WSII-30	White Slip II	Woolley	no info

APPENDIX B - continue

SHERD	NO	TYPE	SQUARE	SHERD	NO	TYPE	SQUARE	SHERD	NO	TYPE	SQUARE
	MN-1	Monochrome	Woolley		MN-7	Monochrome	Woolley		MN-13	Monochrome	Woolley
	MN-2	Monochrome	Woolley		MN-8	Monochrome	Woolley		MN-14	Monochrome	Woolley
	MN-3	Monochrome	Woolley		MN-9	Monochrome	Woolley		MN-15	Monochrome	Woolley
	MN-4	Monochrome	Woolley		MN-10	Monochrome	Woolley		MN-16	Monochrome	Woolley
	MN-5	Monochrome	Woolley		MN-11	Monochrome	Woolley		MN-17	Monochrome	Woolley
	MN-6	Monochrome	Woolley		MN-12	Monochrome	Woolley		MN-18	Monochrome	Woolley

CURRICULUM VITAE



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PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- Kozal, E., **Haciosmanoğlu, S.**, Gutsuz, P., Kibaroglu, M., Sunal, G., 2015, Archaeological and Archaeometric Analysis of Cypriot Pottery from Alalakh, 15th Anniversary of Alalakh Excavations: Workshop, Hatay, TURKEY. (abstract- oral presentation)
- **Haciosmanoğlu, S.**, Kibaroglu, M., Gutsuz, P., Sunal, G., Kozal, E., 2015, Geochemical and Petrographic Analysis of Late Bronze Age Cypriot Ceramics from Tell Atchana/Alalakh (Hatay), In Amuq Valley, 13th European Meeting on Ancient Ceramics, Athens, GREECE. (abstract – poster presentation)
- **Haciosmanoğlu, S.**, Kibaroglu, M., Gutsuz, P., Sunal, G., Kozal, E., 2016, Geochemical and Petrographic Analysis of Late Bronze Age Cypriot Ceramics from Tell Atchana/Alalakh (Hatay), In Amuq Valley. Journal of Archaeological Science Report. (In press). (paper)

