THE INVESTIGATION OF A LATE BRONZE AGE (14TH CENTURY BC) DOMESTIC CRAFT QUARTER: PYROTECHNOLOGY AT TELL ATCHANA /ANCIENT ALALAKH

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To *Nursen and Faruk Dardeniz*

ABSTRACT

This study will offer new insights in pyrotechnology by examining a craft quarter excavated at Tell Atchana/ancient Alalakh during the 2003–2004 seasons. Tell Atchana/ancient Alalakh was the capital city of the territorial kingdom of Mukish, which controlled the Amuq Plain of Hatay during the Middle and Late Bronze Ages. Its strategic location within a dynamic trade network and the continuous changes in the political environment created a complex and hybrid culture at Alalakh. This social complexity is also traceable in its production technologies. The domestic units — with eight distinct pyrotechnological installations — will give us the opportunity to investigate the diverse uses of fire as technology. These representative households will illuminate the significance of pyrotechnology in the social and economic context of a Late Bronze Age capital city.

Key Words: Pyrotechnology, Alalakh, Late Bronze Age, Pottery Kilns, Glass Production

ÖZET

Bu çalışma 2003-2004 kazı sezonunda Açana Höyük/antik Alalakh yerleşkesinde ortaya çıkarılmış bir işlik alanı inceleyerek, piroteknolojiye (ateşli teknolojilere) yeni kazanımlar sağlamayı öngörmektedir. Açana Höyük/antik Alalakh yerleşkesi, Orta ve Geç Tunç Çağı dönemlerinde, günümüz Hatay'ının sınırları içinde bulunan Amik Ovası'nı kontrolü altında bulunduran yerel Mukiş Krallığı'nin başkentidir. İşlek ticaret yollarının ortasında bulunan stratejik konumu, politik ortamdaki sürekli değişimler dolayısıyla, Alalakh'ta karmaşık ve melez bir kültürün ortaya çıkmasında sebep olmuştur. Bu sosyal karmaşıklığın izleri üretim teknolojilerinden de izlenebilmektedir. Sekiz belirgin piroteknolojik enstalasyonu bünyesinde bulunduran üretim birimleri, bize ateşin teknolojik bağlamda farklı kullanımlarını inceleme imkanı sunmaktadır. Bu tipik üretim birimleri, piroteknolojinin bir Geç Tunç Çağı başkentindeki sosyal ve ekonomik ehemmiyetini aydınlığa kavuşturacaktır.

Anahtar Kelimeler: Piroteknoloji, Alalakh, Geç Tunç Çağı, Çanak-Çömlek Fırınları, Cam üretimi.

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CHAPTER I

INTRODUCTION

Pyrotechnology and diverse uses of fire have been one of the primary processes in production technologies throughout history. The archaeological data concerning the pyrotechnology of Late Bronze Age Anatolia and the Near East is vast but has been only rarely scientifically examined. Raw materials and their sources, production technologies, levels of technological knowledge and the specific choices applied by crafts specialists can be further understood by the scientific examination of the archaeological evidence of ancient pyrotechnology. The installation set-ups found in archaeological contexts are often identified as pottery kilns or metal furnaces, but these identifications are restricted to the observation of the excavators but not based on scientific analysis. The scientific and contextual examination of pyrotechnological installations and the advancements observed in firing technologies can be used to evaluate the significant meaning of production technologies that can improve our knowledge of the socio-economic organization of Late Bronze Age societies.

This study aims to contribute to the further understanding of Late Bronze Age pyrotechnology by investigating an area of multiple installations found at Tell Atchana/ancient Alalakh (Area 2, Squares 44.69, 44.79, 44.80, and 45.71). An initial study by the excavators (Yener and Yazıcıoglu 2010) identified this area as a 'craft quarter' due to the numerous pyrotechnical installations present. The term 'craft quarter' which is terminologically loaded will be used throughout this thesis to identify the area since architectural and archaeological characteristics of Area 2 satisfactorily matches with the definition of a craft quarter given by Tosi as a:

> “large activity area, with marked concentration of facilities around which different crafts were performed in close proximity,…” (Tosi 1984:24).

Even though Yener and Yazıcıoğlu (2010) defined the area as a craft quarter, they did not further explore the possible interpretation of the area in the context of production and the ancient city’s socio-economic structure. The contextual and scientific examinations of pyrotechnological installations found in this craft quarter district provided an exceptional dataset to reconstruct the linkages between production technologies and the socio-economic and political structure of Late Bronze Age Tell Atchana/ancient Alalakh.

The Late Bronze Age was a time of great change and development in the political and social environment of the Near East. Rising powers and empires ran all over the place and affected the local cultures of the settlement. Tell Atchana/ancient Alalakh located at the heart of the cultural connections became a significant place to study the local effects of the age of internationalism.

1.1 Alalakh and the Ancient Near East

Tell Atchana/ancient Alalakh is located in the Amuq Valley near the major branch of the Orontes River, about 20 km from the modern Turkish–Syrian border. It was the capital city of the Kingdom of Mukish in the Middle and Late Bronze Ages (c.2000-1200 BC), controlling the territory of the Amuq Valley and lower Orontes Valley of the modern state of Hatay (Yener et al. 2000; Magness-Gardiner 1994; Serangeli 1978). The first rounds of excavations at Tell Atchana were initiated by Sir Leonard Woolley on behalf of the British Museum in London. Eight seasons of excavations conducted between 1936 – 39 and 1946 – y49 revealed eighteen occupational levels now known to correspond to the Middle and Late Bronze Ages (Woolley 1955).

Following the completion of the Woolley expedition, the inconsistencies and discrepancies in the final publication (Woolley 1955) led to an ongoing discussion about the stratigraphy, chronology, and political history of the settlement (Albright 1957; Mellink 1957). Scholars have attempted to fix the problems related with Woolley's excavation data throughout the last sixty years (Gates 1976, 1987; Heinz 1992; Yener 2005, in prep. a, b). Their work showed that a new round of excavations was necessary at Tell Atchana. Focusing on the 2nd millennium BC chronological problems, the Yener expedition at the site was initiated in 2000 with a site survey (Yener et al. 2000; Yener 2005). A new excavation campaign was initiated in 2003 and is currently ongoing under the direction of K. A. Yener.[1] The Late Bronze Ib and IIa levels (Levels IV–I, c.1450-1300BC) corresponding to the period of Mitanni and Hittite political control over the region, are the focus of this research (Yener in prep. a).

The results of the excavations conducted in 2003–2004 were published as an excavation monograph (Yener 2010) including Area 2 craft quarter, located on the northeast margin of the tell, which is subject to further research in this thesis. The eight pyrotechnological installations found in Area 2 were examined using scientific methods and the results were contextualized to understand the role of production technologies in the final levels of the settlement and its role in the Late Bronze Age socio-economic and political milieu.

1.2. Methodology and Research Questions

This research was conducted for the primary purpose of offering a scientific basis to the contextual examination of Area 2 craft quarter. By using Tell Atchana/ancient Alalakh's pyrotechnological installations as a case study, a contextual, functional, and comparative study is presented with the aid of scientific methods. The samples from the pyrotechnological installations were analyzed with instrumental methods including optical microscopy (hereafter; OM), scanning electron microscopy (hereafter; SEM), X-Ray Diffractometer

[1]Alalakh excavations are ongoing under the sponsorship of Koç University, FAVAE (The Fund for Amuq Valley Excavations) and INSTAP (The Institute for Aegean Prehistory).

(hereafter; XRD), and X-Ray Fluorescence (hereafter; XRF). Macroscopic and microscopic analyses of slag and production wastes defined the functional and typological characteristics of the installations. Scientific analyses of the vitrified materials gave insights into the firing temperatures achieved in these installations. By using the firing temperature and the slag recovered, the functional attributions of these structures were defined either as pottery kilns, metal furnaces, glass-faience or frit production units, or multi-purpose installations.

A complementary research question is aimed at investigating the socio-economic system in which these installations were used. By conducting a comparative study, questions on craft specialization and production industries are put forward. The craft production facilities of the craft quarter, with which this study is concerned, were also a part of a complex administrative system in terms of its organization. By examining textual records, questions as to whether the craft workshops were independent or exclusively controlled by the palace are discussed.

1.3. Theoretical Framework

The study of the organization of production has long been important to archaeology. As stated by Boas in an early attempt to define modes of production, “we have simple industries and complex organization” as well as “diverse industries and simple organization” (Boas 1940: 266, 267). In current archaeological theory, economic systems within their idiosyncratic social and cultural mechanisms are studied through two main components: the organization of production and craft specialization.

The organization of production in a society is organically related to sociopolitical and socioeconomic settings. As key elements of an economic system, the production and distribution of products and the consumption or exchange strategies were shaped by political, social, economic and cultural patterns of an ancient community. The socio-political and socio-economic structures of these communities leave traces in the archeological record either as textual information like archives and glyptic, or non-textual data like architectural features or artifacts (Rice 1981, Costin 1991:2). Archeological data contain information that can illuminate the organization of the production and craft specialization in ancient societies. In the archaeological context, production itself leaves its physical, chemical and occasionally biological markers from which the system can be successfully traced. Tools and implements, the architectural contexts of production like craft quarters or workshops, organic residues and the products themselves appear in the archaeological record (Costin 1991:1).

The identification and interpretation of craft quarters and craft specialization in the archaeological record has led several scholars to create various theories and the associated terminology which has since been regularly cited in the literature (van der Leeuw 1977, Peacock 1982, Rice 1987, Costin 1991). Van der Leeuw (1977), Peacock (1982) and Rice (1987) proposed a typology based on household or workshop production. Costin (1991) on the other hand, not only distinguished between household or workshop productions, but also considered the production for general consumption or production for elites. As a result, four general terminologies rose for the discourse of production: household production, workshop production, independent production and attached production.

The craft area highlighted in this thesis could fall within any of the four modes of production cited above. To interpret the archaeological context and terminologically define the area, this study will follow Costin's (1991) theory since she proposed the most descriptive argumentation for the interpretation of archaeological contexts. Tell Atchana/ancient Alalakh Area 2 provides a model to test Costin's theory on a Late Bronze Age craft area.

'Production' is defined as turning raw materials into goods, and 'specialization' as an organized method of this production (Costin 1991:3). Both production and specialization are subsets of the socioeconomic and sociopolitical systems and should be considered key factors in the political economy of complex societies (Brumfiel and Earle 1987). Through examining craft specialization and sociopolitical organization of production, linkages between crafts and hierarchically higher status elites could be better understood. To examine the organization of production in more detail, this thesis will use Costin's model where the context of production is divided into two groups: 'attached' and 'independent' depending on the degree of organizational and economic control exhibited by society's elites.

'Attached production' describes elite control over the production especially for high-status (usually high-cost, restricted access) goods (Earle 1981, Costin 1991:7, 11). Elites or states try to control production of goods and especially luxury items which is important to reinforce their social status and to manipulate their power (Helms 1993, Peregrine 1991, Stein 2001). This maintenance of elite institutions on production and practitioners on crafts were also evidence by profession lists of textual records (Archi 1982, Hauptmann 1988, for Alalakh see von Dassow 2008). Such sponsorships by elites emphasized their social and political position in the society and made the attached specialist producers economically and socially dependent on their patrons.

For 'independent production', the control over production is in the hands of the producers themselves. Manufacturers produce according to demand and distribute products mainly to a public market of customers (Costin 1991:11). The model proposed that archaeological evidence for the scale of production can be found in four parameters: context, concentration, scales of production and intensity of production (Costin 1991). This model, while not without critics, is widely used in archaeological studies today and has proved to be of great use in interpreting archaeological data.

The pyrotechnological units and their relevant architectural features subjected to this thesis are also analyzed through Costin's theory in order to assess the nature of 'attached' or 'independent' characteristics of the craft quarter. The archaeological context of this area, the sizes and numbers of the pyrotechnological installations lead me to hypothesize an attached production in this Late Bronze Age craft quarter. In order to prove this hypothesis, detailed description of the context is discussed in Chapter III. Furthermore, the types of produced materials whether they are luxury goods for elites or goods for general consumption will provide a better understanding for attached production. The results of scientific analyses summarized in Chapter IV will provide information about the produced material in Alalakh craft area, which will help to clarify the hypothesis. All together, these interpretations offer a test case for craft and craft specialization theories through the LBIIa craft area of Alalakh.

1.4. Chapter Breakdown

In the light of the research questions detailed above, Chapter II provides a summary of the historical background of Late Bronze Age Anatolia, Syria, and the Levant based on archaeological and textual records. The strategic importance of Alalakh as a capital city located on the crossroads between the Hittite and Mittani Empires, and Egypt farther to the south, was also reflected in the local production industries. The changes in the socio-political structure of the settlement through the Late Bronze Age, an era of imperial interference in local affairs, and its effect on the technological advancements and production organization of Alalakh society, is discussed at the end of this chapter.

Chapter III is an overview of archaeological evidence from Tell Atchana that provides a contextual and stratigraphical summary of Area 2. A general overview of the excavated area is discussed along with the chronological attributions. Since Area 2 does not articulate with the sequence that defines Tell Atchana's relative chronology (Area 1), it is only possible to date the layers relevant to this thesis within a window of about 100 years (the final LBIb and

LBIIa). Each pyrotechnological installation is typologically and functionally examined along with its architectural setting and location of the samples taken. This archaeological data set is the foundation of this research.

Chapter IV introduces the methodology and scope of the instrumental analysis conducted on the Alalakh samples. The fragments taken from pyrotechnological installations are analyzed with the use of OM, SEM, XRD, and XRF. This analytical data provided information about the temperatures reached inside the installations and also from where and how the heat was applied, resulting in an enhanced understanding of the firing process itself. Archaeometric studies conducted on various artifacts recovered from Tell Atchana are also reviewed to support the results acquired from analysis. The comprehensive dataset, combined with analytical results, presents new information allowing for the proposition of better functionality for the installations according to their usages as either pottery, metal, glass, faience, frit or a combination of these. Evidence for vitrified materials most probably glass production in Area 2 is discussed in the context of the possible role of glass in Alalakh society and Late Bronze Age exchange systems.

Comparative research on pyrotechnological contexts from Anatolia and the Levant is presented in Chapter V. With respect to the results obtained in Chapter IV, the discussion is extended to glass production installations, also including Egypt as a comparative case study. The contemporary installations from neighboring regions are compared and contrasted with the Alalakh installations. This allows for a better understanding of Alalakh's installations and provides an opportunity to interpret the technological knowledge of the Late Bronze Age in a broader context.

The final chapter VI provides a summary of results obtained in this project. An attempt has been made to contextualize the scientific evidence within the frame of the theories of anthropological technology. A discussion on the use of technology, organization, and intensity of production in understanding Late Bronze Age social orders is also presented. Regarding the archaeological and scientific evidence obtained from Tell Atchana/ancient Alalakh, the contribution of this thesis to the field of pyrotechnology of the Late Bronze Age is discussed.

1.5 Contributions of the Study

This study is part of a trend of groundbreaking new research in the Ancient Near East focused on examining urban workshop areas and installations with the aid of scientific methods. The pyrotechnological installations uncovered at Atchana are analyzed typologically, functionally and technologically in order to contribute to our knowledge of the Late Bronze Age. Scientific results not only cover pottery technology but also include significant evidence for vitrified materials most probably glass production in the 2nd millennium BC. This research further underlines the importance of local raw material resources, in this case Orontes river sand, in sourcing Alalakh's locally produced pottery and vitrified materials.

The socio-economic organization of craft production at Alalakh was also interpreted using anthropological theory, an important contribution to the larger project at Tell Atchana. The interpretation of stratigraphic and scientific data using archaeological theory has suggested possible production strategies and elite-craft specialist relations in the Late Bronze Age capital of Alalakh.

This study also contributes an important data-set for further research in the field.

CHAPTER II

THE LATE BRONZE AGE IN ANATOLIA AND THE LEVANT AND THE ROLE OF ALALAKH: AN OVERVIEW

Tell Atchana/ancient Alalakh is located in the province of Hatay in the southern portion of the Amuq Valley near a major branch of the Orontes River. The mound is an oval measuring 750 × 325 m along the northwest–southeast direction with an approximate elevation of 100 m above sea level. The mound extends over a total of 22 hectares with 19 ha of habitable area and rises 9 m from the level of the surrounding plain (Yener 2005).

Alalakh has primarily second millennium BC occupation and after a gap at the end of the 14th century BC, the site was reoccupied in the Early Iron Age (Yener, in prep. b). Excavations conducted over eight seasons by Woolley and seven seasons by Yener exposed remnants of an occupation during the Middle and Late Bronze Ages. Excavations at Tell Atchana have exposed the architectural remains of fortresses, palaces, temples, and residential areas together with a wide range of artifacts including two royal archives containing approximately a thousand tablets and tablet fragments (Smith 1949; Wiseman 1953; Woolley 1955; von Dassow 2008; Yener 2010).

During its occupation in the Bronze Age, Alalakh did not play a dominant role in the overall socio-political setting of the Near East. In the Middle Bronze Age, Alalakh was subservient to the kingdom of Yamhad based at Halab (Aleppo). Its allegiance shifted to Mitanni in the first century of the Late Bronze Age and later to the Hittite Empire in the 14th century BC. Peripheral to the kingdoms of the Middle Bronze Age and empires of the Late Bronze Age, Alalakh was a marginal actor in the political arena during its life span. Alalakh gets attention from scholars and gains importance in Near Eastern archaeology due to its stratigraphy for its occupational levels. Moreover, the archives found in the Level VII and Level IV palaces of Alalakh attract scholars in the field. These archaeological and textual records provide information for the unclear periods of Near Eastern chronology. Compared to the archives from other Near Eastern sites — those that yielded thousands of tablets like Mari, Nuzi, and Ugarit — the archives of Alalakh are very limited in terms of quantity but very enlightening in terms of political, social, and cultural information. In addition to the palatial archives, the famous statue of King Idrimi with its autobiographical inscription is a unique source of information to illuminate the political history and chronology of Alalakh together with its contemporary sites (Smith 1939, 1949; Wiseman 1953; Olivia 1998, 2000; von Dassow 2008). [2]

Prior to the Late Bronze Age and the date of the workshop, throughout the Middle Bronze Age, regional powers dominated in northern Syria. Written records found in settlements like Ebla, Mari, Alalakh, and Tell Leilan quite extensively mentioned political relations and the socio-economic environment among these regional states. Those archives report the names of the five states controlling this landscape. The kingdoms of Yamhad and Qatna were reigning in the west while Shamshi-Adad was ruling in the east; Mari and its successor state Hana were ascendant in the Jezireh region (Akkermans and Schwartz 2005: 288–326).

Among them, the kingdom of Yamhad was based in Aleppo and dominated the northern part of Syria through a chain of subservient states expanding from the Euphrates River to the Mediterranean coast. The names Alalah, Ugarit, Ebla, Emar, Carchemish, Urshu, Hassu, and Tunip are mentioned in the tablets found in the Level VII palatial archive of

[2] Smith published the inscriptions on the statue in 1949 in his book *The Statue of Idrimi*. A discussion of the inscriptions, their interpretations, and chronological implications are presented in the following sections.

Alalakh. These cities were referred to as subservient or ally states and connected to Yamhad (Wiseman 1953; Bryce 2005: 70).

2.1. The Late Bronze Age and Level IV of Alalakh

The Late Bronze Age witnessed the rise of empires. Politically, the Hittite, Mitanni, and in LBIIb, the Middle Assyrian Empires together with the New Kingdom of Egypt were active players in trying to control Syrian lands. The Hittites became the dominant power in the vast territory of Anatolia. Early in the LBI, the Mitanni Kingdom became the rising power of northern Syria and supplanted the role of the vanished kingdom of Yamhad. In the south, Egypt expanded its territory to the borders of Mitanni (Klengel 1992; von Dassow 2008). The fall of the Yamhad Kingdom in Syria also affected the political situation of the vassal cities and states including Alalakh. It served in a subservient position first to the Mitanni Empire and later to the Hittites.[3]

The rise of the Mitanni Empire, based in the Jezireh Plain, as a powerful authority influenced the social and political life in the Anatolian and Levantine region. Its influence in the neighboring regions can be further recognized by understanding the social, political and cultural systems of the Mitanni Empire. This includes further research on the emergence and origins of the Mitanni state, culture, and ethnicity which are still under debate among scholars. There are various arguments attributing the origins of Mitanni strongly with the Hurrians (Wilhelm 1989; Kühne 1999: 206) but these suggestions are still not solid enough to point to the foundations of this great power (von Dassow 2008: 20). Currently the oldest textual record mentioning the name "Mitanni" is an inscription on Amenemhat's tomb found in Egypt. Although the identity of Amenemhat is not clear, he may have been at the service of Amenhotep I and probably Thutmose I, whose reigns date to late 16th through the early

[3] Alalakh might have been also independent for a time c. 1600-1500 BC (von Dassow 2008). This time interval is still waiting for further illumination.

15th centuries. The inscription on the tomb refers to "Mitanni" as an enemy of Egypt and mentions Mitanni as an opponent of Egypt (Brunner 1956).[4]

From the dynasty of Thutmose I onward, the kingdom of Egypt tried to dominate the Levantine region. The desire for ruling this territory brought Egypt and Mitanni into conflict. This confrontation can be traced via the textual records of Egypt. The name *Naharina* "River Land" appears frequently in the texts referring to the Mitanni Empire or to the power behind the Levantine rulers who opposed Egypt (von Dassow 2008: 21). Due to the fact that no textual records from the Mittani capital have yet been found, Egyptian records are used as the main sources to explain the events, people, and places in the region.

Contemporaneous to Mitanni in the north and New Kingdom Egypt (18th Dynasty) in the south, Alalakh was ruled by the dynasty of King Idrimi (c. 1450 BC). Three hundred tablets uncovered in the Level IV palatial archive of Alalakh pertain to the kings Idrimi, Niqmepa, and Ilimilimma. These administrative records certify the subservient position of Alalakh to the Mitanni Empire during the reigns of these kings.

Alalakh's Level IV, its chronology, and the foundations of the Level IV palace have been intensively studied since it was first excavated (Woolley 1955, von Dassow 2008). Woolley stratigraphically attributed the beginning of Level IV, together with the palatial complex, to the reign of Niqmepa. He argued that the Level IV palace was short-lived with an occupation of two generations at most, and assigned Niqmepa as the founder whereas Ilimilimma was responsible for the later additions (Woolley 1955: 110–11).[5] His attributions

[4] The relation of the text to Mitanni is presented in detail in Kühne 1999: 212–13.

[5] Architecturally, the Level IV palace was composed of three blocks; the main block of the palace was elongated toward the northeastern direction, nearby the ruins of the Yarim-Lim Palace in Level VII. The southeastern block (Rooms C4, C5, C6, and C7) should have been used as a service wing since those rooms yielded oven, heart, and several storage jars (Woolley 1955: 111, 129–30). On the northwestern side lies the "Serai Gate" providing an entrance to the courtyard of the palace from the northwestern city walls. The palace itself was a two-story building with a courtyard at the center surrounded by several chambers (Rooms 2–36, C1–8, and D1–2; Woolley 1955: 116–30). Excavations of these rooms exposed a tremendous amount of artifacts of a wide

were mainly based on the contents of the Level IV palatial archives. The palatial archives found in Room 33 of the Level IV palace together with the rest of the tablets found throughout the palatial area pertain mostly to the kings Niqmepa and Ilimilimma. Among the Level IV archives, only two tablets (AIT 3 and AIT 71) and a tablet fragment (AIT 99) pertain to King Idrimi (Wiseman 1953). Tablet AIT 3 is a treaty between Idrimi, the king of Alalakh, and Pilliya, the king of Kizzuwatna, signed under the custody of Mitannian King Parattarna (Wiseman 1953: 31–32). This tablet is a remarkable document; it is evidence to clarify both Alalakh's allegiance to the Mitanni Empire and shed light on its contemporaries during the reign of Idrimi. Based on the rest of the textual records, AIT 71 refers to Idrimi's acquisition of a slave and tablet fragment AIT 99 is part of a contract signed before Idrimi's reign. These tablets in their archaeological and contextual context could challenge Woolley's attribution of the Level IV palace as the "Niqmepa Palace" if reassessed together with the text on the statue of Idrimi.

Von Dassow attributes the Level IV palace to Idrimi (von Dassow 2008: 36). Based on the inscription on Idrimi's statue that says he built a house like a kingly throne, von Dassow points out also the presence of other archival records (AIT 71) pertaining to Idrimi and argues that Idrimi lived in the Level IV palace. According to her, there is no clear evidence for attributing the foundation of the Level IV palace to Niqmepa, but there is some evidence for the attribution of the palace to Niqmepa's predecessor, Idrimi (von Dassow 2008: 35–37).

The life and political history of King Idrimi is understood from the inscriptions carved on the lower skirt of his statue. According to these carvings, Idrimi was a prince of the old

range of types. Pottery — especially white-slip ware and base-ring ware — was found throughout almost the entire complex together with a remarkable amount of Nuzi ware vases and goblets. Gold, silver, copper, bronze, ivory, and basalt objects and fragments together with seals and seal fragments were found throughout the rooms of the palace. In addition to all of these artifacts, excavations in these areas yielded 300 tablets and tablet fragments, mainly found in Room 33 (Tablets ATT/38/73, 76–92, 244–61, 263–65, 267–71; Woolley 1955: 127).

Amorite dynasty of Yamhad and had fled from Aleppo to Emar because a “bad thing” had happened in Aleppo. Although he was the youngest of all his brothers, he decided to get his father’s throne back. He departed from Emar and arrived in the city of Amiyya in northern Canaan. In Amiyya, people from Mukish,[6] Niya, and Ama’e had recognized him as the son of their king and joined him. Seven years after Idrimi had left Alalakh, he returned there with newly recruited troops. Once in Alalakh, Idrimi dealt with seven years of conflict with the Hurrian king, Parattarna, before reaching an agreement that made Alalakh subservient. With the support of the Mitanni Kingdom, Idrimi was the successor to the throne of Alalakh. As the king, Idrimi fought for seven years against the Hatti (Hittites) and eradicated seven cities. With his booty and prosperity, he built a palace and shared his wealth with his relatives. He dedicated himself to religious duties. At the end of his life, he put his son, Addu-nirari, in charge of his duties. This fairytale-like story ended with an unusual column naming and blessing its writer, Sarruwe the Scribe (Smith 1949).

These inscriptions raise issues about the predecessor-successor chain of Idrimi’s dynasty. The name of Addu-nirari does not appear on any tablet found in the Level IV archive of Alalakh. The Level IV archives indicate the name of Niqmepa as the successor of Idrimi, who was the successor of Ilimilimma. According to these records, the dynasty is arranged as Niqmepa — Ilimilimma — Idrimi — Addu-nirari, which assigns Niqmepa as grandfather of Idrimi (Woolley 1955). Woolley attributes the “bad thing” as the removal of Ilimilimma from the throne, which he bases on the unusual find-spots of the archaeological findings (Woolley 1955: 385–95). As a result, Niqmepa of Alalakh becomes the contemporary of Saustatar in Mitanni (Woolley 1955: 385–95). On the contrary, by analyzing the Level IV archives,

[6] Here the name Mukish appears as a city rather than a state (von Dassow 2008).

Wiseman revised the dynastic sequence as Ilimilimma (I)[7] — Idrimi — Niqmepa — Ilimilimma (II) (Wiseman 1953).

Wiseman also suggests two options to explain the absence of Addu-nirari in the archival texts. According to him, either Addu-nirari ruled for a very short time after Idrimi, so no records survived, or he was assigned only for religious duties as recorded on the statue (Wiseman 1953: 5–8). Furthermore, the name Sarruwe[8] as the author of the Idrimi statue inscriptions appears as the writer or witness for several other documents dated to the reigns of Niqmepa and Ilimilimma (Na'aman 1980: 107–10). Thus, the presence of Sarruwe as a scribe in Idrimi's court supports Wiseman's sequencing. Although Wiseman's dynastic chain is accepted generally among scholars, the fate of Addu-nirari still needs to be illuminated.

Aside from the archival records and their interpretations, the archaeological context of the statue also sparks different theories about Idrimi and his dynasty. The statue was found by Woolley in a pit possibly dug from Level IB, but it was chronologically dated to an earlier period.[9] Due to this contextual uncertainty, Sasson argues that the statue was inscribed during Alalakh Level IB as a memorial art piece to remember the re-founder and defender of Alalakh (Sasson 1981: 318–20; Longman 1991: 60–66). On the contrary, Oller disagrees with this theory because of its style and inconsistencies in content to its archaeological context (Oller 1989: 416–17). Since undisputable archaeological and textual evidence of Addu-nirari has not yet been found, none of these theories can be more than a suggestion. Hopefully, further excavations will shed light on these chronological debates.

[7] Ilimilimma I is the Ilimilimma of Aleppo and the father of Idrimi.
[8] Na'aman studied Saruwe's texts and his scribal characteristics (Na'aman 1980: 107–16).
[9] Level I is dated 1273–1194 BC by Woolley (1955:399). Revised chronology dates Level I is to the late 14th– century (Yener, in prep. a).

2.2. The Relationships of Level IV Alalakh to Contemporary Settlements

As discussed above, Alalakh was a vassal to Mitanni during the 15th century BC. Tablet AIT 3 clearly defines Idrimi of Alalakh as a contemporary of Parattarna of Mitanni. This tablet synchronizes the reigns of Idrimi and Parattarna. However to establish further linkages with other regions, the reign of Parattarna is still unclear. There is only a single record found among Nuzi administrative tablets that refers to his name (HSS XIII 165; Wilhelm 1976; Stein 1989).

Unlike Idrimi, the reign of his successor Niqmepa is quite well documented in the Level IV archives. Almost half of the tablets were signed during Niqmepa's reign by alternately using Idrimi's, Abban's[10], or his own seals (Collon 1975). Prosopographical studies by von Dassow also support Collon's assertions by arguing that these tablets were produced during the reign of Niqmepa (von Dassow 2005: 45–46, 48–50; 2008: 45). The name Niqmepa appears in Tablets AIT 13 and AIT 14, which carry a special importance to uncover his synchronic relations to Mitanni. Both of these records are about legal issues[11] that were brought before the Mitannian king, Saustatar (mid-to-late 15th century BC), who sealed these tablets with the seal of his predecessor, Suttarna (Collon 1975: no. 230; Stein 1989: 40; von Dassow 2008: 46). Saustatar of Mitanni is suggested as the successor of Parattarna who is contemporary with Idrimi (von Dassow 2008: 47). Saustatar, who opposed Thutmose III's campaigns into the Levant, was king of *Naharina* which was an attribution to Mitanni. In correlating Hittite chronology to Mitanni, Bryce puts Saustatar as a contemporary to Thutmose III and Tudhaliya I/II (Bryce 2005: 120, 123, 128). Another tablet, AIT 2, found in the Level IV palace courtyard, is a fragment from a treaty signed between Ir-Tessub, king of Tunip, and Niqmepa, king of Mukish. The seal impressed on the treaty tablet of king of

[10]Abban is the son of Šarran. For the dynastic use of Abban's seal by Niqmepa see Dassow 2008: 281; Collon 1975, no.11.
[11] Tablet AIT 14 is about a territorial problem, probably with Kizzuwatna, and tablet AIT 13 is about tribunal of people (von Dassow 2008: 48–49).

Mukish writes “king of Alalakh” creating a problem for the attribution of Mukish and Alalakh as a state or a city.[12] This tablet contains issues about territories and the situation of fugitives’ problems, which points out a military conflict between Alalakh and Tunip, and concludes with an emphasis on the allegiance to the Mitannian king (von Dassow 2008: 53).

The name of Niqmepa was also referred to in a text outside of Alalakh. Ugarit Tablet RS 4449 is the record of a letter sent to Niqmepa, the king of Alalakh, from the king of Ugarit, Ibiranu, mentioning the loss of a fugitive belonging to Niqmepa (Bunnens 1987; Arnaud 1996: 47–54). Since there is not much known about Ibiranu of Ugarit and the name is quite common in the Ugaritic dynasty, the relation of Alalakh and Ugarit in terms of contemporary kings is still unclear.

2.3. The Reign of Ilimilimma and the End of the Level IV Palace

The successor of Niqmepa was his son Ilimilimma. Even though a textual record dedicated to Ilimilimma or clarification of his reign as king has not yet been found, two tablets (AIT 15 and AIT 330) mention Ilimilimma as the son of Niqmepa (Collon 1975: nos. 193, 220). Additionally, nine tablets coming from the non-palatial archives were sealed with his seal (Tablets AIT 48–49, 70, 85, 87–88, 94, 103–04 in von Dassow 2005: 45–48).

According to Woolley, the Level IV palace was looted and burnt during a civilian’s rebellion against the king of Alalakh — not by an outside enemy; he dated this event to ca. 1415 BC (Woolley 1955: 130). He proposed this theory due to the unusual fact that the properties of the Level IV palace should have been carried off if destroyed by an enemy. Furthermore the quality and quantity of the findings are not enough to reflect a court life even compared to findings from the ruins since they were most probably looted. The condition of the tablets and objects lead to the conclusion that there was a hurry to remove or loot goods

[12] Mukish in the inscription on the statue of Idrimi has the determinative identifying it as a city (von Dassow 2008). However, Mukish was referred to as a state rather than a city on tablet AIT2.

(Woolley 1955: 130). According to the traditional understandings of establishing a chronology, imported pottery was used to date these levels. The existence of a Cypriot Base-Ring II shard and a Mycenaean LH IIIA shard among the palatial findings fixes the destruction of the Level IV palace to post-date 1425 BC (Stein 1997: 56). The new round of excavations brought a broader perspective to the new chronology of Alalakh by providing a set of data composed of fine-grained and relational stratigraphy, deposit-defined seriation, ceramic seriation, and textual records as well as radiocarbon dating and dendrochronology. These studies are ongoing to precisely date these levels.

The end of Level IV and the beginning of a new period in Alalakh was interconnected to the political and military environment of the second half of the 2nd millennium BC. The destruction of Level IV is attributed to Hittite King Suppiluliuma I and is dated to ca. 1370 BC by Woolley (1955: 130). However, this date is changed to 1340 BC according to the low chronology (Gates 1987). Mukish became a vassal of the Hittites in the mid-14th century (Bryce 2005; Klengel 1992). This change in Alalakh's political situation and the control of the city by the Hittites were mentioned in the textual records (Astour 1972). The preliminary results of the Yener excavations suggest a new picture for the chronology of Alalakh. According to new dating, the site was abandoned around 1300 – 1290 BC and reoccupied as a minor settlements at the mid- 12th century around 1140 BC (Yener in prep. b, Akar 2012)

Archaeological deposits prove a Hittite presence at Alalakh (Woolley 1955). Woolley defines the Level III/II as "Hittite fortress of Alalakh," extrapolating the archaeological remains of a Hittite style administrative complex and Hittite-based material assemblage found in subsequent levels (Level I; Woolley 1953, 1955). On the other hand, the results of Yener's archaeological expedition at the site disprove Woolley's definitions for Level IV and III (Yener, in prep. a; Akar, in 2012). Instead of a sudden collapse at Level IV followed by a reemergence at Level III/II, new excavations reveal archaeological deposits verifying re-use and reconstruction of the post-Level IV sequences.

Ongoing excavations in the settlement are still searching for answers to the chronological problems. Furthermore, better explanations are now being developed to understand the cause of the destruction or abandonment at the site. According to the latest excavation results, rather than annihilation, Alalakh was abandoned during the late 14th – early 13th centuries, and the occupation ended at the beginning of the 13th century (Yener, in prep. b).

2.4. Reflections of History in the Material Culture of Alalakh

Strategically located at the juncture of multiple trade networks, Alalakh's pivotal role in both land and sea networks was certainly one of the major reason for the Late Bronze Age empires to seek to control the territory of Mukish. Continuous changes in political control together with the dynamic trade network connections that Alalakh was involved with created a complex and hybrid material culture in the settlement. The interchanges between Alalakh and contemporary international cultures built a highly cosmopolitan environment. Intensive and broad trade contacts were widely dispersed according to archaeological and historical data. Archaeological findings together with textual records bring the complex relations into sharp relief (Yener 2010; von Dassow 2008).

The exceptionally rich and unique artifact assemblages provide solid evidence to show the influence of different cultures as the hybridization of the material culture of Alalakh. Various cultural trends such as pottery styles or architectural features left their traces in every element of artistic goods produced in this capital city. Furthermore, archaeological evidence reflecting daily life shows a similar pattern of a complex mixture of cultures. One of the aspects of daily life includes production technologies. Production technologies not only cover the processes and management of the manufacture, but also include related production like pyrotechnological units that are the focus of this study. With respect to that, all these patterns have a significant impact on the pyrotechnology of Alalakh.

The divergence in socio-economic life also triggered new progress and ideas in related technological areas. An increase in demand due to commercial activities or changes in daily life may have activated an advanced expansion in production techniques and technologies including pottery kilns, metal furnaces, and glass, faience, and frit production units. The installations concerned were the archaeological evidence of a variegated socio-economic life of Alalakh. As noted above the cultural influences of the Mitannians were dominant for a long time both in material culture and in the production technologies of Alalakh. With the dominance of the Hittites immediately after the Mitanni Empire, the city was also marked with its characteristic Hittite trends in the material culture.

Besides archaeological evidence, textual records provide critically important information to illuminate various aspects of production like its hybrid material culture, socio-economic relations as well as the social status of the production-related labor, the craftsperson in the Late Bronze Age Alalakh. Tablets unearthed in the Level IV palace, Level III and Level II were examined by various scholars and revealed that various crafts like the potter (*paḫāru*), smith (*nappāḫu*), carpenter (*naggāru*), stone-cutter (*zadimmu*), leather-worker (*aškāpu*), reedworker (*atkuppu*), weaver (*išparu*), seal-cutter (*parkullu (ḫuli)*), bow-maker (*sasinnu* (?)) or scribe (*ṭupšarru*) were done by diverse groups of people having different social status (von Dassow 2008: 256, 262 Table 4.3, 4.4). Whether these four classes[13] were in royal service or

[13] According to these tablets four different social groups were identified: *ḫupše*, *ḫaniaḫḫe*, *eḫelle* and *maryanni*. *ḫupše (ḫupšena* or in some Alalakh IV texts *purre*) was a relatively poor or low-ranking people holding theirown lands (Dietrich and Loretz 1970). Dietrich and Loretz (1970) and von Dassow (2008) argue that *unuššuḫuli* refers "one who owes royal service". *ḫaniaḫḫe* was also referring an impoverished class of the population occupied as craftsperson, daily-workers or soldiers (Schloen 2001:303). *eḫelle* and *maryanni* classes on the other hand refers to a more high ranking status. *eḫelle* (*eḫelena*) describes "released- or freed-men"

not, as von Dassow acknowledges, everything was recorded from the palatial perspective. This information did not include local-social relationships. Tablets documented issues about favored subjects of the royal court. Nevertheless, these tablets are indications of palace and elite interest and their control over crafts. The elite desire to oversee crafts was due to either emphasizing their power or manipulating their social status through the superintendence of production. As the household and personnel lists demonstrated, various kinds of artisans like smiths and potters were categorized in these documents proving palatial governance of them. Although hitherto available textual records did not document details of a control mechanism, this complex administrative system also covered control and organization of raw materials even the distribution and consumption of goods. Eventually, all these craft-palace and craft-elite relationships constitute an example of the socio-economic structure in the Late Bronze Age capital Alalakh which needs to further examination.

Alalakh seems to have created its idiosyncratic culture by harmonizing different elements from various cultures. Different technological advancements were reached in order to provide high-quality goods to palatial and domestic markets. These technological achievements and the socio-economic environment of the period can be further researched by investigating archaeological contexts related to production technology. In this regard, the craft quarter district in Area 2 and its pyrotechnological installations are sources of primary knowledge. The contextual information summarized in Chapter III and scientific examinations collected in Chapter IV demonstrate how technological processes were developed related to the nature of socio-economic and socio-political settings and how different production activities were integrated with each other.

(Dietrich and Loretz 1969:92). Most probably this symbolizes an independence from the royal service. On the other hand, *maryanni* who were chariot warriors constituted a distinct elite class (von Dassow 2008).

CHAPTER III

CONTEXTUAL AND FUNCTIONAL ANALYSIS OF TELL ATCHANA/ANCIENT ALALAKH PYROTECHNOLOGICAL INSTALLATIONS

This chapter aims to re-examine the typological and contextual information of Tell Atchana/ancient Alalakh's pyrotechnological installations originally presented in Yener 2010 and gives general contextual information about the phasing of the craft quarter. During the 2003–2004 excavation seasons at Tell Atchana/ancient Alalakh, four 10 × 10 m trenches (44.69, 44.79, 44.80, and 45.71) on the eastern edge of the mound exposed a domestic craft quarter representing several households (fig. 3.2).[14] In this context, eight distinct pyrotechnological installations were uncovered (Yener and Yazıcıoğlu 2010: 16). These installations were analyzed stratigraphically and contextually in the 2003–2004 excavation monograph (Yener 2010). This thesis will add detailed information on the function and technology of these installations by providing qualitative analyses.

These wide-ranging data reveal potential answers as to how fire was managed in these installations how the materials were processed and what was produced inside. The archaeological information will be added to the scientific examination (Chapter IV) so that reconstructions of type and function for each installation will become possible. These reconstructions will help to interpret probable usages of the installations in terms of processed materials like ceramic, metal, glass, faience, frit or perhaps multi-material.

[14] The reason of assessing the craft quarter as a household is discussed in Chapter I and VI.

This chapter will evaluate eight pyrotechnological installations from Tell Atchana/ancient Alalakh Area 2 craft quarter within their stratigraphic context. Changes in spatial arrangement, typology, and the technology of the installations are identified. Diversity in the installation typologies and technologies — as well as the assemblages within the installations throughout the phases — are evaluated and compared.

3.1. Phasing of the Craft Quarter

The pyrotechnological installations of Atchana Area 2 belong to the Late Bronze IIa (hereafter, LBIIa) phase of the settlement. According to the local square-based phasing system assigned by the Yener excavations, these installations are stratigraphically attributed to *Phase 1* of Area 2. This phase has two sub-phases: *Phase 1b* and *Phase 1a*. Chronologically, *Phase 1b* refers an earlier period than *Phase 1a*. In this stratigraphic arrangement, Installations 1 - 3 were found in *Phase 1b* whereas the Installations 4 - 8 were associated with *Phase 1a*. Area 2 is unfortunately not connected to Area 1, where the primary sequence for Alalakh is established and dated by a variety of methods.

To establish the chronology of Area 2 *Phase 1*, several pottery studies and radiocarbon dates were used (Yener 2010). Assemblages of imported pottery like Mycenaean, Cypriot and Nuzi wares found in the Yener excavations were evaluated since they have distinct chronological attributions; the most narrow dating criteria is the Mycenaean ware, of which only LH IIIA-2 (dating to the 14th century BC) was found in *Phase 1* (Koehl 2010; Kozal 2010). A study examining the local pottery assemblage of *Phase 1* suggested that it should be dated with uncertainty to the 15th – 14th centuries BC (Mullins 2010); however, a comprehensive local typology and seriation had not yet been completed at the time of that study. This broad chronological assessment was supported by the preliminary radiocarbon dating. Radiocarbon samples from the 2003–2004 seasons at Atchana were analyzed at the Vienna Environmental Research Accelerator (VERA) laboratory (Yener and Yazıcıoğlu 2010:

32–33). They were recalibrated for this study using the CALIB Radiocarbon Calibration Program.[15] The archaeological contexts of the samples and recalibration chart are given in Table 13.

There is only one radiocarbon sample from *Phase 1* (Square 44.79) and it was recovered from a context recorded as a street or ditch, not the most secure sort of context for radiocarbon sampling. Additionally, *Phase 1* is very close to the modern ground surface and radiocarbon dating may be inaccurate. The radiocarbon results from VERA for the *Phase 1* sample are 3002+-27 BP calibrated at 1309–1209 BC (1σ, Yener and Yazıcıoğlu 2010) and 1301-1204 BC (1σ) using CALIB. This is trending somewhat later than expected but could still fall within the range of c.1375–1295 suggested by other means for Alalakh Levels III–I,[16] especially if the carbon sample (a charcoal fragment) was deposited late in the phase. It is also possible that Phase 1a continued in use after the rest of Alalakh was abandoned in the early 13th century. Archaeological deposits of the context show use for a maximum of 50–60 years for this phase, which includes Installations 4, 5, 6, 7, and 8.[17]

There are no ^{14}C sample results from *Phase 1b* of the craft quarter, but *Phase 2*, which was right under *Phase 1b*, has two ^{14}C samples. The first date is 3117+-38 BP, calibrated at 1406–1311 BC (1σ, Yener and Yazıcıoğlu 2010: 33) but recalibrated as 1437–1366 and 1346–1331 BC. The second date is 3140+-31BC calibrated as 1434–1380 BC (1σ; Yener and Yazıcıoğlu 2010: 33) and recalibrated as 1446–1394 BC. These samples were also charcoal fragments but were obtained from occupation debris rather than a street/ditch. If *Phase 2* correlates with Alalakh Level IV then these dates will be consistent.

[15] This recalibration was done by Dr. Mara Horowitz.
[16] Note that in the Yener 2010 publication, Area 2 *Local Phase 1a-b* was tentatively synchronized with Alalakh Level III based on the assumption that Alalakh Level II-I were in the 13th century. Current data suggests that Levels III-I were all in the 14th century and ended about 1300-1295BC, thus synchronizing Area 2 *Phase 1a-b* with any or all of Levels III-I.
[17] This estimation was proposed according to personal communication with Murat Akar.

Since *Phase 1b* is later than *Phase 2*, according to the radiocarbon dates, Installations 1, 2, and 3 in *Phase 1b* should be dated later than the approximate range of 1446–1341 BC and earlier than the *Phase 1* date range of 1309–1209 BC. *Phase 1b* should therefore be dated around the mid-14th century. This chronological attribution is supported by the ceramic corpus from the archaeological deposits of *Phase 1b*.

The radiocarbon dates and chronological assessments of the Area 2 *Phase 2* and *Phase 1a-b* appear to be contemporary with Woolley's Levels IV and III-I in the palace district (as per Woolley 1955), although it suggests a more complex stratigraphy than his argument (Yener and Yazıcıoğlu 2010: 32). According to the chronology that Woolley was advocating, which was actually not consistent with any of the High, and Low chronologies,[18] Levels IV–III were proposed by Woolley to span a time interval of the 15th –14th centuries BC. This chronological suggestion is proved partially correct by Yener's excavations, which are now showing that Levels II–I are also 14th century rather than 13th century (Yener in press b). Studies establishing a new chronology and comparing the results of Woolley's levels with Yener's newly established local phases are still in progress. These chronological reassessments will further illuminate the dating of the site as well as contribute a wide range of information to the second millennium chronological debate. At this point, the new 2003–2004 stratigraphy of Tell Atchana dated the Area 2 *Phases 1a-b* to the mid-late 14th century BC.

Besides the craft area subjected to this study, there was another nearby context indicating that craft activities were continuously performed in this part of the mound. In the 2007–2009 and 2011 seasons, another square (Square 45.44, Area 3) excavated on the

[18] High, Middle and Low Chronologies provide differing dates to fix some events, rulers or dynasties in the chronology of the Near East. For example, Middle Chronology accepts1595 BC as date for fall of Babylon, whereas 1531 BC and 1651 BC were accepted by Low and High Chronologies respectively. Woolley's proposed dates began (in Level XVII) far earlier than the highest of the high chronologies and finished (in Level 0) approximately equal to the other chronologies.

southeastern side of Area 2, and which is 10–15 meters away from the craft area in this study, yielded six more pyrotechnological installations dated to different sub-phases (Yener and Yazıcıoğlu 2010:34, 35; figs. 2.1 and 2.2). Although the chronology and stratigraphy of the square are not yet clarified, archaeological deposits and the material assemblage indicate an earlier date than Area 2 *Phase 2*, probably equating with Woolley's Levels V–VI and dating to the LBI period. Excavations in these areas are ongoing. Further archaeological research will clarify the stratigraphic connections of these Area 3 pyrotechnological installations to the craft quarter under consideration. It is important to note that the spatial location, stratigraphy, and assumed chronology of this workshop area imply continuous production activities in this part of the mound.

To sum up, ceramic seriation studies including the chronologically sensitive imports suggest the mid-late 14th century BC (c.1375-1295?) as the life span of the craft quarter area. Archaeological deposits, together with radiocarbon analysis, provide similar results. It is not yet possible to synchronize *Phases 1a-b* with the Alalakh Levels III–I (palace area sequence) and thus it is not known whether *Phases 1a-b* both occur during Hittite management or whether they overlap with the earlier Mitanni hegemony over the city. Ongoing excavations on the site will further clarify the synchronisms and political situation.

3.2. A General Overview of the Craft Quarter District

The craft quarter district with eight pyrotechnological installations is located in Area 2 of the new excavations.[19] Area 2 includes eight 10 x 10 m squares among them Squares 44.69, 44.79, and 44.80 which contain pyrotechnological installations. Besides Area 2 craft quarter, an adjacent Square 45.71 of Area 3 also yielded pyrotechnological features (fig. 3.2). This area has a complex stratigraphy with several occupational sub-phases (*Phase 1b, 1a, 1a early,* and *1a late*). In these multi-phased stratigraphic sequences, the installations were found

[19] Only Square 45.71,containing a portion of Installation 3, is located in Area 3.

primarily in *Phase 1b* and *Phase 1a* (Yener and Yazıcıoğlu 2010: 16, 33). The district covering Area 2 and partially Area 3 is described as a craft quarter due to the high accumulation of diverse pyrotechnological installations. For the sake of further research like this thesis, installations uncovered in this area were classified according to the 2003–2004 monograph and assigned with numbers from 1 to 8 (Yener and Yazıcıoğlu 2010: 16–19).

The pyrotechnological installations extended across four trenches with a high accumulation in Square 44.80. Installations 2, 5, and 6 together (fig. 3.2) with partial constructions of Installations 3 and 4 were located in this unit. The remaining segments of Installations 3 and 4 were found in Squares 45.71 and 44.79, respectively. The entire structures of Installations 1 and 7 were found in Square 44.69 and Installation 8 was discovered in Square 44.79 (Yener and Yazıcıoğlu 2010: 16–19; here fig. 3.2).

The craft quarter area is architecturally differentiated from the rest of the Area 2 with a northeast–southwest-oriented stone wall preserved only at the foundation level. This stone enclosure wall extended into both Squares 44.80 and 45.71 in *Phase 1a* and had two parallel extensions. In the northeast–southwest direction, this wall connected to another northwest–southeast wall segment, which is 3.5 m long and approximately 40 cm wide. This stone wall foundation bordered a courtyard of approximately 7 m^2. This spot presumably served as an outdoor activity area for the craft quarter since it is contemporary to the *Phase 1b* and *Phase 1a* installations (Yener and Yazıcıoğlu 2010: 16, 22).[20] Additionally, a mud brick deposit[21]

[20]From the floor deposit of this activity area, several copper-based fragments (A04-R322, A04-R330, A04-R451, A04-R558, A04-R593, and A04-R627), a bronze needle (A04-R321), slag (A04-R364, A04-453, and A04-R591), bone and ground stone tools (A04-R475, A04-R263, A04-R264, A04-R265, A04-R329, and A04-R376), and beads (A04-R258, A04-R455, A04-R458, A04-R474, and A04-R592) were recovered (Yener and Yazıcıoğlu 2010: 22).
[21] This deposit layer thought to belong *early Phase 1a* as an early construction phase of the stone enclosure wall. The floor above this layer is suggested as a renovation phase of the wall and was related to *late Phase 1b* (Yener and Yazıcıoğlu 2010: 22).

below this stone enclosure wall seems to be associated with the *Phase 1a* installations (Yener and Yazıcıoğlu 2010: 22).[22]

The installations in the craft quarter area are related to architectural remains excavated in Squares 44.45, 44.46, 44.54, 44.55, and 44.68 in Area 2 (fig. 3.2). A likely outdoor activity area linked to the craft quarter was excavated in Squares 44.45 and 44.55, which are located on the northwest side of the installations. In this domestic or craft-related activity area, a notable number of cooking pots were uncovered. The architectural features include a bin and couple of tandırs. These features were used both in *Phase 1a* and in *Phase 1b* (Yener and Yazıcıoğlu 2010: 19, 35 fig. 2.2).[23]

Another activity area was recovered in Square 44.68 (fig. 3.2), which was located adjacent to Squares 44.69 and 44.79. This activity area was bordered by a northeast–southwest directed stone wall foundation. The eastern and western sides of the wall yielded a remarkable amount of artifacts and architectural features indicating a relationship with the craft quarter (Yener and Yazıcıoğlu 2010: 20–22). Although only a faience bead[24] together with couple of chert and animal bone samples were found on the western side of the wall, the eastern part of the wall bordered a courtyard that revealed a great assemblage of artifacts indicating production activity (Yener and Yazıcıoğlu 2010: 20). An elongated plastered bin made out of unbaked clay, a heavily burnt, well-preserved small tandır (approximately 50 cm in diameter), and a larger collapsed in-situ tandır (approximately 70 cm in diameter) were found in this courtyard. The floor between these two tandırs yielded twelve restorable in-situ

[22] This layer yielded copper-based fragments (A04-R403 and A04-R419), slag (A03-R349, A04-R378, A04-R384, A04-R422, A04-R428, A04-R452, and A04-R576), bone tools (A03-R366 and A04-R448) and beads (A04-R367 and A04-R432; Yener and Yazıcıoğlu 2010: 22).

[23] For the Phase 1 architectural plans of the Squares 44.45 and 44.55, consult Yazıcıoğlu 2010: 201, fig. A.9; 204, fig. A.12.

[24] A03-R1085 (Yener 2010: Appendix B, p. 269).

fine wares together with cooking and storage vessels.[25] Zoomorphic figurine fragments[26] and an object[27] made out of clay, two awls made out of bone,[28] several copper objects and slag,[29] beads,[30] and a piece of glass[31] were found in the fill above the in-situ pottery assemblage. A remarkable amount of grain processing elements made out of basalt[32] together with stone-grinding object fragments[33] were found in the same fill (Yener and Yazıcıoğlu 2010: 20). The spatially linked location of this activity area to the craft quarter together with the variation and amount of production related findings (basalt and stone grinding tools, clay fragments, and metal slag) connect this outdoor area to the craft quarter.

Other than these production-related activity areas, two wall features were excavated in Squares 44.46 and 44.55 in the northwest of Area 2 (fig. 3.2). Excavations of the wall in Square 44.55 show that this feature was built haphazardly above the main southwestern wall of Building B of *Phase 2* by using fieldstones and waste materials, like ceramic shards and baked oven and basalt mortar fragments. Additionally, in Square 44.46, a corner of a room was excavated (Yener and Yazıcıoğlu 2010: 20). The architectural features of the Squares 44.46, 44.55, and 44.68 continue in *Phase 2*, *Phase 1b*, and *Phase 1a*, though the features in Squares 44.45 and 44.54 continue only in *Phase 2* and *Phase 1a* (Yener and Yazıcıoğlu 2010: 34–35, figs. 2.1–2).

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[25] A04-R467, A03-R1552, A03-R1763, A03-R1804, A03-R1844, A03-R1846, A03-R1847, A03-R1848, A03-R1849, A03-R1854, A03-R1855, and A03-R2031 (Yener 2010: figs. 2.20.4–7; p. 45 and figs. 3.3.4, 3.3.6; p. 66).
[26] A03-1556, A03-1557, and A03-1558 (Yener and Yazıcıoğlu 2010: 20).
[27] A03-R1295 (Yener and Yazıcıoğlu 2010: 20).
[28] A03-R1272 and A03-R1643 (Yener and Yazıcıoğlu 2010: 20).
[29] A03-R1512, A03-R1128, A03-R1129, A03-R1275, A03-R1311, A03-R178, A03-R1420, A03-R1526, and A03-R1528 (Yener and Yazıcıoğlu 2010: 20).
[30] A03-R1130, A03-R1224, and A03-R1256 (Yener and Yazıcıoğlu 2010: 20).
[31] A03-R1351 (Yener and Yazıcıoğlu 2010: 20).
[32] A03-R1500, A03-R1502, A03-R1503, A03-R1504, A03-R1506, and A03-R1507 (Yener and Yazıcıoğlu 2010: 20).
[33] A03-R1442, A03-R1505, A03-R1529, A03-R1568, and A03-R1575 (Yener and Yazıcıoğlu 2010: 20).

3.3. Typological Designations for the Installations

The identification of the function of Alalakh's pyrotechnological installations, and designating them as pottery kilns, metal furnaces, or glass, faience or frit production units needs excessive caution. The compartments of the installations have terminologically loaded descriptions. To have a standard terminology throughout this thesis, and avoid any misconceptions in terms, this section elucidates the proper structural definitions for the special parts of the installations.

The main kiln construction technique in use for the Late Bronze Age craft quarter district of Alalakh was the so-called "updraft kiln." The updraft installations consist of a firing chamber and a generally subterranean combustion chamber associated with an exterior stoking chamber. The fuel was burnt at the entrance of the combustion chamber in the stoking chamber — in other words, in a firing pit (fig. 3.1). Hot gases produced by the burning of fuel in the stoking pit were accumulated in the combustion chamber. The shape of a combustion chamber could be rectangular, circular, or oval (Hasaki 2002: 77). This chamber was generally lined with bricks to provide better air circulation. The chamber working as a heat depot transferred the hot gases to the upper chamber via holes in the chamber floor.

The firing chamber was the upper part or second-story of the structure. The second stage was the compartment where the artifacts were deposited and fired. This part was separated from the combustion chamber with a floor because there was a need to prevent the direct contact of objects inside the upper chamber with high temperatures (Hasaki 2002: 82). This floor was generally perforated by ventilation holes (fig. 3.6). These ventilation holes allowed the hot gases to move from the combustion chamber to the upper chamber. In updraft structures, the upper chamber was generally covered with a dome-shaped ceiling that had a chimney. The hot gases circulated in the upper chamber and left via the chimney so that more hot gases from the combustion chamber could be pumped into the upper chamber (Hasaki

2002: 89–90). In updraft installations, the circulation of heat happened naturally due to the special structural arrangement and the fact that hot gasses naturally rise.

In archaeological contexts, the combustion chamber and stoking chamber are generally preserved. However, the survival of a firing chamber is rare. Among the updraft pyrotechnological installations of Alalakh (Installations 1–5), the combustion chambers were generally well preserved (figs. 3.3 - 3.11). Additionally, Installation 2 (figs. 3.4 - 3.6) had a partially preserved firing chamber, which has a special importance for archaeological studies.

Installations 6, 7, and 8, on the other hand, are subterranean oval or arch-shaped features. In other areas, these installations were generally 30–60 cm deep and were plastered inside; they were probably for open-air or pit firings (figs. 3.12 – 3.15). Fuel would have been placed inside the structures together with materials to be fired. Controlling the firing conditions and temperature in these installations was difficult (Sinopoli 1991). Obviously, these types of installations are not as complex structures as updraft kilns, but one can find contemporary parallels at other Late Bronze Age settlements, like Tell Afis (Venturi, in press) and Tell Sabi Abyad (Duistermaat 2008). These installations will provide further information and assist in the testing of theoretical assumptions about the typologies and process of updraft kiln firings.

3.4. Phase 1b: An Overview of the Craft Quarter

From *Phase 1b*, three installations were recovered (figs. 3.2, 3.3 – 3.7). Installations 1 and 2 are well preserved. On the other hand, Installation 3 was badly damaged due to the collapsed deposit of the *Phase 2* kitchen/workshop context[34] in Square 45.71 (Yener and Yazıcıoğlu 2010: 18, 33 table 2.1). As a result, the contents of Installation 3 were not secure when compared with Installations 1 and 2 from this phase.

[34]For a detailed discussion of the Square 45.71 kitchen/workshop context, see Yener 2010: 26–27.

The installations of *Phase 1b* were excavated (figs. 3.2, 3.8 – 3.15) and the actual floor level was reached. Among them, only Installation 2 was fully excavated, whereas Installations 1 and 3 were partially excavated since these structures were partially located under the balk of the trench borders. Excavations showed that the *Phase 1b* installations were rectangular, multi-chambered, and double-decked. The lower deck (stage), where the combustion chambers were located, is partially under the ground surface. The upper deck was freestanding and was not associated with the other archaeological features. Traces of multiple firings were observable from the clay walls by variations in color (Yener and Yazıcıoğlu 2010: 16–17). Further excavations in this area will clarify the stratigraphic and contextual relations of these installations with the other floors.

3.4.1. Installation 1: Typology and Contextual Information[35]

Installation 1 (fig. 3.3) was excavated in Square 44.69 near the southern partition wall of the trench. This large installation was the most complex pyrotechnological structure of *Phase 1b* and was identified as a pottery kiln (Yener and Yazıcıoğlu 2010: 17). Spanning an area of 4.6 m^2, the horizontal extensions were 2.0 × 2.6 m. This rectangular kiln is double-decked. Although the upper deck did not survive, white plaster with burnt mud bricks was recovered inside the kiln fill, roughly six centimeters below the top soil. These white plastered mud bricks must have been the floor fragments of the upper deck. Inside the fill circular compartments were found. These should be remnants of ventilation holes. At a depth[36] of 46 cm, the combustion chamber was unearthed almost intact with partition walls. The construction material was very hard, indicating repeated firing. The combustion chamber, walls, and lining had an orange color together with green and black spots of glassy vitrification, proving high firing temperatures.

[35] Contextual information is from the 2004 season, Square 44.69 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 180, 182, table A.2.
[36] Highest elevation 97.85 m, lowest elevation 97.39 m above sea level (hereafter, asl).

The kiln has two big chambers dividing the combustion area into two compartments in a south–north direction. Since the southern part was going under the balk of Square 44.69, only the northern part was excavated. This northern part of the kiln exposed two separate circular compartments and two separate chambers. The colors of the interior part of this area vary from green and black to orange. At the northeastern side of the installation, an ashy surface was also excavated, which may have been the dump from the original stokehole. Due to the balk and the natural slope at the southern part of the context, floor levels of all the combustion chambers have not been reached yet. Most probably, there may have been a stokehole for the continuous fuel supply to the kiln (Yener and Yazıcıoğlu 2010: 17).

Installation 1 was an updraft kiln with quite extensive dimensions. From the fill of the kiln and the kiln itself, charcoal, bones, and ceramic shards were collected.[37] Copper-based fragments, pins, slag,[38] and a bead[39] were found 30 cm away from the structure. The assemblage around the kiln signifies a metal-related activity in the region. Preservation conditions and associated assemblages make this installation a unique example for further research. Scientific samples collected from the walls, linings and chambers of this installation were analyzed and presented in Chapter IV.

3.4.2. Installation 2: Typology and Contextual Information[40]

Installation 2 (figs. 3.4–6) was uncovered in the center of Square 44.80. This almost-square mud brick installation is multi-chambered and double-decked. This pyrotechnological installation is the best preserved among all of the installations in the craft quarter and is a perfect example of a pottery kiln. Measuring 1.5 × 1.5 m, Installation 2 had an upper chamber

[37]The locus for the fill of the kiln is L03-2086 and the kiln itself is L03-2044 (Yazıcıoğlu 2010: Appendix A, pp. 182, 180).
[38]A03-1713, A03-1720, A03-1781, A03-1705, and A03-1741 (Yener 2010:17).
[39]A03-1743 (Yener 2010:17).
[40] Contextual information is from the 2004 season, Square 44.80 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 185, 187–88, table A.2.

with ventilation holes recovered intact. Each of the four corners of the installation had air flues and the interior part had thirteen plastered holes for air circulation inside. Hard-fired white plaster was detected as two different layers at the floor and the ventilation openings were also perforations. The lower deck was a semi-subterranean combustion chamber. The color of the mud brick walls of the interior change from brown to orange with partial vitrification indicating different temperature degrees reached during firing practices. The primary features of the installation were unearthed in three loci (L04-2048, L04-2015, and L04-2071).

Typologically, Installation 2 is an updraft kiln. The architectural feature[41] of the multi-chambered kiln extended 1.5 × 1.5 m (ca. 2.25 m^2) with a depth[42] of 51 cm and was composed of fired mud bricks and mud plaster (Yazıcıoğlu 2010: 187, table A.2). A plaster sample[43] and a burnt bone[44] were recovered from this feature. In terms of comparing this structure to the contemporary example Installation 1 by size, Installation 2 is smaller.

The inside fill of the kiln[45] had brown soil containing fired mud and mud brick pieces together with ashy patches. A variety of artifacts — a chert chip,[46] a flint or chert flake,[47] a ceramic disc,[48] a bead,[49] and a piece of iron[50] — were recovered and soil samples were collected for analyses[51] from a depth of 36 cm in this layer[52] of kiln fill. Moreover, pieces of bone, charcoal, mother-of-pearl, and shell were found in the fill. Within the fill from the

[41]Locus L04-2048 (Yazıcıoğlu 2010: Appendix A p. 187).
[42] Highest elevation 97.62 cm, lowest elevation 97.01 cm asl.
[43] R04-607 (Tell Atchana archives).
[44] R04-DIS? (Tell Atchana archives).
[45] Locus L04-2015 (Yazıcıoğlu 2010: Appendix A, p. 185).
[46] R04-368 (Tell Atchana archives).
[47] R04-370 (Tell Atchana archives).
[48] R04-372 (Yener 2010:17).
[49] R04-377 (Yener 2010:17).
[50] R04-436 (Yener 2010:17).
[51] R04-424 (Tell Atchana archives).
[52] Highest elevation 97.62 cm, lowest elevation 97.26 cm asl.

combustion chamber,[53] a nearly similar picture of the interior fill of the kiln was observed. Beneath the plaster platform, burnt soil with light brown and orange color containing ash was excavated together with fired mud bricks.

The extremely good preservation conditions and wealth of associated finds of the installation provide an exceptional chance for investigating it scientifically. The analysis of structural features like wall linings and plasters together with various slag fragments found in the fill are in Chapter IV.

3.4.3. Installation 3: Typology and Contextual Information[54]

Located at the juncture of Squares 44.80 and 45.71, Installation 3 (fig. 3.7) was excavated in two parts in both 2003 and 2004. The remnants of the installation were first recovered in Square 45.71 in 2003. The rest, including the collapsed structural fragments, were identified in 2004 in Square 44.80. This oval-shaped structure, with the dimensions 3.5 × 2.6 m, is unique in terms of size among all of the installations in the craft quarter. This installation was double-decked; however, the second story did not survive as it did for Installation 2. White plastered fragments indicating the surface of the upper-deck were identified in the interior fill of the kiln.

A hue varying from orange to red was documented on the linings of the installation, evidence of repeated firing activity in the structure. Hard-fired mud-bricks, burnt soil, and ash covered the interior fill. The thick white plaster of the second stage continued down into the combustion chamber where the southeastern air flues were located. The combustion chamber was divided into two with fired mud-bricks placed in a northeast–southwest direction. These two small compartments could not be identified and described in detail due to the collapse of

[53] Locus L04-2071 (Yazıcıoğlu 2010: Appendix A, p. 185).
[54] Contextual information is from the 2004 season, Square 44.80 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 188, table A.2.

the installation itself (Yener and Yazıcıoğlu 2010: 18). From the fill inside the kiln and from the kiln debris[55] a figurine,[56] a stone vessel,[57] and slag[58] were recovered together with plenty of ceiling and plaster samples,[59] bone, shell, and mother-of-pearl fragments.

3.5. Phase 1a: An Overview of the Craft Quarter

Contrary to *Phase 1b*, in *Phase 1a*, large pyrotechnological installations vanished and were substituted with smaller structures. Instead of having a standard structural shape, the typology of *Phase 1a* installations varied from circular and semi-circular to elongated and apsidal. Updraft kilns also existed in this phase. None of the installations were free-standing but rather were supported by other architectural features, like stone walls (Yener and Yazıcıoğlu 2010: 18).

3.5.1. Installation 4: Typology and Contextual Information[60]

Installation 4 (fig. 3.9) covered both the northeastern corner of Square 44.79 and the northwestern balk of Square 44.80. This elongated structure measured roughly 1.25 × 4.00 m and had a depth of approximately 16 cm at the western portion.[61] This oval structure was dug as a pit and the walls were covered with mud bricks. There is a possibility of having compartments in this installation, but it is not possible to document it due to the soil balk separating the two squares. The interior material composed of brown soil with yellow-orange burnt fragments of mud brick and hardened clay indicate continuous firing activities in this

[55] Locus L04-2072 (Yazıcıoğlu 2010: Appendix A, p. 188).
[56] A04-692 (Yener 2010:18).
[57] A04-683 (Yener 2010:18).
[58] A04-653 and A04-691 (Yener 2010:18).
[59] R04-649, R04-689, and R04-690 (Tell Atchana archives).
[60] Contextual information is from the 2004 season, Square 44.80 and 44.79 field books (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 185, 187–88, table A.2.
[61] From Square 44.80, Locus L04-2020, which represents the fill of the mud installation, elevations are: Highest elevation 97.72 cm, lowest elevation 97.46 cm asl. From Square 44.80, Locus L04-2046,which represents the mud installation itself, elevations are: Highest elevation 97.72 cm, lowest elevation 97.43 cm asl.

subterranean installation. Shell, bone, mother-of-pearl, an obsidian chip,[62] a copper-based pin[63] (needle?), and slag[64] were found inside the fill.[65] Combustion chambers of this feature made out of hard-fired mud brick were excavated together with an ashy fill and burnt black soil.

3.5.2. Installation 5: Typology and Contextual Information[66]

Installation 5 (figs. 3.10–11) is located adjacent to the western balk of Square 44.80. This mud installation with horizontal dimensions[67] of 2.0 × 0.6 m and a depth[68] of 33.0 cm was excavated to its floor. It is composed of two chambers with brown soil and ashy patches. The locus[69] of installation revealed pottery slag[70] and charcoal[71] together with bone and shell fragments. Furthermore, a black-grayish tuff-like slag was commonly unearthed in this installation. On the other hand, no artifacts were recovered from the locus of the fill inside[72] the installation (Yener and Yazıcıoğlu 2010: 18–19).

3.5.3. Installation 6: Typology and Contextual Information[73]

Installation 6 (figs. 3.12–13) was excavated in the northern–central portion of Square 44.80. This rectangular mud installation with dimensions of 1.8 × 1.0 m has a depth of 40 cm.[74] This pit-like installation was plastered with mud and mortar-like material and the

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[62] R04-369 (Tell Atchana archives).
[63] A04-392 (Yener 2010:18).
[64] A04-661 (Yener 2010:18).
[65] Loci L04-2020 and L04-2040 (Yazıcıoğlu 2010: Appendix A, pp. 186–87).
[66] Contextual information is from the 2004 season, Square 44.80 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 187, table A.2.
[67] Dimension directions: 2.0 m southwest–northeast; 0.6m northwest–southeast.
[68] Highest elevation 97.73 cm, lowest elevation 97.40 cm asl.
[69] L04-2039 (Yazıcıoğlu 2010: Appendix A, p. 187).
[70] A04-421 and A04-560 (Yener 2010:18).
[71] R04-521 (Tell Atchana archives).
[72] L04-2047 (Yazıcıoğlu 2010: Appendix A, p. 187).
[73] Contextual information is from the 2004 season, Square 44.80 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010:185, 187, table A.2.
[74] Highest elevation 97.61 cm, lowest elevation 97.21 cm asl.

interior was surrounded by mud bricks (Yener and Yazıcıoğlu 2010: 19). A second row of mud bricks was excavated on the northeastern side of the primary feature of the installation itself.[75] This second row was interpreted as a later, supportive construction (Yener and Yazıcıoğlu 2010: 19). From the context of the installation structure, a plaster sample[76] was taken together with bone fragments and flotation samples. The fill inside the installation[77] showed features of brown soil and ashy patches of burnt brick fragments. Chert-flake[78] and flint[79] artifacts were uncovered from this fill together with pieces of bone and shell.

3.5.4. Installation 7: Typology and Contextual Information[80]

Installation 7 was recovered in the northwestern balk of Square 44.69. This structure was partially excavated and was identified as a plastered clay bin. Measuring 1.0 × 0.4 m and 28 cm in depth,[81] this installation had a semi-circular shape. But the rest of the architectural features are unknown since the rest of the structure is still under the northwestern balk and therefore not excavated. Inside the installation, a few pot shards with significant amount of ash was found. Hard-clay, plaster, and mud brick fragments were also recovered[82] (Yener and Yazıcıoğlu 2010: 19).

3.5.5. Installation 8: Typology and Contextual Information[83]

Installation 8 (fig. 3.14) was excavated in the southern part of Square 44.79. This installation, located at the southern part of a collapsed wall, measured 90 × 50 cm and 59 cm

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[75] Locus L04-2049 (Yazıcıoğlu 2010: Appendix A, p. 187).
[76] R04-540 (Tell Atchana archives).
[77] Locus L04-2014 (Yazıcıoğlu 2010: Appendix A, p. 185).
[78] R04-429 (Tell Atchana archives).
[79] R04-493 (Tell Atchana archives).
[80] Contextual information is from the 2004 season, Square 44.69 field book (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010: 180, table A.2.
[81] Highest elevation 98.04 cm, lowest elevation 97.76 cm asl.
[82] R1533, R1534, and R1537 (Tell Atchana archives).
[83] Contextual information is from the 2004 season, Square 44.79 field book. (Tell Atchana archives). The locus information is accessible in Yazıcıoğlu 2010:185,188; Table A.2.

in depth.[84] This oval structure was plastered inside and the bottom part had an ashy surface with fragments of mud bricks. From the interior fill,[85] a bead,[86] a clay bulla,[87] and a partial vessel[88] were recovered. The installation itself was very fragile. Although fragile constructions are low fired and not suitable to be used as kilns or furnaces, the dimensions of the installation together with its mud brick support resists the idea that this should be a simple oven (Yener and Yazıcıoğlu 2010: 19). Ovens found in LBIIa contexts of Alalakh did not reach these sizes and generally did not have mud brick supports which were a characteristic feature of kilns.

3.6. Concluding Remarks for the Craft Quarter and Pyrotechnological Installations

Excavations in the craft quarter district showed that there was dynamic production activity in this part of the mound. Pyrotechnological installations together with associated architectural features like open courtyard areas confirm large-scale production. Installations of *Phase 1b* did not survive into *Phase 1a,* though more varied types of installations substituted for the earlier versions. Furthermore, a decrease was observed in the sizes of the structures. Variations both in typology and size may signify situations like a divergence in produced material(s), changes in production technology, and a reorganization or rearrangement in the production area.

To give credit to any of these possibilities, archaeological investigations at this part of the mound should be extended. This will help us to understand the relationship — if any — between the production areas and the correlations of installations. An interpretation of qualitative information with quantitative methods will allow our understanding of the

[84] Highest elevation 97.99 cm, lowest elevation 97.40 cm asl.
[85] Locus L04-2005 (Yazıcıoğlu 2010: Appendix A, p. 185).
[86] A04-502 (Yener 2010:19).
[87] A04-637 (Yener 2010:19).
[88] A04-639 (Yener 2010:19).

connections in production activity to flourish. The following chapter approaches all of these options from a scientific point of view.

CHAPTER IV

FIRING TEMPERATURES AND THE DETERMINATION OF PYROTECHNOLOGICAL PROCESSES

"…, because fire is life,…"

The Other Wind

This chapter documents the scientific investigations applied to the Tell Atchana/ancient Alalakh pyrotechnological installations. The main goal is to determine the firing temperatures of these pyrotechnic units. In order to enhance our understanding of the activities processed inside the installations and further understand the technology and function of the Alalakh pyrotechnological units. The specific uses and processes of the installations will not only illuminate the technology of these massive structures, but will also increase our understanding of the technological knowledge level and production activities of craftspeople in Late Bronze Age Alalakh.

As a potential tool to understand how people confront and manage fire, pyrotechnology furnishes archaeology with primary data for ancient technological activities. Every pyrotechnological activity has left its traces on an object. Microstructures have distinguishing marks of materials and processes, so each object has a record of its technological history of formation and as a result suggests the cultural decisions made.

Often in such research, there is an examination of the artifacts found either *within the find* context, and/or an examination of the installations in terms of shape, size, and coloration/discoloration. In other words, studies of the archaeological material remain descriptive. The determination of the firing temperatures opens a new field of perspective to re-evaluate the artifacts; thus, this is an innovative niche for ancient technology studies. The pyrotechnological installations themselves are the sites of the greatest density of information. These structures absorb the information of the processes pursued. The walls, chambers, and linings of the installations retain the evidence of activities practiced during production. Production activities change the microstructures of these materials, which are directly exposed to fire. This makes the installations one of the primary sources to elucidate ancient firing practices and conditions effectively.

Physical and chemical processes that took place inside the installations are identifiable through laboratory investigations by chemical and instrumental analysis and materials science. This research follows a scientific methodology covering different techniques of instrumental analysis to determine the firing temperatures of the Tell Atchana/ancient Alalakh pyrotechnological installations.

Firing temperatures applied throughout the production processes can cause the formation or deformation of macro and microstructures of the materials. Thus, the determination of firing temperatures through scientific examination has shed light in identification of firing procedures, the level of technological knowledge, and the effectiveness of the technological choices of ancient artisans.

For the investigation of the installations, the methodology applied was composed of optical microscopy (hereafter, OM), scanning electron microscopy (hereafter, SEM), and X-Ray diffraction (hereafter, XRD) and was applied to the samples. Furthermore, various *in-situ* slag samples were examined with both X-Ray Fluorescence (hereafter, XRF) and XRD analyses.

Optical microscopy is a method to obtain general information of the samples' microstructures. This microscopic method provides the opportunity to view and classify the installation samples in general. However, the magnification capacity of this method is limited and microstructural images are sometimes not sufficiently detailed to make interpretations of firing temperatures. The optical microscope available at Koç University Archaeology Laboratory is a Olympus B52 polarizing light microscope with a maximum 200x magnification. To ensure a more precise measuring parameter, a more advanced methodology, the SEM, was used.

The use of the SEM for archaeological materials is superior to optical microscopy because it provides higher magnification together with a three-dimensional aspect (Price and Burton 2011: 77). SEM examination offers information on the internal morphology developed during the firing process and provides an opportunity to investigate the degree of vitrification and the porous structure (Kingery 1974; Tite and Maniatis 1975; Maniatis and Tite 1978, 1981). Analyzing either a fresh fracture or a polished cross-section of the sample gives the extent of vitrification, which is a measuring parameter to estimate firing temperatures (Tite et al. 1982: 109).

XRD is a perfect method for determining mineralogy and microstructure and thus it is commonly used for firing temperature determinations of archaeological materials (Maniatis and Tite 1981: 60; Tite et al. 1982: 109; Tite 1995: 40). XRD gives information about crystalline phases formed during the firing processes. Different conditions and temperatures achieved inside the installations result in the development of divergent mineralogical patterns in the microstructure. The examination and identification of these patterns with XRD provides scientific evidence of the progression of pyrotechnological activities.

Although SEM and XRD analyses provide information about the firing temperatures and crystalline phasing of the microstructures, in this research, XRF was also used as supportive scientific investigation to provide more detailed results of the samples. In addition to wall and floor linings and the structural features of the installations, the archaeological deposit also yielded various *in-situ* slag fragments. To elucidate the chemical composition of these scientific samples and shed light on possible technological activities behind these production wastes, XRF was also used to obtain a comprehensive data set.

Combining these methods provided a powerful technique to understand firing temperatures through the structural and mineralogical changes that occurred during firing. The chemical compositions achieved by XRF inform us about the formation procedures of not only the final product but also the intermediate steps of production. The data provided via the scientific examinations not only complete the microstructural and elemental picture of the installations, but also serve as complementary information for the understanding of production processes of ancient materials (Tite et al. 1982: 119).

4.1. Literature Review for Comparative Firing Temperature Studies

In the early 1960s, a new door was opened for archaeologists. “New Archaeology” — in other words “Processual Archaeology” — introduced scientific perspectives and methods into archaeology (Binford 1962, 1965; Binford and Binford 1968). Chemical analysis and instrumental chemistry started to be widely used among archaeologists and scholars working in archaeological sciences. As a result, archaeological evidence began to be supported by interdisciplinary techniques.

Firing temperature studies started in the late 1970s and they are still used by a group of researchers.[89] With a wide range of instrumental methods including petrographic thin section analysis, optical microscopy, infrared spectroscopy (hereafter, IR), neutron activation analysis (hereafter, NAA), SEM, XRD, and XRF, an estimation can be obtained of firing temperatures of both artifacts and pyrotechnological installations. The firing temperature estimations were

[89] Kingery 1974; Maniatis and Tite 1975, 1978, 1981; Tite et al. 1982; Freestone and Middleton 1987; Tite 1995; Shoval 1993, 1994; Kilikoglou and Maniatis 1993; Kilikoglou 1994; Day and Kilikoglou 2001.

generally applied to pottery and ceramic shards. The earliest study, including samples from Anatolia, examined two shards from Hacılar that dated to around 5000 BC. Samples were re-fired in known temperatures and re-examined with the SEM to obtain an approximate firing temperature. In this article, Y. Maniatis and M. S. Tite (1975) argued for a careful selection of clay for firing temperatures above 1000˚ C. For calcareous clay pottery, like the samples from Hacılar, they suggest a range of 800–1000˚ C for firing (Tite and Maniatis 1975).

In their seminal study, Maniatis and Tite examined firing temperatures and the firing atmosphere of pottery shards from Europe, Greece, and the Near East spanning a period from the Neolithic to the Middle Bronze Age (Maniatis and Tite 1981). The SEM, XRD, and XRF were used to determine vitrification degrees and chemical composition. Additionally, the use of an oxidizing or reducing atmosphere during the firing process and the nature of the clay were also studied to reconstruct the manufacturing techniques of the shards. According to the results, the non-calcareous clays were fired in a reducing atmosphere with temperatures lower than 800˚ C, whereas calcareous clays were manufactured in an oxidizing atmosphere with temperatures higher than 800˚ C (Maniatis and Tite 1981). Two shards from the Chalcolithic Anatolian site Hacılar were defined as calcareous and fired in an oxidizing atmosphere lower than 800˚ C (Maniatis and Tite 1981: 74). Seventeen shards from the Egyptian settlement of Tell el-Dab'a, which is a Middle and Late Bronze Age site contemporary with Alalakh, were also examined. The results show that both calcareous and non-calcareous clays and both of the firing atmospheres were processed in this settlement, which means that firing temperatures varied from 750˚ C to 1050˚ C according to the varying parameters (Maniatis and Tite 1981: 73).

The 1981 study of Maniatis and Tite study triggered another research of Tite and I. Freestone's article in the book *Archaeological Ceramics* (Tite et al. 1982). The authors again used SEM, XRD, petrographic thin section, and electron microprobe analysis on a ceramic shard assemblage that dated from the Chalcolithic to the Roman periods and was collected from the Aegean, Near East, India, and France. This article included samples from Chalcolithic Hacılar and gave similar results as Maniatis and Tite's (1981) research. Other than correlating calcium contents and firing atmosphere for the shards, Tite and Freestone also examined the relationship between firing temperatures and the installations. They suggested that firing in a bonfire reaches temperatures of around 800–850˚ C, whereas a normal kiln firing will achieve temperatures of 800–1000˚ C, or a high temperature kiln will easily exceed 1000˚ C (Tite et al. 1982: 113). Since kilns reach up to 1000˚ C without difficulty, there is no need to prefer calcareous clay as Tite and Maniatis suggested in their article, "Examination of Ancient Pottery using the Scanning Electron Microscope" (Maniatis and Tite 1981; *contra* Tite and Maniatis 1975).

Following the approaches explored by Maniatis (1975), Maniatis and Tite (1981), and Tite et al. (1982), Freestone and Middleton (1987) published an article with a series of mineralogical explorations demonstrating the usefulness of the SEM for archaeological questions. These investigations included different studies examining various aspects of raw material characterization, production of objects and firing processes. In addition to their fundamental research, Freestone and Middleton summarized the changes in the microstructures during the firing processes. The microstructures examined by the SEM shows that at 800˚ C there is a partial grain-to-grain boundary which defines an interface between to grains or crystallites. Localized melting starts around 1000–1050˚ C. The connection between particles in the microstructure increases and porosity decreases at these temperatures, which is the sign for the beginning of vitrification. Around 1100–1150˚ C, the pores were isolated and at 1200–1250˚ C, microscopic bloating started (Freestone and Middleton 1987: 21–23). In terms of applying the potential uses of the SEM to archaeological problems, this article has an immense importance in firing temperature studies.

A very similar study in terms of methodology was completed for the site of Tel Michal[90] by S. Shoval. The firing temperatures of a Persian period (5^{th} – 4^{th} centuries BC) pottery kiln, which were estimated by XRD and IR spectroscopy methods, were published in two different articles. The first article used the composition of the slag material in the wall linings of the kiln to determine the firing temperatures (Shoval 1993). In the second paper, Shoval analyzed the pottery assemblage in the kiln (Shoval 1994). Melted and vitrified non-calcareous sandy materials formed in the firing chamber of the kiln show a maximum burning temperature of 1100–1200˚ C in the lower chamber (Shoval 1993). Fragments of storage jars found inside the kiln debris indicated a firing temperature of 800–900˚ C for the upper chamber (Shoval 1994).

In addition to scientific methodology and firing temperature studies, the Tel Michal pottery kiln is important for Alalakh due to typological similarities. The mud brick pottery kiln of Tel Michal was dome shaped. The upper and the lower chambers were separated with a horizontal floor. The lower chamber measures 2.2 × 2.4 m in diameter with a 0.4 m wide entrance for fire. The installation shows repeated marks of plastering. Together with the fragments of storage jars, clay, and mud bricks of the installation, linings were found in the kiln debris (Herzog et al. 1978, 1989). Although this pottery kiln was dated to a later period, its typology of lower chamber is similar to the Alalakh Installations 1 and 2 referred to in Chapter III. However, making a suggestion to a dome-shape was not possible for Alalakh with the available archaeological findings. From this point of view, the firing temperatures of the Tel Michal kiln are a provisional representative for the pyrotechnological structures examined in this thesis.

[90] Tel Michal is located on the Mediterranean coast of Israel on the northern side of Tel Aviv. For further information on the excavations at the site, please refer *Excavation in Tel Michal*, Institute of Archaeology, Tel Aviv University (Herzog et al. 1978, 1989).

All of the research summarized above applied various instrumental techniques and gave quantitative data without elaborating on the importance of firing temperatures to the archaeological questions. This problematic issue was first argued by O. P. Gosselain and discussed further by Tite (Gosselain 1992: 243; Tite 1995). Gosselain used firing temperatures together with ethno-archaeological data to identify firing procedures and to establish a comparison between open firing, pit firing, and updraft kiln firing.[91] Heating rates[92] and time of exposure[93] were proposed as an alternative way to interpret the technological processes. This study demonstrated temperatures varied approximately 300–900˚ C with a high proportion measured as 600–800˚ C for open firing, and 500–1000˚ C with most at 750–950˚ C for the updraft kiln firings. This comparison shows that regardless of the firing technique, temperatures can reach the same degrees (Gosselain 1992: 244). Gosselain therefore argued that there is not much differentiation between the firing techniques and similar results can be attained by using different methods.

In his article "Firing Temperature Determinations — How and Why?," Tite re-evaluated Gosselain's (1992) methodology of measuring maximum firing temperatures (Tite 1995: 40). Tite proposed an "equivalent firing temperature" that defined a one-hour temperature causing the formation of the mineralogical and microstructural changes in the artifact. With this methodology, the "equivalent firing temperature" for open firings is estimated around 550–750˚ C, which is clearly lower than Gosselain's (1992) data. However neither Tite nor any other scholar proposed a range for the updraft kiln firings.

Beyond just distinguishing between the firing techniques, Tite advocated that firing temperatures enable archaeologists to elaborate on the production types within the society

[91] Gosselain used Cameroon traditional firing methods as ethno-archaeological thermal data (Gosselain 1992).
[92] Gosselain used heating rates to define the required time to reach the maximum temperatures (Gosselain 1992: 244).
[93] Exposure of the artifacts to heat.

(Tite 1995). Open firing is related to household production or industry, whereas kiln firing is connected to an individual or nucleated workshop (Peacock 1981: 187). These combined data allow scholars to contemplate the effectiveness of the technology (Tite 1995: 40–41) and its role within the socio-economic fabric of the settlement. Finally, Tite pointed out the knowledge of technology of the craftsperson and compared the required temperatures for pottery production (around 1000˚ C) and copper smelting (around 1100–1150˚ C) to question whether pottery production initiated the copper smelting technology or vice versa (Tite 1995: 41).

Reviewing the step-by-step the progress of firing temperature studies, this thesis seeks to contribute both instrumental methods and the archaeological utilization of quantitative data. With the examination of Alalakh pyrotechnology through the LBIIa pyrotechnological installations, knowledge and developments and/or improvements among the ancient technologies are discussed below.

4.2. Examination of Tell Atchana/Ancient Alalakh Pyrotechnological Installations

4.2.1. Sampling

Scientific sampling of archaeological material is crucial for the success and reliability of the rest of the analysis and results. Before taking any sample from an artifact, everything should be documented in detail to provide the most extensive information possible. A sample should be taken from the most representative spot to obtain a comprehensive conclusion for the material. Each step should be recorded carefully so that the whole process can be repeated if needed.

Archaeological materials related to the pyrotechnological installations and to the craft quarter area excavated in the 2003–2004 seasons were kept in the Atchana Excavation Depot located in the village of Tayfur Sökmen, Hatay. In the 2010 season, the author sampled the installations for scientific analysis. During the sampling, the main consideration first was to document each of the samples as exhaustively as possible in order to avoid any loss of information and then to take samples from the most representative and best-preserved spots of the installations.

To have a detailed record of the samples, first the artifacts — primarily the ones that were going to be sampled — were photographed from different angles (Catalogue: 1-17). These pictures are the main records of shape, size, and color. Second, a sketch of the artifact was drawn on a sample tag in order to keep basic evidence of the typology and form. This primary documentation was followed by sampling. Samples were cut with pliers or a fret saw. While taking the samples, the primary concern was to sever a piece from the most representative spot, which often was an area exposed to a direct application of fire, like the walls, lining, and floor of the installations, which were most likely exposed to a direct application of fire. After sampling, the original piece and the sample itself were photographed separately and the spot of sampling was defined with an arrow on the sample tag. The original artifact tags were also marked, specifying that the author sampled them. If the artifact was too small or too hard to sample with the facilities at the Alalakh Excavation Compound, then the original piece was taken to the Archaeology Laboratory of Koç University (Istanbul), where there were better tools to cut samples. All of the samples were documented with their excavation number in a database and were brought to the Koç University Archaeology Laboratory with the permission of the Antakya Archaeological Museum.

4.2.2. Instrumentation and the Process

All of the samples were categorized and examined in the Koç University Archaeology Laboratory. The basic investigation was made with the aid of a polarizing light microscope

Olympus B52. Other instrumental explorations were conducted at Koç University in the center of KUYTAM.[94] For the SEM, a Zeiss Evo LS 15 with electron beam lithography system was used. XRD analyses were run with a Brucker Advance D8 or Brucker Phaser D2 instrument. XRF analyses were done with a Bruker S8 Tiger.

Before processing the samples with the SEM, a pre-cleaning was done. With this pre-cleaning, the accumulated silica or dust on the samples was removed either with bamboo sticks or a proper solution like methanol or generally, acetone. After that, the samples were treated with a high vacuum to remove any fragments that were weakly bonded to the main body and could fall into the SEM chamber. Both of these processes were valid not only for protecting the chamber of the SEM from dust or falling and flying fragments of the samples, but also help to obtain better microstructural images of the artifacts.

After pre-treatment, the samples were attached to small steel stubs with double-sided carbon tape. The installation samples were highly non-conductive so that they were charging high voltages of electrons coming out of the SEM gun. To prevent the samples from self-charging and burning during the analysis, a coating with gold was used as a precaution. For gold-coating, a Cressington Sputter Coater 108 Auto and a Cressington Thickness Monitor mtm 10 extension were used. This instrument works with a high voltage low current and covers the samples with approximately 10–15 nm gold sputtered in 20 seconds. This thickness of Au-coat worked best for the installation samples. During the SEM analysis, an electron high tension value, varying from 1.00 kV to 10.00 kV, was applied depending on the charging capacity of the samples. The best images were obtained with 10.00 kV electron high tension value. Magnification, electron high tension value (hereafter, EHT), working distance (hereafter, WD), and the scale to obtain the best surface structure image of the samples were pasted in a frame located at bottom-right corner of each photograph.

[94] Koç University Surface Technologies Research Center.

For XRD analyses, samples were cleaned to remove the dust accumulated on the surface. They were cut with a thickness of 0.5–1.0 cm with Metkon thin section and petrography machine MICROCUT extension and fixed to a plastic plate with a special white paste. For analyses, copper radiation (Cu-Kα) was used.

For XRF analyses, two different types of samples were prepared. The first group[95] was directly put into the steel cups of the XRF machine chamber and fixed with tape. This group of samples was not pre-processed. For the second group,[96] boric acid (H_3BO_3) pellets were prepared. To obtain the pellets, 1.0–2.0 gr fragments were cut from the most representative section of the main sample and ground until they turned into a powdered form. This powder was pressed on the surface of a boric acid pellet, which was prepared by putting 10.0 gr of boric acid on a special plate and packing it under high pressure.

Although all of the installations were sampled, Installations 1 and 2 were analyzed with the SEM and XRD and Installation 5 was analyzed with the SEM, XRD, and XRF. The reason behind choosing only Installations 1, 2, and 5 for instrumental analyses was because these structures are the best-preserved examples from their archaeological contexts. Furthermore, the diversity of the samples was also considered. Differentiation in physical appearance like coloring, burning traces, or vitrification also affected the choice of these installations, associated archaeological samples, and slag.

An examination of vitrified samples with the SEM provided information concerning their micromorphology from which we can obtain the degree of the firing temperature and vitrification stages. This information has a direct relationship to production processes and the specific technology of the installations. XRD and XRF both afforded scientific evidence for crystalline phasing and oxide compositions of the microstructure. Analysis of a variety of *in-*

[95] These are glass samples from the Woolley depot. For details, see Section 4.2.3.5.
[96] R04-349, R04-378, R04-421, R04-472.

situ metal artifacts and slag samples collected from some of these installations are now in progress, as part of a Ph.D. study by Emre Kuruçayırlı. Since this data is not available now, it could not be integrated into this study as supplementary data. Interpretations to understand what was produced inside the installations were made only on the basis of the author's analysis and other comparative material.

4.2.3. Analytical Results

Samples were taken from Installations 1, 2, and 5 for instrumental analysis since these were the best-preserved and most representative examples of the craft quarter area. All analyzed samples are listed in Appendix A, Table 1. The SEM images are presented in Appendix B, Figures 1 – 54 and the XRD results are presented in Appendix B, Figures 55 – 59. The XRF results are also presented in Appendix A as tables.

To evaluate the SEM images and to interpret firing temperatures from the observed microstructures, a standard was needed to both compare and contrast the images obtained in this study. Research done by Maniatis and Tite (1981), Tite et al. (1982), Day and Kilikoglou (2001), and Hein and Kilikoglou (2007) were used as the main standard comparative data. Vitrification levels and the proposed firing temperatures of each sample analyzed with the SEM were compared with these research studies and the results are summarized in Table 2.

XRD diagrams were examined with a soft ware connected to a standard database, International Centre for Diffraction Data (herafter, ICDD). Every crystalline phase gives its idiosyncratic peak(s) in XRD. These peaks in the diagrams were searched and matched with standard crystalline phases provided by ICDD. Finally, the results of XRF were calculated as oxide forms instead of elemental composition. The reason for choosing oxide compositions is discussed below in Sections 4.2.3.3–5.

4.2.3.1. Samples from Installation 1

The combustion chamber and the plastered floor of Installation 1 were completely excavated during the 2003–2004 seasons. These structural fragments were collected and kept in the excavation house depot. All of these fragments were tagged with the same Atchana number (AT 11474, Appendix C; Catalogue 14, 15). Rather than choosing a specific sample from the collection bag, all of them were brought to the Koç University Archaeology Laboratory. Among these structural fragments, six samples were taken for SEM analysis. All of the sample contexts and descriptions are documented in Table 3.

Out of the six SEM samples, five of them were taken from the fire-exposed linings of the combustion chamber. The last sample was taken from the plastered floor lining that separates the combustion chamber from the firing chamber. Using the SEM, the combustion chamber facet of the floor-lining was analyzed (Table 3). Each of these six samples were named Bulk#1 to Bulk#6 in the laboratory since each of these samples had the same AT number but were investigated separately. Furthermore, each sample was examined separately and photographed from multiple views. The images in the Appendix B demonstrate the most representative picture of the general microstructure.

The SEM images of Bulk#1, which was taken from the red-colored surface of the combustion chamber of Installation 1, do not show any proper feature of vitrification. The surface seems quite smooth, which indicates a firing temperature lower than 750° C (figs. 4.1 and 4.2).

Bulk#2, which was a sample from the black-colored spot of the combustion chamber, displays features of extensive vitrification. The surface looked melted (figs. 4.3–4.5). The extensive vitrification defines a firing temperature of 850–1050° C or 1050–1080° C depending on the calcareous level of the material’s structure. If the sample contains 6–10%

CaO, it is defined as medium calcareous and vitrifies extensively at 850–1050° C. If the CaO content is higher than 10%, it is accepted as highly calcareous and extensive vitrification occurs at 1050–1080° C (Day and Kilikoglou 2001: 122). Since this study does not cover an extensive analysis of the CaO contents of the samples, I can only propose that Bulk#2 was exposed to a temperature higher than 850° C and lower than 1080° C.[97]

Another combustion chamber fragment, again red colored as in Bulk#1 though slightly darker, shows very different results than Bulk#1. The black, rounded holes observed in Figures 4.6, 4.7, and 4.8 were defined as bloating pores and appear at temperatures around 850–1000° C (Maniatis and Tite 1981: 68). Maniatis and Tite define microstructures with bloating pores as "continuous vitrification" whereas Day and Kilikoglou use the term "total vitrification." This study follows Day and Kilikoglou's terminology and classifies Bulk#3 as a total vitrified sample. This indicates that dark red-colored combustion chamber fragments would have been exposed to temperatures higher than 1080° C.

Bulk#4 is the plaster fragment taken from the floor separating the combustion and firing chambers. Specifically, the facet that was thought to be the side of the combustion chamber was viewed with the SEM imaging capabilities. The images (figs. 4.9–4.11) show extensive vitrification like Bulk#2 suggesting firing temperatures of 850–1080° C. It is worthwhile to clarify here that the black horizontal lines appearing on the images are due to the charging of the sample. Although the sample was covered with 14.4 nm Au, it continued to self-charge.

The gray-colored combustion chamber sample, Bulk#5, shows features of incomplete or no vitrification. This designates a firing temperature of 750–800° C (figs. 4.12–4.14). Green- and gray-colored combustion chamber linings samples, like Bulk#6, show distinct

[97] Mara Horowitz, the ceramic specialist of the Tell Atchana Excavation, defines the local Late Bronze Age pottery assemblage of Alalakh as generally calcareous (personal communication).

features of extensive vitrification and total vitrification (figs. 4.15–4.21). As aforementioned, these melted and nested microstructures are evidence exposure to temperatures over 1080° C.

To sum up, the SEM analysis of Installation 1 samples suggest a firing temperature ranging from 750° C to over 1080° C. This range is well suited for the required temperatures to fire pottery in an updraft kiln (Tite 1995). Notably, there were no *in-situ* finds inside the kiln fill except a few ceramic shards.[98] The archaeological assemblage together with the information obtained from the SEM suggests that Installation 1 would have been used as a pottery kiln in the Late Bronze Age craft quarter district of Alalakh.

4.2.3.2. Samples from Installation 2

For Installation 2, the structural compartments samples were labeled AT 11475 (Appendix C; Catalogue 16, 17). Among this batch of samples, three bulk samples from the fire-exposed sides of the combustion chamber were chosen for SEM analysis. These were Bulk #1–3 like the Installation 1 samples in order to avoid any confusion. Moreover, two plaster fragments (R04-581, Catalogue 3 and R04-607, Catalogue 4) from the floor of the firing chamber were also analyzed with SEM. The list of sample contexts and definitions are presented in Table 4. The suggested firing temperatures are summarized in Table 2.

The general appearance of the Installation 2 samples demonstrated different tones of green and light green. The first sample, analyzed as Bulk #1, was taken from the light–medium green-colored fragments of the combustion chamber, which were the most probable areas for fire exposure. The surface microstructure shows partial melting and bloating, which are indicators of extensive vitrification (figs. 4.22–4.26). Compared to the standard comparative data obtained from Maniatis and Tite (1981), Tite et al. (1982), and Day and

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[98] For a detailed description of the artifacts see Chapter III, Section 3.4.1.

Kilikoglou (2001), these lining locations of the combustion chamber would have been exposed to temperatures over 1080° C.

Bulk #2 was sampled from the green-colored fragments of the combustion chamber. Although the sample was charging, a couple of images, which are evidence of extensive vitrification, were obtained (figs. 4.27–4.32). As with Bulk #2 from Installation 1, a more specific temperature range for extensive vitrification needs the CaO content of the sample. Since these analyses do not cover CaO percentages of the samples, it would be a safe suggestion to advocate a firing temperature range of 850–1080° C.

The most interesting microstructural results were obtained from sample Bulk #3. This sample was taken from a green surface of the combustion chamber. Nine SEM images taken from different spots of this sample not only show total vitrification, but also the distribution, amount, and size of the bloating pores are very striking (figs. 4.33–4.41). The amount and size/radius of the bloating pores were increased and they are frequently distributed. Maniatis and Tite obtained a similar microstructure and proposed a firing temperature of 1150° C for the formation of such a degree of vitrification (Maniatis and Tite 1981: 66, fig. 6).

To compare this extensive vitrification level with the similar samples from the same archaeological context, two ceramic slag samples (R04-328, Catalogue: 1 and R04-534, Catalogue: 2)[99] were further examined. Both R04-328 (figs. 4.42–4.44) and R04-534 (figs. 4.45–4.47) demonstrate total vitrification with an extensive amount of bloating pores with similar features to Bulk #3 of Installation 2. An examination of these contemporary samples also indicates a common and successful usage of high firing temperatures at or around this installation.

[99] R04-328 and R04-534 are two samples collected from Square 44.80. This context is the same as the location of Installation 2. Sample R04-328 was collected in Locus 04-2002, Lot 78, which was a secondary deposit. R04-534 was found in Locus 04-2013, Lot 196, which was a primary deposit. For further details of these contexts,see Yazıcıoğlu 2010: 185 table A.2.

In addition to the wall linings two plaster samples from the installation were also analyzed. A plaster sample on a mud brick fragment (R04-581) and another plaster fragment belonging to the fire chamber floor (R04-607) introduced microstructural features of initial vitrification. This signifies that they had been exposed to firing temperatures around 800° C (figs. 4.48–4.49).

The SEM analyses of the linings of Installation 2, as well as ceramic slag fragments from the fill deposit, show that this installation was exposed to temperatures varying from 750–800° C to 1150° C. This temperature range is sufficient for firing pottery but compared to the contemporary structure (Installation 1), which was most probably a pottery kiln, Installation 2 was processing materials at higher temperatures. Concerning that, why did Alalakh's craftsmen need to achieve higher temperatures in Installation 2 unless they were producing different types of pottery such as glazed wares or materials other than ceramic? This increase in firing temperature requires discussion on other possible processes at work at the installation; these possibilities are discussed in Section 4.4.

4.2.3.3. Samples from Installation 5

Installation 5 is located at a later occupational level, *Phase 1a*, than Installations 1 and 2, which are situated at *Phase 1b*.[100] From Installation 5, three samples (R04-560, Catalogue: 5; R04-452, Catalogue: 6 and R04-428, Catalogue: 9) were analyzed with the SEM to determine firing temperatures. R04-560 and R04-452 were collected from Square 44.80, Locus 04-2039 and lots 209 and 147 respectively. These contexts belonged to the fill inside the installation. R04-428 was found in the same square, but in a different locus (Locus 138), which was related to the fill above the floor of Installation 5. These three samples are grayish green colored and have a porous and frothy appearance.

[100] For a detailed phasing of the Installation 5, see Chapter III.

R04-421 (Catalogue: 7), R04-378 (Catalogue: 10), and R04-349 (Catalogue: 8) were the three scientific samples collected from the fill inside the installation and fill immediately above the floor related to the installation contexts. In contrast to the grayish-green samples, these samples were blacker in color and looked like tuff but were even lighter in weight than tuff. Inside some of the pores, brown and black inclusions were visible. These types of slag/wasters were found neither in Installation 1 nor in Installation 2. These slag/waster samples were analyzed with the aid of both XRF and XRD in terms of clarifying elemental composition, oxide forms, as well as mineralogical structure. The combination of XRF and XRD results together with the SEM information of the installation served as a useful tool to elucidate the crystalline structure of these slag formations.

The SEM images of samples R04-560, R04-452, and R04-428 show a similar trend in microstructure formations and demonstrate total vitrification with an extensive amount of bloating pores (figs. 4.50–4.53). These microstructures were compared to both the SEM images introduced by Maniatis and Tite (1981) and Hein and Kilikoglou (2007). This comparative research shows that this degree of total vitrification and occurrence of bloating pores would have been formed over 1100° C. Furthermore, sample R04-560 demonstrates even higher levels of bloating pore formation than the aforesaid studies, which means this sample was possibly exposed to higher temperature values than 1100° C, but to test this option, a re-firing experiment should be done in the future. The sample should be heated to known temperatures and each time the microstructure should be checked as to whether it shows similar patterns so that the known temperatures can be matched with the known microstructure. However, in this research project, comparative data was given preference over re-firing experiments. In their study, Hein and Kilikoglou propose 1200° C for a very similar microstructure (Hein and Kilikoglou 2007: 150, fig. 13-f). Based on their research, but to be in a safer situation, I propose a maximum of 1150–1200° C as firing temperature for this sample (fig. 4.50).

R04-349 (Catalogue: 8) and R04-378 (Catalogue: 10) were the two samples found in the floor fill of Installation 5. R04-349 is dark greenish-gray in color and is highly porous with a frothy surface. Inside the pores, black particles are visible even with the naked eye. These fragments were most likely charcoal fragments used as fuel during the firing process. R04-378 is grayish-black in color, highly porous, and frothy structured. This sample also shows charcoal fragments embedded into its pores. Another sample, R04-421 (Catalogue: 7), found in the fill of the installation has a similar macrostructure. This sample is greener in color and shows lower amount of pores compared to the other samples. Furthermore, the non-frothy surface of the sample does not indicate any charcoal fragments. These three samples were analyzed both with XRF and XRD.

The XRF results indicate high amounts of SiO_2 (silica; 51.10–44.66%) and CaO (lime; 22.02–15.00%).[101] In addition to these two oxides, all three samples have prominent amounts of Al_2O_3 (alumina; 12.96–10.86%), Fe_2O_3 (3.136–6.536%), MgO (4.63–3.75%) and K_2O (potash; 2.54–1.72%). Additionally, Na_2O (soda; 1.590–0.619%) and TiO_2 (0.811–0.718%) are higher compared to the rest of the oxide composition (Table 5).

The main component is silica, constituting almost half of the oxide compositions. The variation in the rest of the oxide components does not designate similar properties with ceramic slag formations. The percentage concentration of metals like copper, tin, and iron are either too low or not even detectable. This eliminates the possibility of samples being metal slag (Özbal 2005).[102] Furthermore, the chemical compositions of the samples show close

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[101] The percentages given in the parenthesis are designating the highest and the lowest oxide content of three samples.
[102] That the composition of these samples does not show similar contents either with copper or iron slag is also agreed by Prof. Hadi Özbal (personal communication).

parallels with the characterization of vitrified materials especially glass. The production of glass depends on three main components: silica, soda, and potash. Lime is also added in the form of purified lime or limestone to perform as stabilizer (Shortland 2000). Additionally, iron, copper, cobalt, antimony, manganese, or lead oxides are used as colorants (Shortland and Eremin 2006: 591–93). XRF results of the Alalakh samples demonstrate a compatible amount of silica, lime, and soda, most probably indicating a production waster or a semi-finished product formed during the production of a vitrified material possibly while glass processing.

Nonetheless, the varieties of oxide formations in the composition are not sufficient evidence for glass production, since its main components — silica, soda, and potash — were commonly used in different branches of ancient industries like production of faience, frit or Egyptian blue. To prevent any misinterpretation of the XRF results and to clarify the significance of the data proving glass production, further scientific investigations were needed.

In terms of correlating the relationship of these samples to pyrotechnological activity in the craft quarter and classifying them as either glass production wastes or any other vitrified material slag like faience or frit, XRD was used. XRD examination shows the mineralogical composition of the samples as well as the difference between the mineral phases. Under different firing conditions and treatments, the microstructures of the materials which are distinctive from each other change configuration. The formations of specific mineralogical phases are diagnostic for the identification of vitreous material production especially for the formation of glass. For example, the presence of crystalline phases like diopside or wollastonite is strongly indicative of semi-finished glass production (Smirniou and Rehren 2011: 65).

To acquire a comprehensive dataset, samples R04-349, R04-378, and R04-421 were also examined with XRD. R04-349 showed that it was composed of diopside, augite, and calcite. Diopside is an indicative lime-rich phase for glass production whereas augite is also placed in pyroxene groups and directly related to diopside (fig. 4.55). R04-378 contains diopside, augite, and calcite together with albite. In this sample, diopside is in ferroan form, which designates the iron content of the lime-rich newly formed phase (fig. 4.56). R04-421 demonstrates a similar pattern of crystalline phases. It includes diopside, aegirine-augite, cristobalite and albite. Both diopside and aegirine-augite are in aluminian form, which indicates the presence of aluminum in the mineral phasing (fig. 4.57).

The XRD results of the samples demonstrate similar or chemically related compositions in crystalline phases. All of the samples have a diopside formation, which is a strong implication of semi-finished glass (Smirniou and Rehren 2011: 65). Furthermore, the crystalline phase augite is a sodium-rich member of diopside. Albite, with the chemical formula $NaAlSi_3O_8$, also contains sodium and aluminum content but is a sodium-rich member of the albite–anorthite mineralogical series.[103] Concerning their chemical contents, all of them almost cover the same elements with different molecular combinations and similar impurities.

Together, the XRF and XRD results lend further confirmation to the suggestion of a vitrified material production most probably glass production in Installation 5. The XRD results of ferroan and aluminian crystalline phasing overlap with the XRF data showing high levels of iron and aluminum oxides. Other crystalline phases, especially the formation of diopside, are an intermediate step during glass production. Oxide compositions and the silica, soda, and potash content of the samples give comparable results to the well-studied glasses of Qantir, Malqata, Tell Brak, and Nuzi (Shortland and Eremin 2006; Vandiver 1982, 1983; Brill 1999a–c). In addition to the composition, crystalline formations in the microstructure

[103] www.mindat.org

especially the existence of diopside, suggests strong evidence for glass production in Installation 5. Supportive of the XRF and XRD results, the SEM images demonstrate firing temperatures even reaching 1100–1200° C in the installation. Compared to the studies that propose temperatures of 900–1000° C for Egyptian glass working (Vandiver 1991; Stern and Schlick-Nolte 1994), Installation 5 achieved adequate temperatures for working with glass.

The most significant about the Installation 5 samples analysis is that the alumina and lime is not at all similar to what is associated with Mesopotamian glasses. The cored-vessel glasses and other glass artifacts from well studied sites like Nuzi, Tell Brak or Tell al-Rimah do not have that high levels of alumina and their lime is always considerably greater than the Alalakh glass. The comparisons of these sites to Alalakh and possible indications of the results are discussed in Chapter V.

4.2.3.4. Samples from Mixed Floor Fill Deposit of Installation 2 and Installation 5

The scientific samples collected from the linings of the architectural features as well as the interior fills of the installations raise the question of a vitrified material production either in Installations 2 or 5, or both. To provide more complete scientific information in terms of illuminating the ancient activities processed of this craft quarter, supplementary examinations from related contexts gain importance. Samples from a very secure fill above the floor context were chosen to clarify the details of fire-related activities in this area. Square 44.80, Locus 04-2038, is the context of leveling fill located above the surface of both the southern portion of Installation 2 and the northern side of Installation 5. Three samples (R04-538, Catalogue 11; R04-698, Catalogue: 12 and R04-472, Catalogue: 13) were analyzed with SEM, XRF, and XRD techniques.

Sample R04-538, analyzed using the SEM, shows a total vitrified microstructure with bloating pores, indicating a firing temperature of 1100° C (fig. 4. 54). This sample was also analyzed with XRD. The XRD peak shows only one pattern, which is calcite (fig. 4.58). Thus R04-538 cannot be interpreted as being related to glass production. Samples R04-472 and R04-698 were analyzed with the aid of XRF. These samples were chosen for XRF analysis since their visual appearances were considerably dissimilar to pottery slag. They are gray-greenish black in color and have frothy surfaces. Physically they look like a vitrified material slag identified in Installation 5.

The sample XRF analyses show the main components as silica and lime. The silica content of R04-472 is 52.44%, which is similar to the compositions of the Installation 5 samples. On the other hand, R04-698 has a silica percentage of 29.40%, which is almost half of the other samples. Aluminum, iron, and magnesium oxides are noteworthy components of the samples, as well as soda and potash contents. Among the oxides, aluminum and iron are significant and are as high as the samples from Installation 5. Besides the oxide compositions, the total sum of the percentages does not complete 100% since there should be a considerable amount of carbon inside the sample, which is undetectable using XRF. Having carbon in the sample is significant since it is a production waste of pyrotechnic activity (Table 6).

Sample R04-472 was also examined with XRD (fig. 4.59). Crystalline phases observed in the microstructure are ferrous diopside, augite, and magnetite. As aforementioned, diopside is an indicator of semi-finished glass production and augite is also related to diopside in pyroxene groups. The existence of ferrian diopside and magnetite is due to the high amounts of iron in the sample.[104]

As a result, among these three samples, R04-472 demonstrates similar compositions to the samples from Installation 5. Although it is not clear if this fragment belonged to either

[104] The possible sources of iron in the samples are discussed in Chapter VI.

Installation 5 or Installation 2, finding this type of slag in such a secure context clearly supports vitrified material most probably glass-related production in this phase.

4.2.3.5. Samples from the Woolley Depot

Glass artifacts are frequently found in the Late Bronze Age contexts of Tell Atchana/ancient Alalakh. Woolley found glass fragments and objects starting from Level VI dating to the early Late Bronze Age (Woolley 1955). In Yener's excavations, an extraordinary amount of glass artifacts, especially beads and vase fragments, were found in the Late Bronze Age strata (Yener 2010:107). To compare and contrast the chemical composition of Alalakh glass artifacts to the slag samples of the craft quarter and in order to create a broader dataset for Alalakh glass, two glass samples from Woolley's depot, dated most likely to Woolley's Level IV were analyzed with XRF.[105] One of these samples was a fragment of a white opaque glass goblet with wavy yellow and brown inlaid linear decorations. The other sample was a transparent dark blue piece with an almost 0.2 cm opaque white glass surface, indicating an oxidation of the surface. Rather than being fragments of a glass bead or vase, this glass artifact might have been a fragment of a glass ingot, since the other pieces belonging to the same piece look like flakes and do not resemble any beads, vases, or other features.

The XRF analysis of these samples yielded remarkable results. The oxide composition of the glass goblet shows that the artifact contained high percentages of Al_2O_3 (6.02%), PbO (2.72%), and Fe_2O_3 (2.32%; Table 7). Compared to the ancient glasses from the well-studied Egyptian sites like Malqata and Amarna, the Alalakh goblet fragment has higher Al_2O_3 and Fe_2O_3 percentages. Moreover, the amount of lead oxide (PbO) is noteworthy. PbO was used as a colorant in ancient glasses to obtain the color yellow (Shortland and Eremin 2006). As described above, the glass goblet has a yellow decoration whose origin is most probably PbO.

[105] For details of Woolley's depot study see Yener 2005.

Furthermore, the PbO percentage of the Alalakh goblet is close to the values of opaque yellow glass or green-colored glass samples from Malqata and Amarna (Shortland and Eremin 2006: 584–88, table 1).

The opaque dark blue sample shows different properties than the glass goblet in terms of oxide composition. CuO (1.41%) and MgO (2.64%) appear in higher concentrations (Table 8). For ancient glass, CuO was one of the colorants used to obtain blue color. More to the point is the almost identical CuO percentage of the Alalakh ingot (?) fragment to the copper-blue Malqata and Amarna glasses (Shortland and Eremin 2006: 584–85, table 1). However, the MgO percentage is lower than the average values obtained for Egyptian glass. Still, some white- and yellow-colored Egyptian glasses have approximately the same MgO percentages as Alalakh. This similarity should be due to the weathered, opaque white surface of the fragment.

To sum up, these two glass fragments found in the Woolley depot show similar molecular composition with Alalakh's contemporary second millennium sites, Amarna and Malqata in Egypt. The oxide compositions show silica, lime, and potash as the main constituents of the Alalakh glass samples, with the exception of the iron and aluminum oxide percentages of the glass goblet fragment. On the other hand soda is very low which may indicate that the glass is weathered and the soda has leached out. That is an expected situation for ancient glasses buried in the earth for a long time. The variations in the chemical compositions of Alalakh glass and Egyptian glass may emanate from the divergence of the glass artifacts (colors or raw materials of colorants) and most plausibly indicate a local glass production unit in Alalakh. Furthermore, although the vitrified slag of Installation 5 and mixed floor fill context of Installations 2 and 5 do not yield high percentages of copper, the blue glass ingot (?) fragment provides the highest copper oxide amount among all of the samples analyzed with XRF. This may indicate the processing of a non-local glass ingot, which may have come by trade as semi-finished and would be shaped to its final form in Alalakh. This may also designate a local production of the craft quarter since copper was a commonly used metal in Alalakh and could be possibly added as a colorant during glass, faience or frit production.

4.3. Supplementary Studies from Tell Atchana/Ancient Alalakh

Along with its royal architecture, private houses, temples, and tablet archives, discoveries at Tell Atchana/ancient Alalakh include a wealth of artifacts. This assemblage has not only raised attention for typological studies, but has also received analytical interest among scholars. As a result artifacts reflecting technological production like metal objects, various types of metallic and non-metallic slag, and fragments of a crucible were analyzed by other researchers.

4.3.1. Research on Non-Metallic Finds

This section summarizes various ceramic, ceramic slag, and glassy slag analyses contextually relevant to the craft quarter. These samples were not found in the installations themselves but collected from neighboring trenches.

A slag fragment,[106] excavated in the 2003 season and categorized as "glass or non-metallic slag," was analyzed by Jennifer Hissett.[107] This grayish, porous fragment was recovered in Square 44.54 from Locus 03-2027, which was a primary deposit of fill above a floor and a courtyard (Yazıcıoğlu 2010: 179, table A.2). This locus was dated as *Phase 1*/ *Phase 2*, which refers to the Late Bronze Age levels of Alalakh.[108] Along with the slag fragment, a faience bead (R1352), fragments of a Phoenician fluted glass vessel (R1380), a

[106] Excavation sample number S35 registration number A03-R1313.
[107]Unpublished term paper. from the graduate seminar, Archaeology of Technology (Anthro 398/399) University of Chicago, given by K.Aslıhan Yener in the Spring 2004 semester.
[108] Local *Phases 1* and *2* of Area 2 dated c. mid- 15th to 13th century BC. at site-wide levels. The top most levels excavated in 2003-2004 excavations in Area 2 were found almost contemporaty to Level IV and III in the Royal Precinct assigned by Woolley (Yener and Yazıcıoğlu 2010:31)

bronze pin (R1264), a projectile point (R1401), a carnelian bead (R1263), two pieces of chert (R1269 and R1353), and a figurine fragment (R1407) were recovered together with bone, shell, and charcoal deposits.[109] Together with optical microscopy, SEM, and XRD were used to investigate the microstructural composition. SEM-EDX analysis applied to different spots of the sample showed a high percentage of silica, varying from 37.99% to 0.14% with different amounts of calcium (43.56–0.14%), iron (7.13–0.11%), and copper (0.91–0.17%; Table 9). However, Hissett did not evaluate the chemical compositions as oxides and only ran the experiment for silicon, calcium, iron, and copper, and did not test the possibility of other minerals such as magnesium or aluminum. A detailed description of the XRD results was not given, but she argued that the mineralogical structure obtained demonstrated the heterogeneous character of the sample. Even though she did not signify a single and concluding answer through SEM and XRD data, she argued that the sample may have been an intermediate product of frit, faience or glass mixed prior to the addition of alkali flux (Hissett 2004 unpublished term paper page:16). Regarding this information, it is hard to make any interpretations for the characterization of this sample, but it may be frit, faience, glass or metallic slag which were commonly recovered artifacts in Alalakh.

A structurally very similar slag sample (R04-503) from Square 44.79 Locus 04-2033[110] was analyzed by the author. Although this sample was not from a secure surface context, like the fill debris of any installation, it is relevant to the pyrotechnic zone since it is associated with *Phase 2* of the craft quarter district. The analysis was done with XRF. Even though a fast scanning method was applied, which is not as precise as the best detection technique, the elemental composition of the slag shows similarities with the average compositional percentages of Hissett's work (Table 10). The general composition of the

[109] For details of the Locus 03-2047 see Tell Atchana/ancient Alalakh Square 44.54 field book of the 2003 season. With the discovery of Iron Age levels at Alalakh in 2007 and 2011, the Phoenician style vessel now is given more relevance.
[110] For further details of the context, please see Yazıcıoğlu 2010: 186, table A.2.

sample contained 24.43% silica, 10.25% Ca and 8.83% iron. Instead of copper, the high amounts of Al and Mg are noteworthy. Compared to the glassy slag compositions of Installation 5 and the Woolley depot glass fragments material, R04-503 shows almost comparable amounts of potash, whereas soda is non-existent in the chemical composition. Regarding the fact that silica, soda, lime, and/or potash are the main constituents of glass, this fragment is lacking one of the main constituents. On the other hand, the non-existence only of soda does not disprove a correlation with glass production. Since it is a slag fragment, the analyzed spot may be deficient of this mineral. Furthermore, the similarity of the rest of the composition cannot be underestimated.

Other than this glassy slag, four ceramic slag samples were analyzed with XRD at the Bergbau Museum, Germany.[111] Samples AT 3894,[112] AT 10608,[113] and AT 10407[114] were recovered in Late Bronze I contexts, while AT 10198[115] was found in a Late Bronze II level. The mineralogical structures of these ceramic slag samples show similar crystalline phasing composed of cristolbalite, diopside, and anorthite; all of them are high temperature (1050–1100˚ C, 1150–1200˚ C) formations (figs. 4.60–4.63; Maniatis and Tite 1981: 61; Tite et al. 1982: 111). These XRD results show that there was a continuous tradition of using similar raw materials in ceramic production technology from the Late Bronze I and II periods. The achievement of high temperature degrees was already accomplished in the Late Bronze I period or probably earlier and continued to be in use until the end of Late Bronze II by Alalakh potters.

[111] These results were provided with the courtesy of Emre Kuruçayırlı.
[112] Square 32.37, Locus 89, Lot 307
[113] Square 45.44, Locus 80, Lot 434
[114] Square 32.34, Locus 11, Lot 25
[115] Square 43.53, Locus 40, Lot 218

4.3.2. Research on Metallic Finds

Metal objects, and object fragments, and metallic slag were excavated in abundance at Tell Atchana. Samples from both the Middle and Late Bronze Age contexts of the site were extensively studied. This subsection documents the scientific results of the Late Bronze Age metallic finds in terms of their chemical characteristics whether they were alloyed or not, their possible ore sources, and production techniques such as hammering or casting.

A fragment of a crucible together with slag remains on the interior surface was analyzed by Erin Unverferth[116] with the aid of optical microscopy and the SEM. This sample was found in the 2003 season in Square 44.55 Locus 03-2019, which was a primary context of a wall foundation (Yazıcıoğlu 2010: 178, table A.2). Although nothing associated with this artifact was found in the primary locus, several examples of metal pieces were found in locus 03-2021, which was located just below this level and are most probably copper alloy fragments.[117] Both the bulk of the crucible and a slag fragment recovered from the inner surface were examined. A metal prill observed at the surface had 6.87% tin. Moreover, the slag contained various amounts of tin and arsenic (Table 11).[118] These high amounts of arsenic are also significant since such percentages of arsenic together with tin could be a result of using a polymetallic ore, be the result of remelting scrap or could indicate an intension to produce ternary alloys (Yener 2010:102). Although intentional production of ternary alloys or the recycling of scrap metals are still under debate among scholars, ternary alloy production was documented by Özbal as a feature of ancient Alalakh metallurgy (Özbal

[116]Unpublished term paper from the graduate seminar, Archaeology of Technology (Anthro 398/399) University of Chicago,given by K.Aslıhan Yener in the Spring 2004 semester.
[117] The Atchana numbers A03-R1322, A03-R1354, A03-R1665, and A03-R1718. For details of the artifacts,see Square 44.55 field book of the 2003 season.
[118] After identifying 6.87% Sn at a particular spot, ten more points in a linear direction were analyzed in terms of establishing a general overview of the composition. The Cu amounts vary from 6.90–62.64%. Sn has a range of 0.47–18.96%, whereas As amounts differ from 0.47 to 7.56%.

2005). Other than the tin prill on the surface, the clay fabric of the crucible contained silica and low amounts copper tin and iron (Table 12; Unverferth 2004, unpub.).

Regarding the metallurgy of Alalakh, Özbal examined forty-three copper and copper-based alloy samples dated to the Late Bronze Age levels of the site (Özbal 2005, Yener 2010). According to the trace element analysis done with Atomic Absorption Spectroscopy (AAS), twenty-three out of forty-three of the metal samples contained more than 2% tin, which gives evidence for an intentional tin-bronze production at Alalakh. Moreover, even though they were highly corroded, more than 1% arsenic was detected in eight of the samples, with the highest percentage being 1.65%. This indicates that working with tin to produce tin-bronze with arsenic was a common process for the metal smiths of Late Bronze Age Alalakh (Özbal 2005).

The arsenic contents of the artifacts signify another interesting feature of metal production technology. Of the samples, 18.6% contain more than 1% arsenic, where most of them have an elemental value of 1–2%. These types of bronzes are defined as ternary bronzes and with respect to those scientific results, ternary alloy production may have been a technique used in the crafts of the region. This conclusion is not only supplementary for Unverferth's crucible analysis, but also supportive for a generally observed trend in metallurgy around the region. At settlements like Tarsus–Gözlükule, researches also encountered with this type of tin-arsenic-copper bronzes (Kuruçayırlı and Özbal 2005; Dardeniz 2007, Yener 2010). As previously mentioned, another implication may be a recycling process applied to scrap metals that may also cause an accumulation of tin and arsenic in the recycled metal and result in the formation of ternary bronzes (Yener 2010:102).

S. Selover who analyzed 15 clothing pins found in Alalakh at 2003 excavation season also suggested ternary alloy production in the Late Bronze Age Alalakh (Selover 2010:150, 152). In her study, Selover used polarizing light microscope and SEM to understand chemical compositions and production techniques of the clothing pins. The results showed that all of the samples were casted and cold worked with a few slightly annealed. In terms of the chemical composition, all clothing pins were bronze except one artifact (A04-R388) which was made out of lead. Out of 14 bronze samples, two samples (A04-R388 and A04-R392) were arsenical bronzes containing 7% of arsenic. Seven of them were containing both arsenic and tin varying 4 – 5% and 2 – 6% respectively. These tin-arsenic bronzes samples were indicatives of ternary alloy usage also in clothing pins (Selover 2010:152).

In another study, the three copper ingots found in Woolley's depot were analyzed by Ergun Kaptan with the aid of XRF (Kaptan 2004).[119] The results of the study show copper contents varying from 55.31% to 94.00%. This extreme deviation in the copper concentration of the ingots caused Kaptan to suggest that these three copper ingots were low in quality and the results of sub-standard production (Kaptan 2004). However, a lack of standardization in the elemental composition of copper ingots may not be an indication of a non-qualified smelting process, but also could be caused by variations in the raw materials. Furthermore, the location of production of the ingots is not exactly known. They may have been produced in Alalakh or imported. The issue of whether they are from the same origin is not yet clarified. These artifacts were sampled for scientific analysis after waiting for sixty-eight years in the Woolley's depot, which has extremely bad conditions in terms of weathering and humidity. Although Kaptan sampled them from several spots, any oxidation product interfused to the metallic sample may have yielded the divergence in the elemental composition of the ingots.[120]

[119] According to the calibrated radiocarbon date of the wood found embedded in the ingots, these ingots were dated to 1620–1430 BC (Yener 2006; Kaptan 2004: 6). These rough dates fix the artifacts to the final MBII- late LBI levels of Atchana, so these should belong to Woolley LevelsVII-IV.
[120] These ingots were sampled again in 2010 by the author and Emre Kuruçayırlı. The results will be published in Kuruçayırlı's dissertation.

In order to integrate the craft quarter with the above-cited studies, a metal slag sample, A03-R1366 found in a primary context of the production area was analyzed by Özge Demirci with the aid of the author.[121] This metal slag was recovered in Square 45.71, Locus 03-3005[122] from the interior of Installation 3 associated with *Phase 1b*/*Phase 2*. A small fragment was cut from a minimally oxidized and silica-covered location and imbedded in an epoxy resin for observation with optical microscopy. This polished cross-section examination demonstrated the existence of tin in the copper matrix, suggesting a tin-bronze production in the Installation 3 (fig. 4.64). Moreover, sulfur was also observed in the microstructure (the yellow spot in fig. 5). This element is found in secondary deposits of copper ores, which were more difficult to smelt compared to primary copper ores such as oxides and carbonates. Obtaining copper from secondary deposits requires a pre-treatment before smelting. This process is called roasting and depends on elimination of sulfur as SO_2 from the ore (Craddock 1995). These results clearly suggest metallurgical activity in this installation. Still, there is not enough evidence to advocate that Installation 3 was a metal furnace. This installation may have also been used for the pre-treatment of highly impure metal ores while processing for production the other pyrotechnic materials for production; in other words, this installation could have had a multi-functional use.

4.4. Assessment of the Scientific Results

To work toward a complete knowledge of pyrotechnological activities practiced in the Late Bronze Age context of Alalakh, three installations out of eight were examined with a set of scientific methods. Scientific data was compared, contrasted, and correlated with the results of previously published and relevant archaeometric research. For a more complete reconstruction of the Alalakh pyrotechnological activities, the function of the installations and

[121]Unpublished term paper (Özge Demirci) forthe Spring 2011 Archaeological Theory and Methods Class, given by K. A. Yener.
[122] For detailed locus information,see Yazıcıoğlu 2010: 189, table A.3.

the technological skills of the crafts, is integrated with archaeological contexts this section. An attempt is made to bring clarity to causal linkages in ancient technologies and societies.

Among the three installations chosen for scientific examination, Installations 1 and 2 belong to *Phase 1b* and Installation 5 was part of *Phase 1a*. Radiocarbon results are available for *Phase 1a* whereas there is no radiocarbon result from *Phase 1b* (Yener and Yazıcıoğlu 2010: 33, table 2.1).[123] Although the chronological difference is not yet elucidated, pyrotechnology and the functionality of the installations demonstrate a remarkable change between the two occupational levels of the craft quarter.

Installation 1 was defined as a pottery kiln in *Tell Atchana, Ancient Alalakh Volume 1* and a firing temperature of around 800° C was given as an estimated firing temperature (Yener and Yazıcıoğlu 2010: 18–19, 32). SEM analyses of this study support the hypothesis that Installation 1 was used as a pottery kiln. However, SEM images provide higher firing temperatures, achieving up to 1080° C in the combustion chamber.

Temperatures obtained in the combustion chamber are not the same as temperatures achieved in the firing chamber. While hot gases move upward to the firing chamber, they cool down so that to obtain the needed temperature in the firing chamber, an elevated temperature in the combustion chamber is necessary (Shoval 1993: 1,167). Thus the pottery fired in the upper chamber may have been exposed to temperatures of 950–980° C if the temperature obtained in the firing chamber was almost 100° C lower.[124] Nonetheless, further quantitative and qualitative examinations are essential to propose an exact firing temperature for the upper chamber. Methods like thin-section petrography together with XRD on the complete or fragmentary pieces of pottery found *in-situ* will help solve this problem, but such an assemblage was not found in the Installation 1 context.

[123]For a detailed discussion of radiocarbon dating of the craft quarter ,see Chapter III, Section 3.1.
[124] This estimation between combustion chamber-firing chamber firing temperatures see Shoval 1993, 1994.

Other than determining the firing temperatures of Installation 1, Ian Freestone remarks on a typological-functional relation for this pottery kiln (Yener 2010:31). He points out that the attempt to separate fired materials from the smoke is a procedure applied while firing plain red wares, glazed wares, and highly decorated wares so as to avoid blemishing the surface. All of these three types of pottery especially Atchana Red Slip wares, Nuzi wares, and glazed pottery were found in various contexts contemporaneous to Installation 1 (Yener and Yazıcıoğlu 2010: 31). Certainly, this does not provide evidence that Installation 1 was used to fire these ceramics, but it does not contradict the properties of its contemporary ceramic assemblage.

The lack of *in-situ* pottery either inside the kiln debris or in its related contexts possibly indicates an abandonment of Installation 1 during its related occupational phase. Instead of being destroyed, this pottery kiln was simply left out of use. The reason for the abandonment is uncertain. However, production in this area continued in later occupational phases when other installations were built in the craft quarter. Abandoning Installation 1 but continuing production activity at the same location in the later levels may signify a variation or change in the produced material, production strategy, or a rearrangement of the organization in the craft quarter.

Installation 2, which is located almost seven meters to the southeastern side of Installation 1, also functioned as a pottery kiln. The SEM images suggest firing temperatures of around 1150–1200° C for the combustion chamber fragments, which should be lower in the firing chamber. Similar to Installation 1, with an approximate 100° C decrease, firing temperatures achieved in the firing chamber would be around 1050–1100° C. These temperature degrees also need further investigation to be determined precisely. However, Installation 2 with its associated contexts did not yield any *in-situ* pottery, which would have completed our knowledge of what was produced inside and at what temperature.

At this point, before reconstructing Installation 2 according to the scientific and contextual data, it is worthwhile to summarize the 2009 experimental archaeology project based on the replication of this kiln. Installation 2 was used as a model providing an opportunity to clarify the construction technique and function (see video at www.alalakh.org). Installation 2 was chosen as a model for this experimental archaeology project because it is the best-preserved example among all the installations in the craft quarter with an intact upper deck and combustion chamber (fig 4.65). To reconstruct the combustion chamber, a 1.5 × 1.5 m square was cleaned and dug almost to a depth of 30 cm. The ground floor was coated with a mixture of mud and straw to provide insulation for the kiln and bedding for the mud-bricks. Thirteen 20 × 40 cm mud-bricks were laid on their short sides to create three rows of east–west-directed horizontal flues. These rows have approximately 20 to 30 cm of space between them. Additionally, mud bridges were made between each of the four bricks to supply a better-supported platform for the floor level of the upper-deck. Behind this construction, a one-meter-deep firing pit with a 1.70 m diameter was dug to burn the fuel and keep a continuous fuel supply.

The combustion chamber was separated from the second story with a mud-brick wall. This wall was built daily by putting only a portion of mud plaster horizontally on the floor. This construction needs a special type of clay plaster with enough strength and cohesion; this clay is accessible from the eastern part of Tell Atchana, in the deep canal constructed to drain Lake Antioch. Today, villagers still use this clay source to make mud-brick and pisé structures like bread ovens. This special clay was carried from the source, partially dried, and mixed with straw. This material was used to cover the foundation of the upper-deck. Air holes were perforated to allow the hot air to flow from the combustion chamber to the upper-deck (fig. 4.66).

For the surrounding walls of the upper-deck, a vaulting method called corbelling was applied. The walls were elevated by four mud-bricks which lay slightly inward to create an arch. Each day, only three courses were added to allow the mud and straw mixture to dry and harden. Otherwise, the entire structure would have collapsed since there was no wood to support the construction. By the end, 200 mud-bricks, which is quite a notable amount, were used to construct the walls (fig. 4.67).

The kiln was fired using six thermocouples to measure the firing temperatures. One of the thermocouples was affixed to the wall face of the firing pit; two were attached inside the lower chamber. Two more were located on the upper-deck and a final one was affixed to the chimney. While 600° C was reached in the firing pit, the temperature inside the kiln did not increase more than 34° C. This technical error was caused by a constructional mistake. While this experiment was processed, the height of the walls of the firing chamber was equal to the height of the combustion chamber. This mistake in construction prevented hot air from returning to the lower chamber. Instead, hot air reached the ceiling and expended due to the lack of insulation.

For the second trial, the height of the walls was built compared to the combustion chamber and a lower ceiling was created in order to have a leveled air circulation between the upper and lower decks. A lower ceiling for the upper-deck pushes the hot air into the channels of the lower chamber and does not allow the hot air to rise toward the ceiling. After it was fixed, the experiment was retried[125] and a clay figurine[126] was baked. This clay figurine, made out of calcareous clay, needed a minimum temperature of 800° C, which is an easily

[125] This time, firing temperatures could not be measured due to the absence of the geologist team member Pınar Ertepınar Kaymakçı.
[126] This figure was shaped by registrar Ferhat Can.

attainable temperature in an updraft kiln.[127] These experimental installations provided vital information toward understanding of Installation 1.

Compared to Installation 1, Installation 2 was firing at higher temperatures between 100–150° C compared to Installation 1. Concerning the fact that they were both located in the same phase and situated only seven meters away from each other, why did they need to process at different temperatures? To achieve a 100–150° C increase in temperature inside updraft kiln conditions, an enhancement in fuel consumption would be expected, undoubtedly together with an increase of work and labor. This difference between the firing temperatures of two similar types of kilns could be caused by a divergence in the requirements of ancient crafts. Unless they were not producing different types of pottery or materials, the increasing process temperatures would be an unsuccessful and inefficient way to produce similar types of pottery. Due to the fact that they were specialized in their craft, the decision to process two similar kilns in different temperatures could indicate a variation in the finished product. This variation may be due to a change in types of pottery, like hard-fired or low-fired products. For instance, firing temperatures for a terracotta type of pottery is below 900° C, while earthen-wares need 900–1200° C, and stone-wares require 1200–1350° C (Sinopoli 1991: 29, table 2.2). Additionally, the type of material produced inside the installation may not be limited to pottery. The firing temperatures achieved are suitable for managing other materials, like metal, faience, frit or glass.

Pottery excavated both in the Late Bronze I/Late Bronze II transition and Late Bronze II levels of Alalakh by Woolley as well as Yener's excavations include imported and local pottery assemblages. In his book, Woolley defines the Level IV pottery assemblage as including Cypriote pottery (Base Ring jugs, White Slip ware) together with white painted

[127] This reconstructed kiln was damaged due to weather conditions and biological elements (animals, plants) and the floor of the firing chamber collapsed. The 2011 Atchana excavation team fixed the construction and this experimental archaeology project will be repeated in the 2012 excavation season.

Nuzi ware, large flat plates and beakers with red or black band decoration, local flat open plates, and hemispherical handled bowls (Woolley 1955: 318). In Level III, Level IV fashions continue in local productions as well as imported goods like Cypriote pottery and Nuzi ware (Woolley 1955: 319). In Level II, Mycenaean pottery became common; Woolley argued that Alalakh potters probably were inspired to manufacture Mycenaean[128] pottery in Nuzi style (Woolley 1955: 319). In Woolley's final level, Level I, Mycenean pottery was found collectively with Cypriote and Nuzi wares. Other than these pottery assemblages, it is important to note that starting from Level IV until the end of Level I, glazed earthenware was found (Woolley 1955: 297–300). Pottery assemblages found in Yener's excavations confirm Woolley, except for the fact that Yener redates Woolley's Level III as a sub-phase of Level IV (Yener in prep. b; Akar 2012.). This new evidence supports the Woolley's observation about the continuity of the Level IV pottery trends in Level III, according to his stratigraphy. If Level III was a sub-phase of Level IV, having a similar pottery assemblage from these levels becomes clearer.

In terms of the manufacturing techniques associated with the Late Bronze I/Late Bronze II and Late Bronze II periods, glazed earthenware as well as Nuzi ware needs high firing degrees, which were easily obtainable in a kiln like Installation 2. The XRD results of Late Bronze I ceramic slag fragments documented in Section 4.3.1 demonstrate that there was a long-used tradition of achieving high temperatures and producing high-fired pottery at Alalakh. Regarding this evidence, the craft quarter under consideration might be one of the production areas for fabricating high-temperature pottery. At this point, I am not suggesting that Nuzi wares or other imitational pottery were fired in Installation 2, but I argue that the Alalakh craft quarter has the technological capacity of manufacturing the hard-fired pottery

[128] Woolley wrote Minoan but he confused Minoan and Mycenaean terms so that his 1955 publication became confusing. There is no LMIII ware, only LHIII ware which is Mycenaean (personal communication Mara Horowitz).

found in Levels IV–II, contemporary with the workshop area. Furthermore, a mixed floor deposit of Installation 2 and Installation 5 yielded vitrified material slag. If these samples belong to Installation 2, this would be evidence of faience, frit or glass production in this structure. It is important to note here that a recent research published on Nuzi Wares by Erb-Satullo *et al.* shows that Nuzi wares of Alalakh (Atchana wares) has a different chemical and mineralogical composition (especially higher in iron contexts) implicating a local production of Alalakh. In other words, Alalakh Nuzi wares were not Nuzi-originated but locally produced (Erb-Satullo 2011). The later occupational phases of the craft quarter yielded five installations (Installations 4–8); among them, only Installation 5 was investigated by scientific methods due to its preservation and typological similarity to Installations 1 and 2. Moreover, a variety and abundant amount of slag samples were collected from the interior fill and floor debris of the structure.

The SEM examination showed impressive results in terms of firing temperatures. The vitrification degrees of microstructures and frequency of bloating pores in the molecular structure demonstrates that firings were achieved at 1100–1200° C. These temperatures were obtained by an examination of slag fragments. The complete set of scientific results of Installation 5 shows ceramic and vitrified material slag together, which indicates a multi-functional use of the kiln.

Glass artifacts contemporary with the craft quarter were found in both the Woolley and Yener excavations. The earliest polychrome glass vessel fragment (AT/39/225) found by Woolley was from Level VI (Woolley 1955: 300). Levels VI and V yielded several examples of a glass vase and bead fragments. In addition Levels IV and III, which are chronologically contemporary to the craft quarter, yielded several glass artifacts. An entire, but broken, bowl with yellow-wavy decoration on blue (ATG/39/85); grey, yellow, and opaque white fragments (AT/47/144); and fragments of three bottles from just above the Level V

"Mithraeum" (AT/47/145) were found in Level IV. Woolley noted the similarities of the rich coloring of one of AT/47/145 bottles with Tell Amarna (Woolley 1955: 301). Furthermore, Level III yielded a notable amount of comb-designed glass objects and white glass with oval inlaid spots (AT/46/114). This same inlaying technique was observed on a Level II open bowl rim (AT/46/122) and pale green and yellow on opaque white glass fragment (AT/39/149) (Woolley 1955: 300–02). Based on the amount of samples, Woolley suggested that these were imports rather than a local production (Woolley 1955: 301). However, excavations conducted by Yener not only enlarged the number of glass artifacts, but also unearthed several frit, faience, and glass artifacts in well-preserved workshop contexts (Yener 2010: 107) suggesting local production. These workshops and their artifact assemblages will need further investigation and will be a part of another study.

By providing brand new information on vitrified material most probably glass production from *Phase 1a* of Alalakh, Installation 5 also serves as an example for the divergent uses of pyrotechnoloy in the craft quarter district. More than manufacturing pottery, the production of other desired materials is evidenced by this occupational phase of the mound.

The examination of the three installations enhanced our knowledge about the function of these mud brick kilns as well as pyrotechnological processes practiced in the craft quarter. Diverse uses of fire verify the advanced level of technological knowledge of Alalakh artisans. The contribution of scientific results in the archaeological context of Alalakh, the Late Bronze Age production technologies, as well as craft specialization and technology theories are discussed in Chapter VI.

CHAPTER V

PYROTECHNOLOGY OF THE LATE BRONZE AGE: CONTEMPORARY POTTERY AND GLASS PRODUCTION TECHNOLOGIES FROM ANATOLIA, THE LEVANT AND EGYPT

This chapter discusses a comprehensive set of pyrotechnological installations related to pottery and glass industries. A more complete understanding of pyrotechnology in Late Bronze Age societies can be achieved with a broader study of archaeological contexts within the same region. Regarding that, the significance of Tell Atchana/ancient Alalakh's pyrotechnological activity area can be defined and interpreted comprehensively with a comparative and supplementary study. Various pyrotechnological installations from Late Bronze Age Anatolia, the Levant, and Egypt not only provide integrative information for the form (typology) and function of the Alalakh installations, but also create a complete set of information about the progress and innovations in the technology of the period.

Based on this reasoning, this chapter compiles all the information from published material. Chronologically, the Late Bronze Age is the main focus of this literature review. Nevertheless, settlements yielding typologically similar and relevant installations dated either earlier or later than the Late Bronze Age were also included as comparative material in order to establish a linkage for understanding the continuity of the pyrotechnological typology of installations and management of processes.

Due to Alalakh's location as an intersection between Anatolia and the Levant, these regions were inspected for fire-related installations, especially pottery kilns, as comparative material. In terms of glass technology, a sub-section of Egypt was also included in the discussion since excavations and research about Egyptian glass and glass technology are very important in the field of the Near Eastern archaeology and Egyptian-related artifacts were found at Alalakh.

Since fire-related activities were a mainstay for ancient societies, pyrotechnological installations are essential sources of archaeological information to evaluate how ancient artisans used and controlled fire. Hence, pyrotechnological installations are frequently unearthed in archaeological excavations of Bronze Age settlements. These architectural features, their contextual information, and *in-situ* material (or lack thereof) were recorded as "kilns," "ovens," "furnaces," or "hearths." While these contextual and typological descriptions were assigned, quantitative information was generally not included to support such functionally loaded terminology. As a result, archaeological excavations conducted in Anatolia and the Levant has very limited comparative archaeological material furnished with quantitative analyses of pyrotechnological installations (Casana 2000). Each ancient settlement and pyrotechnological installation carries information of critical value and plays a particular role to fill the gaps in our knowledge. Each archaeological element has its own cumulative knowledge to re-establish the ancient web of socio-political and socio-technological relations and to display the importance of pyrotechnology in the material culture of the Late Bronze Age.

In this literature review, the main limitation was the deficiency of the publications. Together with the rarity of scientific research, finding a comparative pyrotechnological installation became a critical problem. This was especially the case for Anatolia since a Late Bronze Age comparative of an Alalakh pottery kiln was only found in Hattusa, where no glass-related pyrotechnological unit is documented. These limitations once more demonstrate that pyrotechnology is an open and developing field of study and signify the importance of research and publications in the scholarly world of archaeology and archaeometry.

5.1. Pottery Production Technology in Anatolia: The Middle and Late Bronze Age Pottery Kilns

The poverty of available information and publications on Late Bronze Age pottery kilns causes a handicap for the evaluation of pyrotechnology in Anatolia. Despite the abundance of ceramic material culture, there is a dearth of knowledge aimed at understanding the technologies and organization of production. Aiming to fill the gap and providing a linkage between products and their technologies, all of the available information documenting pottery kilns spanning the Middle and Late Bronze Ages is covered in this section.

The salvage excavations at Şaraga Höyük, located on the western side of the Euphrates roughly 10 km north of the famous ancient site of Carchemish, yielded two pottery kilns. These kilns were unearthed in the Middle Bronze Age levels. One of these kilns, Kiln B95, was a double-decked kiln with an oval dome. Although the structure was destroyed by other levels, the firing chamber, floor of the upper chamber with partially preserved perforated floors, and ventilation holes were excavated. In the firing chamber, unfired pottery together with local ceramic was recovered (Sertok et al. 2005: 283). The associated kiln next to Kiln B95 was badly preserved, but figurines and bronze pins were found in relation to this structure. Although there was no information published about the Late Bronze Age pottery kilns, Sertok et. al (2005: 283–84) noted that the Late Bronze Age sequence of Şaraga Höyük yielded remains of metallurgical activity such as bronze tools, copper, glass and faience beads, metal slag, and five casting molds. The description of the Şaraga Höyük pottery kilns sounds similar to the Late Bronze Age installations of Alalakh, which provides evidence for continuity of the double-decked installations from the Middle to the Late Bronze Ages around the Euphrates region. The sites in Syria documented in Section 5.2 will also contribute more supporting data for this continuity of technology hypothesis.

Typologically and functionally, the best documentation of Late Bronze Age pottery kilns was published by A. Müller-Karpe. Hattusa-Boğazköy, located in central Anatolia in the province of Çorum, was the capital city of the Hittite Empire. Excavations in the Bogazköy-Hattusa upper-city yielded five pottery kilns (*Ofen* 1–5) dated to around 13th century BC (Müller-Karpe 1988). Chronologically, this period offers a slightly later time interval than Alalakh Phase 1, which is the period to which the craft quarter and installations studied in this thesis were dated.

Architecturally, these updraft kilns were made out of stone with a characteristically Hittite technique. During the excavations, none of these double-story structures were found with an intact upper deck. Kiln 1 (*Ofen* 1) was rectangular and had a combustion chamber measuring 4.0–4.5 m long, 1.0–1.5 m wide, and 0.8 m deep (Müller-Karpe 1988: 7, taf. 63.1–5, plan 5.6). The structure had a limestone backbone, having especially large components on the corners. The interiors were plastered with mud and in some spots the fingerprints of the mud-worker were still visible. The firing chamber was filled with clay debris and had evidence of heavy firing. It is important to note here that a coarse ware shard found in the kiln had a hieroglyphic stamp on its handle (Müller-Karpe 1988: taf. 17, T 2c, 3). In terms of pottery production technologies, this kiln should have been constructed with the same production principle used in both the Alalakh installations and their Syria-Levantine counterparts; however, the extensive dimensions of this kiln were not reached in Alalakh, nor in any comparative settlements around the Levantine region.[129] Moreover, in terms of building strategies, Syria and the Levant preferred mud brick instead of stone. The choice of building material probably depended on local resources and the availability of raw materials due to the geological character of the landscape. However, constructing a pottery kiln in an oversized dimension should have another reason and must have been done intentionally.

[129]For details of the Levantine pyrotechnological installation, see Section 5.2.

In terms of production capacity, with these pottery kilns, the amount of production can be doubled compared to the pottery production units found in Syria or the Levant. These characteristic production capacities can be evaluated as parameters in the standardization theory advocated first by M. H. Gates (Gates 2001). The hieroglyphic-stamped coarse ware offers also a supportive argument to suggest standardized mass pottery production in such a kiln. Although quantitative and qualitative information about the detailed function, firing temperatures, and quality of output of these kilns were not included in the publication — which makes it hard to make assumptions about the produced material, these pottery kilns are a good fit for the idea of standardized mass production.

The second pottery kiln documented in Hattusa-Boğazköy was *Ofen* 2 and only published as a drawing (Müller-Karpe 1988: plan 5). This installation was not as well preserved as *Ofen* 1, but the lowest stone layer, parts of the walls, and firing pit were still standing (Müller-Karpe 1988: 9). The firing pit measured 3.0 × 1.1 × 0.9 m and was filled with ashy debris. While reconstructing the kiln, Müller-Karpe suggested a minimum height of 2.5–3.0 m for the dome (Müller-Karpe 1988: 9). Even though it is hard to suggest any size for this kiln, the measurements of the firing pit suggests it most probably had a big structure like *Ofen* 1.

Ofen 3 represents a different typological style. This kiln was rounded with a diameter of almost 1 m. The walls were standing on the stone foundation, plastered with mud (Müller-Karpe 1988: 10, taf. 63, 6, plan 7). The debris contained ceramic shards together with stone and clay fragments. The existence of air holes between the combustion and firing chambers was questionable, but the stoke hole survived. According to this archaeological evidence, Müller-Karpe left it under debate as to whether this installation was of the pit-type or had a simple dome made out of mud (Müller-Karpe 1988: 10).

Ofen 4, excavated in slightly earlier strata, showed close similarities with *Ofen* 1. The firing pit, measuring 4.3 m long, 3.1 m wide, and 0.4–0.8 m deep, was standing on the slope. The stoke pit was 1.25 m wide and defined as "*birnenförmig*" (pear-shaped) by Müller-Karpe (Müller Karpe 1988: 10, taf. 64, plan 5.6). Plastering was also quite commonly observed on different parts of the installation. Like Ofen 1, sherds of coarse ware with a stamp on the handle were also recovered (Müller-Karpe 1988: taf. 48 Kn 1, 3). A probable reconstruction by Müller-Karpe proposed a width of 3.0 m and 3.0–4.0 m height for the original installation (Müller-Karpe 1988: 11). These dimensions put forward once more the similarity between *Ofen* 1 and *Ofen* 3.

Other research was done on the botanical samples collected from the floor of *Ofen* 4. Dr. H. Schlichtherle analyzed the samples to understand the fuel-source of this kiln. He proved that oak wood, which was known as an efficient energy source to reach higher temperatures, was used as a fuel in this kiln (Müller-Karpe 1988: 12). Even though the firing temperatures were not clearly defined and only the term "high temperatures" were used to describe the capacity, this study introduced data for identifying the fuel-supply for the Hittite production.

The last kiln from Boğazköy-Hattusa was found in the northern part of *Ofen* 2 and *Ofen* 3, but only published as a drawing in the plans, which make it difficult to compare with the others. Nonetheless, Müller-Karpe defined *Ofen* 5 as similar to *Ofen* 2, which makes this installation also similar to *Ofen* 1 (Müller-Karpe 1988: 12, plan 12). This kiln was constructed on serpentine bedrock and the floor and side walls were plastered. Unfortunately, preservation conditions did not allow detailed elaboration.

After the 1988 publication of Müller-Karpe, P. Neve presented pottery kilns and metallurgical activity areas in 1990 at the 1st Hittitology Conference (Neve 1990: 118). In his article, he drew attention to the new architectural work started in the central temple area and he referred to Hittite ceramics that were produced in the aforementioned pottery kilns. Unfortunately, neither the architectural or functional details nor a photograph or drawing of this kiln was published.

Hittite pottery kilns from Büyükkaya were recently published by J. Seeher. The 1995 excavations in Square (plan quadrat) 355/430–432 yielded two Late Bronze Age (spät-großzeitlich) free-standing pottery kilns. The kiln at the southern end of Square 355/431 had a pit of 2.00 m long, 1.00 m wide, and 1.35 m deep excavated together with a fragment of the second-story. The northern kiln, measuring 90 × 50 × 100 cm, was smaller compared to the first one and was poorly preserved (Seeher 1996: 335–36, Abb. 3, here fig.5.3). Both of them had an apsidal foundation of firing pit colored in black due to heavy firing. In the kiln debris, well-fired bricks were found together with miniature vessel fragments. More than forty pieces of miniature and votive vessels and their fragments were found in and around the kilns, providing a foundation for interpretations, such as suggesting that these kilns are specifically for miniature pottery production (Seeher 1996: 337, Abb. 4–5, here fig. 5.4).

Another kiln from the 1995 excavations was unearthed almost 10 meters away from the aforementioned kilns. This kiln was found standing almost 60–70 cm above the firing chamber floor and a partially preserved second-story with *in-situ* ventilation holes. The kiln was 1.60 m wide and 0.90 m deep, but the length cannot be measured accurately due to the damaged sides (Seeher 1996: 338).

Two Hittite locations at the capital yielded information on pottery kilns and provided comparable information about the typology and size of their pottery production units. First of all, the pottery kilns documented by Seeher were smaller than those documented by Müller-Karpe. Seeher pointed to this when arguing that Büyükkale had its own production area, though in smaller scale (Seeher 1996: 338). Secondly, the dissimilarity of the dimensions of the kilns and archaeological assemblage in the kiln fills may likewise designate specialized production for specific pottery. For example, Boğazköy *Ofen* 1 and *Ofen* 4 yielded sherds of coarse ware with stamps on the handle, whereas Büyükkale 355/430–432 kilns yielded an extensive amount of miniature and votive vessel fragments. In order to confirm this hypothesis, more comparative assemblages need to be obtained through further excavations at the Hittite capital.

Another point to highlight is the stylistic and dimensional similarity of the Boğazköy pottery kilns to the Minoan world. A Late Minoan I (16th century BC) pottery kiln from Kommos, Crete, shows very similar parallels with *Ofen*1 and *Ofen* 4 of Boğazköy (figs. 5.1–2). Even though the Kommos kiln was dated almost three centuries earlier, the similarities are undeniable. This kiln also had a stone, rectangular structure measuring a diameter of 4.20 m internally and 5.40 m externally. The width was 2.70–3.20 m with an average depth of 1.23 m (Shaw 2001: 12, table 1). The reconstruction gives an idea about how the Kommos kiln may have looked (Bianco in Shaw 2001: 23; here in fig. 5.5). This drawing offers an opportunity to visualize the Boğazköy kilns as well. Additionally, another kiln, excavated in southern Crete near Kommos, was the Hagia Triada pottery kiln, which dates broadly to the same period (Late Minoan I) and shows similar patterns (Levi and Laviosa 1986; Tomasello 1996). The archaeological remains were not as intact as at Kommos, but enough survived to establish uniformity. The reconstruction showing the cross-section of the Hagia Triada kiln establishes another notable example of typological connections between Hittite and Minoan pottery production units (Di Vita et al. 1984: fig. 277; here fig. 5.6).[130]

[130]This uniformity is also present in the fabrics and raw materials used in the pottery assemblages of these Minoan kilns (Myer and Betancourt 1990; Shaw et al. 2001: 118; Belfiore et al. 2007: 650).

In addition to *Ofen* 1 and *Ofen* 4, circular Ofen 3 (fig. 5.5) has an equivalent in the Minoan world. A Late Minoan III pyrotechnological installation described as an oven was excavated in association with the Kommos kiln (Shaw 2001: figs. 5, 11; here fig. 5.8). Despite its description as an "oven" by Shaw, Müller-Karpe described it as a kiln. Interestingly, the same typology was apparent in Late Bronze Age Sarepta Kiln S, dated to around 1570–1380 BC (Anderson 1989: 204).[131] The Sarepta kilns were defined as the bilobate form and were most probably the later versions of these Hittite and Minoan kilns (Anderson 1989: figs. 5, 8; here figs. 5.9-10).

To sum up, the dimensions and typology of the Boğazköy (*Ofen* 1 and *Ofen* 4) and Kommos pottery kilns and the typological similarity between Boğazköy (*Ofen* 3), the Late Minoan III Kommos so-called oven, and the Sarepta bilobate-form kilns can be used as an archaeological element to demonstrate similar technologies between the Hittite, Minoan, and Levantine worlds. Even though the examples summarized here are not absolutely contemporary, the similarity of pottery production technology is very strong. This allows me to underline once more the continuity of technology in pottery production over a long period of time and the sharing or copying of effective technological knowledge, and perhaps choices of material or production strategy as well. However, this pattern in kiln size and circular typology did not have a counterpart in Late Bronze Age Alalakh or Syria, which will be discussed below.

Concerning instrumental research in Anatolia, a Hittite settlement located in the southeastern part of Çorum province dated to around the 14th century BC, provides a noteworthy investigation of a sample group including ceramic shards, soil, mud brick, plaster,

[131]Details of the Sarepta kilns are discussed in Section 5.2.

mortar, slag and tablet fragments (Demirci et al. 1998).[132] Weight loss on ignition[133], thin-section petrography, porosity determination, and XRD methods applied on the samples established a firing temperature of 700° C for most of the samples. The shards included wollastonite crystals in their microstructure which proved a firing temperature of over 1000° C (Demirci et al. 1998: 146, 148). The terra-cotta ceramic group was defined as 30% porous, coarse, unglazed, and generally low-fired, and was found to have been produced at 900° C or less (Demirci et al. 1998: 146; Rice 1987). These results are compatible with the ceramic slag SEM and XRD results presented in my study. Although, Demirci et al.'s study does not include the petrographic analysis of ceramic shards, the firing temperatures suggested for Installation 1 and 2 show the same degrees, indicating a standardized pyrotechnological management in pottery production.

5.2. The Late Bronze Age Pottery Kilns from Syria and the Levant

To establish a more comprehensive description of Bronze Age pyrotechnology, studies that report comparative archaeological material for pyrotechnic installations from the Levantine region were also of interest to this study. Pottery kilns, metal furnaces, and glass and faience productions areas excavated at relevant archaeological sites are overviewed in this section to establish pyrotechnological linkages to Alalakh's installations.

Excavations at the Late Bronze Age site of Tell Sabi Abyad yielded ten pottery kilns. K. Duistermaat described and analyzed these kilns as a part of her Ph.D. thesis (2007) and then published her work in *The Pots and Potters of Assyria: Technology and Organization of Production, Ceramics Sequence and Vessel Function at Late Bronze Age Tell Sabi Abyad, Syria* (Duistermaat 2008). Tell Sabi Abyad is located in the northern part of Syria, 500 km

[132]All of these samples were found in Ortaköy-Şapinuva Building A and Building B storage (Demirci et al. 1998).
[133]A method to determine organic content of the material. For procedural details see http://www.geog.ucl.ac.uk/about-the-department/support-services/laboratory/laboratory-methods/lake-sediment-analysis/loss-on-ignition.

northeast of Damascus along the Balikh River. This ancient settlement was continuously occupied from the seventh millennium BC to the Middle Assyrian Period (late 13th–early 12th centuries BC). The earliest Late Bronze Age date of the site is the late 14th or beginning of the 13th century (Akkermans 1997; Akkermans and Duistermaat 2001; Duistermaat 2007: 23).

The workshops and pottery kilns were excavated in two levels of occupation, Level 6 and Level 5, referred to as the Middle Assyrian period (Duistermaat 2008). All of the kilns are two-chambered updraft kilns (Duistermaat 2008: 489). Level 6 has two kilns (Kiln Q and Kiln L). Kiln Q has a pottery chamber measuring 2.27 × 1.73 m and a firing chamber with the dimensions 1.74 × 0.90 m and a volume of 3.08 m^2. The rectangular firing chamber has a semi-circular fuel entrance. The firing chamber pits were not covered with bricks, but were plastered with mud-plaster. This plastering was repeated several times, indicating repair and reuse of the kiln. The colors changed from green to dark green and had sintered spots that are the evidence of repeated firing activity. In the fill of the firing chamber, unfired ceramics, sherds, sintered plaster, ash, and animal bones were found (Duistermaat 2008: 491, 503).

Kiln L was not as well preserved as Kiln Q. The pottery chamber of Kiln L did not survive, but the firing chamber measures 1.74 × 0.90 m with a volume of 1.88 m^2 (Duistermaat 2008: 490–92, 503). The firing chamber is rectangular, but neither the fueling entrance nor the plastering was preserved. Like Kiln Q, this kiln also varied from green- to grey-colored due to the high temperatures reached inside. The fill inside the firing chamber contained unbaked pottery, shards, and animal bones (Duistermaat 2008: 492, 503).

Compared with each other, Kiln Q is almost double Kiln L in size. Moreover, Kiln Q was located in an open area and used in an earlier level whereas Kiln L was located in a courtyard area. Duistermaat suggests that after the abandonment of Kiln Q, the use of Kiln L began. She also proposed a theory of the simultaneous use of these kilns, but Kiln L continued to be in use after Kiln Q (Duistermaat 2008: 357). According to a cuneiform tablet, the usage and process of these installations were under the control of a local administration system which was called as *dunnu* (Duistermaat 2008: 357).

In comparison with the Tell Atchana/ancient Alalakh pyrotechnological installations, these two kilns are similar to Installations 1 and 2. The typology and the structural details like the double-decks, free-standing construction and the ventilation holes are almost identical. Kiln Q of Tell Sabi Abyad is the largest installation of its context, but Installation 1 of Alalakh is larger in terms of its foundation area. This dimensional difference does not definitely point to a more advanced pyrotechnological capacity at Alalakh, but it may outline variations around the region probably shaped according to needs. Furthermore, the color changes are almost the same, which indicates that these kilns were processed almost at the same firing temperatures.

In another occupation level, Level 5 of Tell Sabi Abyad, kilns and production activity related areas were excavated in three different phases described as the ‘eastern workshop’, the ‘west workshop’, and the ‘north location’ (Duistermaat 2008: 357–58, 365–69). The eastern workshop has three updraft kilns called Kiln H, Kiln T/U, and Kiln AC/AR. For all three of these kilns, the preserved structure is the whole or partial firing chamber. For Kiln H, although the stratigraphy is not clear, it is probably in Level 5. Duistermaat gives dimensions for a pottery chamber measuring 2.65 × 2.54 m, and a firing chamber larger than 1.85 × 1.10 m and over 1.62 m^2 in volume (Duistermaat 2008: 358, 493, 503). The shape is almost rectangular. The interior of the chamber was plastered with mud-plaster and behind the chamber there are burnt stone bricks, whose association with the kiln is unclear. The fill was composed of ashy layers, baked bricks, and sherds. A pottery assemblage was composed of four bowls, a goblet, and a spindle whorl was found inside the kiln. There were no slag or wasters (Duistermaat 2008: 358, 493).

Kiln T/U was a small updraft kiln with a firing chamber measuring 1.53 × 0.89 m. Its structure was made out of half mud-bricks with plastering inside. The interior was heavily fired. The fill of the firing chamber contained black and ashy soil, with some large stones, a couple of burnt shards, and a burnt bowl (Duistermaat 2007: 157; 2008: 495).

The last kiln of the Level 5 eastern workshop of Tell Sabi Abyad is Kiln AC/AI. This one is very badly preserved and was damaged by a later bin. The intact part of the firing chamber measured 1.50 × 0.90 m. The firing chamber pit was plastered and a couple of mud-bricks survived as well. The fill was composed of a brownish grey soil, with unfired and fired sherds and three goblets (Duistermaat 2007: 157; 2008: 494).

Among the Level 5 eastern workshop updraft kilns, in terms of its shape, structural features like use of mud-bricks, plastering, and contamination of the fill, Kiln H of Tell Sabi Abyad is very similar to the Phase 1a Installation 6 of Alalakh.

The Level 5 west location is defined as a little bit later than the eastern pottery activity area. Here, two small updraft kilns were excavated without any *in-situ* finds. Since pottery production-related artifacts like unfired vessel fragments and wasters are stratigraphically not contemporary and look like a dump area rather than an activity location, Duistermaat terms this context as a production unit instead of a workshop (Duistermaat 2007: 163). The evidence is not clear enough to identify this space as workshop (Duistermaat 2007: 165).

The two kilns located in this location are Kiln H/AE and Kiln I. Both of them were supported by the walls of the workshop and the firing chambers were the only preserved parts. The lower part of the firing chamber of Kiln H/AE was almost rectangular and plastered. The part that survives measures 1.44 × 0.68 m. The linings of the wall were greenish-grey in color and molten due to the high temperatures reached. A couple of sherds, unbaked vessel fragments, kiln wasters, and two bowls were found in the fill of the firing chamber (Duistermaat 2007: 163–64; 2008: 496–97).

Kiln I has similar features with Kiln H/AE. The firing chamber measures 1.12 × 0.65 m, which is comparable to the other kiln in this area. The plastered feature of the firing chamber has traces of high temperature firing. The fill of the chamber exposed unfired pottery and sherds in the blue-grey and grey-brown ashy soil (Duistermaat 2007: 164–65; 2008: 498). Like Kiln H of the eastern workshop, Kiln H/AE has a similar apsidal wall at one end and is rectangular at the other end. These structures are similar to the subterranean structures of the *Phase 1a* Installations 6 and 8 of Tell Atchana/ancient Alalakh.

The final location of pottery production activity in Level 5 is the north, where two updraft kilns were excavated. Kiln AR was a large kiln, one of the largest among the Tell Sabi Abyad kilns. Kiln AR has a rectangular firing chamber and a semi-circular firing pit that have survived. Moreover, the air flues were also traced. The inside part of the firing chamber measures 2.25 × 1.26 m, carrying the traces of at least three episodes of re-plastering or repair. The plastering and mud-bricks of the structure are heavily burnt; the color varies from grey to red. The firing chamber fill has black-white ash with burnt and unburnt mud-bricks, sintered plaster pieces, and pottery slag. A baked clay sealing, a bowl, and a bronze ring were found in the lower kiln fill (Duistermaat 2007: 166–67; 2008: 494).

Kiln CJ/V of the northern location is a unique example for Tell Sabi Abyad in terms of its excellent preservation. Together with a firing chamber with firing hole and pottery floor, the pottery chamber construction also survived. Six of the flue holes of the pottery chamber floor were found with good plastering. This upper part measures almost 1.60 × 1.0 m while the rectangular firing chamber measures 1.40 × 0.68 m. The fill of the pottery chamber yielded plaster fragments, charcoal, and a bowl in the brown soil. A small piece of faience and a clay jar stopper were found in the firing chamber filled with blackish-grey ash (Duistermaat 2007: 167; 2008: 499–500).

The pottery workshops or production units of Tell Sabi Abyad have nine updraft kilns in different sizes and shapes in two main stratigraphic units identified as Level 6 and Level 5. Other than these kilns, there is one more updraft kiln excavated in a later context (Level 4), which dates to the late 2nd millennium BC, around 1192–1187 BC. This kiln, Kiln K, is worthwhile to analyze here as a comparative sample since it has quite similar features with Alalakh *Phase 1b* Installations 1, 2, and 3.

Kiln K was a large updraft kiln, rectangular in shape with a semi-circular fire pit. The installation had another semi-circular entrance, most probably used for fuel. The firing chamber measures 2.16 × 0.64 m. The pottery chamber floor, with nine air flue holes, was also preserved and measured 3.00 × 2.34 m. The firing chamber and flue holes were covered with mud plaster, similar to the Level 6 and Level 5 pottery kilns. The mud-bricks inside the firing chamber have colors varying from green to red and orange, implying the high temperatures reached during the firing process. Vitrification is also observed on the mud-bricks. Ashy soil, sherds, burnt bones, and mud bricks were recovered from inside the firing chamber fill (Duistermaat 2008: 501–02). Kiln K is similar to Alalakh Installations 1, 2, and 3 in terms of its typology, condition of interior surfaces, and contamination of kiln debris. However, the Alalakh installations yielded a notable number of metallic finds together with ceramic artifacts.

Kiln K was also analyzed in another article by Duistermaat and Akkermans that included a firing temperature study (Akkermans and Duistermaat 2001). They propose a range of 900–950° C as the operational temperature of this kiln by looking at ancient and modern examples of similar updraft kilns (Akkermans and Duistermaat 2001: 13–14). Since archaeometric analysis has not been conducted for this pottery kiln, this range cannot be more than a suggestion.

All of the pottery kilns excavated at Tell Sabi Abyad have a counterpart at Alalakh. The unity and similarity of pottery production features signify the expansion of these typologies around the Syrian region. The abundant use of these constructions around the Syrian provinces may have been the result of a dominant tradition practiced for a long time by the local potters. Both Alalakh and Sabi Abyad were under Mitannian[134] influence during the Late Bronze Age and reflected characteristics of Mitannian impact in their material culture. Thus, the typology of pottery production units could be added as another parameter of archaeological evidence showing the impact of the Mitannians on every element of material culture.

Another ancient settlement from Syria is Tell Mishrifeh/ancient Qatna, located roughly 200 km north of Damascus; it has occupational levels contemporary with Alalakh. Two excavation squares, Operation K and Operation J, yielded several pyrotechnological installations dated to the Late Bronze Age, as well as the Middle Bronze and Iron Ages. During the 1999–2002 seasons, seven pyrotechnological installations were found in Operation K. Out of seven, two of them were dated to the Late Bronze Age, while the rest chronologically related to the Iron Age. Although these Late Bronze Age installations were identified, they were not fully excavated. Since the entire structures were not unearthed, there is not enough information to understand the construction or operation properties, but circular single clay walls with air intakes were observed at first sight. Both of them were completely covered with white plaster, and the lowest level reached was entirely full of cooking

[134] When the Hurro-Mitannians moved into Syria in the early LBI, they pretty much took over the local material culture that went way back into the EBA. It would be necessary to compare kilns to before the Mitanni arrived to make this connection. However, this MA thesis only covers on the Late Bronze Age so that this comparative material was kept out of focus (thanks to Mara Horowitz for personal discussion on this subject).

potsherds (Intilia 2003). Although this information indicates that these Late Bronze Age pyrotechnic installations were most probably pottery kilns, hypotheses cannot go further than a suggestion without supportive quantitative analyses.

Operation J at Qatna provided a stratigraphic sequence spanning a time period from the Early Bronze Age III to the Iron Age (ca. 2800–535 BC). This extensive continuity yielded a pottery production area that was established in the Middle Bronze I (Operation J Phase 18, ca. 2000–1800 BC) and continued until the Late Bronze I (Operation J Phase 7, ca. 1600–1400 BC) level of the site. In the Late Bronze I sequence, two pottery kilns (3056 and 3291) were excavated. Kiln 3056 was a rectangular, mud-brick structure measuring 2.50 × 2.10 m; it was separated from the other structures with a small north–south directed wall. The kiln deposit was ashy and contained pottery slag (Morandi Bonacossi 2008: 112). It should be stressed that this rectangular kiln is unique among the Operation J installations. The other kiln, Kiln 3291, was a circular pit that Morandi Bonacossi describes as having a “bell-shaped” profile. In the kiln fill, pottery slag was found together with clay wall fragments (Morandi Bonacossi 2008: 112). A pit connected to both Kilns 3056 and 3291 indicates synchronic usage of the installations (Morandi Bonacossi 2008: 112).

Evidence of pottery production in Qatna was also found in earlier levels of Operation J. Operational sequences dated to the Middle Bronze I and Middle Bronze II periods yielded a large number of pottery kilns of various types, especially kilns with “bell-shaped” profiles. The typology and distribution of the Middle Bronze Age pyrotechnological installations of Qatna are out of the scope of this study. Nevertheless, it is important to not overlook them because they demonstrate a pattern of continuity in pottery production technology and the existence of permanent workshop areas within ancient settlements.

Additionally, archaeometric research conducted on potsherds from Areas J and K of Qatna provided information on petrographic and chemical characteristics, firing temperature estimations, and firing conditions applied during pottery production (Maritan et al. 2007: 207–15).[135] Firing temperatures obtained from XRD analyses show quite standardized limits for pottery production processes. Twenty percent of the Late Bronze Age shards were found to be fired below 750ºC, whereas almost 40% were fired at approximately 800ºC, and the rest around 850ºC. The same XRD method applied to the Middle Bronze Age shards gave firing temperatures of around 850ºC (Maritan et al. 2007: 214, fig. 5). Further, reduction indices representing the firing conditions inside pottery kilns showed divergences in reducing-oxidizing (redox) conditions in the Middle Bronze Age shards, whereas the Late Bronze Age shards show oxidizing conditions with a few exceptions (Maritan et al. 2007: 214, fig. 6). Maritan et al. linked deviations in firing temperatures and redox conditions to variations in kiln size (Maritan et al. 2007: 215) and typology without attributing the samples to a specific kiln.

Rectangular Kiln 3056 and circular in other words, "bell-shaped" profile Kiln 3291 of the Late Bronze Age sequences together with the Middle Bronze I and Middle Bronze II bell-shaped kilns have analogous structures in the Late Bronze Age craft quarter of Alalakh. Installations 1 and 2 are rectangular updraft kilns and Installations 6 and 8 are circular subterranean structures which are typologically equal to the Qatna examples. Furthermore, as explained in Section 5.1, the rectangular installations correspond to smaller versions of the Hittite large-scale pottery kilns. As for the bell-shaped typology at Qatna, I will argue that Middle Bronze I and Middle Bronze II examples were possibly predecessors of the Hittite rounded and Sarepta bilobate forms and may have been characteristically similar to the

[135]Maritan et al. 's study also covers several potsherd samples from Area H that were out of context as comparative in this thesis.

Minoan world, too. However, proving this hypothesis and proposing an alternate argument requires a more detailed publication of these Qatna pyrotechnological installations.

Sarepta (modern Sarafand) was another ancient settlement in the Levantine region yielding striking features indicative of an industry. Located on the Mediterranean coast of Lebanon between Sidon and Tyre, Sarepta yielded a workshop and kilns dating from the Late Bronze Age (mid-15th century BC) to the Persian Period (5th–4th centuries BC; Pritchard 1978; Anderson 1989). A context titled Area II-X was called the "Industrial Quarter" due to its significant assemblage of artifacts including tools for metallurgy and molds for casting, in addition to the tools of a pottery workshop (Anderson 1989; Khalifeh 1988). This workshop area, spanning almost 400 m^2, included twenty-two pottery kilns. Associated with these kilns, raw clay, unfired vessel fragments, kiln slag, and wasters were also unearthed. Besides Area II, X, in another area called Area II, Y, two more kiln were excavated (Anderson 1989).

In general, the Sarepta pottery kilns were double-decked structures with a rounded combustion chamber. This chamber was subterranean and separated into two lobes with a tongue-shaped wall. Anderson defines this style as the "bilobate form" (Anderson 1989: 204; here figs. 5.9 and 5.10). The lobes of the combustion chamber were lined with clay from the inside. The firing pit was a narrow opening in front of the combustion chamber. The upper chamber was covered with a dome-shaped roof, which was possibly temporary and reconstructed for each firing with clay and wasters (Anderson 1989: 201–03). Between the two decks, a clay plastered floor with a couple of ventilation holes was constructed to support the air accumulation in the upper chamber. The radiocarbon dates from the firing chamber of the earliest Sarepta kiln[136] dates to 1570–1380 BC. Its associated pottery covers Mycenaean Bronze Age and Cypriot ceramics, which suggest younger dates 1425–1375 BC.

[136]Kiln S of Sarepta (Anderson 1989: 203, fig. 7).

Although Anderson described the Sarepta kilns as unique and traditional in style for approximately a thousand years (Anderson 1989: 204), I think my thesis demonstrates close parallels to Sarepta typology from the Hittite, Minoan, and Mitannian cultural spheres. The associated Mycenaean Bronze Age pottery assemblages of Serapta kilns support this correlation by providing evidence from the final product. All Hittite, Minoan, and Syrian settlements more or less yielded the same type of pottery. At this point, I am not suggesting that each of them were making local imitations of the same style regarding traded originals, but crafts in these settlements somehow shared the technology behind its production. The units of production were defined alternatively as circular, bell shaped, or bilobate; this pottery kiln typology refers to a similar trend in pottery kiln construction. On the other hand, this argument does not confirm a wide-reaching usage of these kiln technology in each settlement. The Alalakh craft quarter did not include a similar example in its typological varieties of installations. Due to this fact, Alalakh seems not to have been included in this stylistic trend or somehow Alalakh's artisans did not prefer to adopt/use circular pyrotechnological structures.

On the northwestern Syrian plateau, in the Idlib region, another ancient settlement, Tell Afis, was located with successive Late Bronze Age levels contemporary to Alalakh. Phases VII, VI, and Vb of Tell Afis were assigned to the Late Bronze II. In Phase VI at Tell Afis, a very large industrial complex was excavated with several sunken installations (Kiln 7978 and Structure 9040) but without any clear function assigned to them (Venturi in press: figs. 3–4). Structure 9040[137] measured 4.00 × 2.30 × 2.30 m and is an almost oval mud-brick pit with plastered interior linings. Venturi suggests that it is a combustion chamber since they also found vitrified linings and burnt wood fragments in the fill (Venturi in press). This installation is typologically the same as Installations 6 and 8 at Alalakh. Compared

[137] This structure was defined as Structure 9002 in the article, but referred as Structure 9040 in the figures section. There may be a misprinting either in the text or in the figures.

typologically, Tell Afis Structure 9040 of Level VI and Alalakh Installations 6 and 8 of *Phase 1a* carry the same characteristics. Moreover, chronologically they were both representative of Late Bronze II.

Yorgan Tepe/Nuzi was an important settlement located almost 13 km southwest from the modern city of Kirkuk. This ancient settlement flourished during the 2nd millennium BC and its material culture was strongly associated with Mitannian high-status materials, such as glass and a white-on-dark decorated pottery described as “Nuzi Ware.” Excavations at the northwestern slope of Yorgan Tepe yielded two rectangular updraft kilns, which dated to the Late Bronze Age; however, these were not documented in detail (Starr 1939: 240, pl. 22B; 239, fig. 36). Even so, a recent article on Nuzi Ware has revealed important information on pottery production technology not only at Nuzi, but also at Alalakh.

Nuzi ware samples collected from Nuzi, Tell Billa, and Tell Rimah were analyzed with SEM-EDS[138] and ICP-AES[139] (Erb-Satullo et al. 2011). The pottery samples from Alalakh was part of this research especially with its characteristic Nuzi ceramics called “Atchana Ware.” Previously, the production location of Nuzi/Atchana Ware was discussed by several scholars and this type of pottery was thought to be either local production (Woolley 1955) or an import (Fink 2010: 102–10). Chemical and mineralogical examinations of the samples showed that Nuzi, Tell Billa, and Tell Rimah had similar chemical and mineralogical features whereas the Alalakh Nuzi/Atchana Ware was dramatically different. Nuzi/Atchana Ware was rich in ferromagnesian minerals and lacked minerals like epidote, which characterized Nuzi ceramics, indicating a local production of these wares at least in the vicinity of Alalakh (Orontes valley) and Nuzi (Tigris valley) (Erb-Satullo et al. 2011: 1182).

[138]Scanning Electron Microscope-Energy Dispersive Spectroscopy.
[139]Inductively Coupled Plasma-Atomic Emission Spectroscopy.

Furthermore, the Alalakh Nuzi/Atchana Ware results of Erb-Satullo *et al.* provide closely parallel results to this thesis. The XRF results of Installation 5 (Table 5) and Installations 2 or 5 (Table 6) show quite close chemical composition with the Nuzi/Atchana Ware and demonstrate a different mineral composition than the Nuzi-originating Nuzi Ware. Samples analyzed in the Erb-Satullo *et al*. study indicated a different source of raw materials. Atchana/Nuzi Wares had their idiosyncratic ratios for iron and aluminum designating a different geological zone used to obtain raw materials. Furthermore, in Chapter IV, I argued for glass production based on these results. A similar conclusion was made by Erb-Satullo et al., referring to the connection of the ceramic analyses and Late Bronze Age glasses (Erb-Satullo et al. 2011: 1190; Degryse et al. 2010).

There are two more sites that, while not providing detailed information on pottery kilns, cannot be excluded this study. One is Tell Zubeidi, a Levantine site dated to the late Kassite period. In this settlement, two rectangular rooms with several updraft kilns were excavated (Dämmer 1985: 28–31). This area was declared as a pottery workshop, but there is not a qualitative or quantitative study on these installations. The other one is the famous ancient settlement of Mari, located on the eastern side of Syria, close to the modern Iraqi border. This site also yielded a pottery workshop that consisted of two rooms. These rooms were rectangular in shape and both of them had a hearth in the middle. One of these rooms opened onto a courtyard area with a pottery kiln (Weygand 1997). Unfortunately, the typological and functional details of this kiln were also not published. Relying on published materials, it is not possible to establish any linkage of these kilns to the rest of the 2nd millennium settlements.

5.3. The Late Bronze Age Glass Production in Anatolia, the Levant, and Egypt

One aspect of pyrotechnology is the production of vitreous materials, such as glass, faience, Egyptian blue, and frit production. Pioneering typological (Barag 1962, 1970), analytical (Brill 1970, 1978, 1999 a-c), and textual (Oppenheim 1970) glass studies begun in the 1960s still form the basis of modern research. The production processes and relationship of technological basics of vitreous materials have been discussed by various scholars since the 1980s and several theories were under debate for 2nd millennium BC pyrotechnological processes, raw materials, and local/import patterns (Peltenburg 1987; Tite 1987; Rehren 1997; Mass et al. 2002; Shortland 2009). This section highlights the glass production technologies with respect to findings from Anatolia, the Levant, and particularly Egypt. As for the scientific results obtained in Chapter IV, it is now time for the material culture of Alalakh to foreshadow its vitrified material especially glass production further and shed light on research in other regions.

Explained simply, glass was produced by combining quartz pebbles with plant ash flux and adding metal based colorants and opacifiers like copper, cobalt, antimony, lead or manganese (Brill 1970; Moorey 1998; Shortland 2009). It was distinguished from other vitreous materials by its advanced production techniques. Among the vitreous materials, frit, Egyptian blue, and the copper-based pale blue frits are suggested as the result of the same technology, whereas the production of glass and faience are argued as the products of a further development in technological processes (Tite 1987).

The emergence of glass technology and the relationship of glass production to other specialized crafts are another aspect of the relationship of technology to socio-economic structure. Vandiver relates faience production to glass manufacture (Vandiver 1983). On the contrary, Peltenburg suggests faience production only as a background, but not a real trigger, for glass production due to the rapid emergence of glass technology around 1500 BC. For example, Nicholson and Henderson suggest that glass production was driven by foreign crafts since it is not possible that an internally developed craft begin in an advanced stage (Nicholson and Henderson 2000). There are also two hypotheses relating metal smiths and glassworkers. Lambert proposed glass as colored silicate slag collected and processed by metal smiths of second millennium BC (Lambert 1997). Peltenburg argued for a relationship between metal and glass workers since both of them were using similar skills while dealing with molten material; meanwhile, faience makers were dealing with cold-state materials (Peltenburg 1987). Bronze by-products and corrosion products used as colorant for blue-opaque glasses and potential use of silver refining litharge in yellow and green glasses supported Peltenburg's hypothesis (Mass et al. 2002). Since the firing temperature for Egyptian glass working is accepted as 900–1000° C (Vandiver 1991; Stern and Schlick-Nolte 1994), metal smith and glassworkers possibly shared related working conditions (Peltenburg 1987).

The appearance of glass production in textual records goes back to the Ur III period (end of the 3rd millennium BC); a material named *anzaḫḫu* is believed to be an intermediate of glass production (Oppenheim 1970: 19–20). Artifacts especially glass beads excavated in Ur (Woolley 1934, 1974), Nineveh level 4 (Beck 1933: 180-I, pl. LXXIX 25–26), Nuzi stratum IV (Starr 1939: 32, 515), Tell Judaidah phase G (Braidwood et al. 1960: 341, fig. 258), Tell Asmar (Gibson 1982), Nippur (Gibson 1990: 5), Eridu (Barag 1985: no. 179), and Akkadian levels of Tell Brak (Oates and Oates 1991: 138) provide evidence for a technical innovation that had already started in the 3rd millennium BC in Mesopotamia. In the first half of the 2nd millennium BC, glass was still not a common material though examples were found in Troy (Schliemann 1884: 478, 480), Boğazköy-Büyükkale (Boehmer 1972: 175, no. 1809), Alişar

(Osten 1937: 284–85, fig. 309), Tell Atchana/ancient Alalakh Level VII (Woolley 1955: 269),[140] and in Egypt (Lucas 1962; Peltenburg 1987).

Starting from the second half of the 2nd millennium BC, the number of glass objects increased and glass vessels began to dominate glass assemblages of the settlements. Tablets deciphered by A. L. Oppenheim and K. Riemschneider include Middle Babylonian (BM 120960),[141] Babylonian (VAT 16453), and Hittite (BM108561, KBo VIII 65, KBo XVIII 201, and KUB XLIII 74) textual records of glass production (Oppenheim 1970, 1973; Riemschneider 1974). Besides written sources, the first example of polychrome glass vessel sherds[142] was recorded in Tell Atchana Level VI (Woolley 1955: 300). Various artifacts representing this lively industry were also found in Nuzi stratum II (Starr 1939), Chagar Bazar (Mallowan 1947; Barag 1970: 146), Assur[143] (Barag 1970), Tell al Rimah[144] (Harden 1969; Barag 1970), Tell Brak (Oates et al. 1997), and Kassite levels[145] of Ur (Woolley 1965) and Nippur (Peters 1898). Yet, although there was a remarkable amount of glass assemblages found, no associated production areas were excavated or recognized as a glass production unit in Anatolia or the Levant.

On the other hand, 2nd millennium Egypt flourished as a key region providing not only objects, but also workshop areas associated with glass production. Egyptian sites like Malqata, Lisht, Amarna, and Qantir provide the earliest examples for glass production sites. Before referring to the details of the sites, it is worth noting the two different terminologies in the production of glass: "glassmaking" and "glass-working." "Glassmaking" is to produce

[140]Alalakh polychrome glass referred in Woolley (1955: 269) as a Level VII finding was not included in the glass subsection of his account. Instead, the earliest polychrome glass of Alalakh was attributed to Level VI (AT /47/60) in the glass section (Woolley 1955: 300).
[141] This text was dated to the second half of the second millennium, but it may have belonged one or two centuries later (Oppenheim 1970: 60).
[142] AT/39/225.
[143] Finds from ca. 13th century levels
[144] Finds from middle Assyrian levels date to ca. 1250 BC (Harden 1969: 29).
[145] Dated to ca. 1300 BC for Ur (Woolley 1965) and last quarter of the 14th century BC for Nippur (Barag 1970: 148).

glass from its raw materials. “Glass-working” is the conversion of glass into finished objects (Mass et al. 2002; Shortland 2009). Similar to the production of copper ingots, which provided an ease of transfer and were transformed to their final shape in a different place than their production, glass ingots must have been produced for the same reason.[146] Summarizing the difference between “glassmaking” and “glass-working,” the ancient Egyptian glass production sites were used for either one or the other, or sometimes for both purposes.

Malqata is located on the western side of the Nile close to Thebes. Dated to the reign of Amenhotep III (ca. 1391–1353 BC), Malqata provides the earliest data for glass technology. Although it is not clear whether it is either a “glassmaking” or a “glass-working” site, a wide assemblage of glass inlays, beads, rings, bowls, and vessels were found together with glassmaking debris including glass drops, hollow glass tubes, and glass rods (Mass et al. 2002: 69).

Lisht or El-Lisht is a site located in a technological complex dated to the 12th Dynasty of Amenemhet I and Senusert I (1295–1070 BC). Glass waste, slag, ceramic crucibles, beads, and vessel fragments together with one glass ingot were recovered from the site. This archaeological evidence is not enough to classify the area as either “glassmaking” or “glass-working,” but what Mass *et al.* argue is that Lisht glass is substandard compared with Malqata’s wares (Mass et al. 2002: 69). The reason for this argument is the lower concentration of colorants and muddy colors of Lisht glasses, which is proposed as a glass-recycling activity at the site (Keller 1983; Mass *et al.* 2002: 79).

At Amarna (1353–1337 BC), in the southern part of the ancient settlement, glass workshops were found. P. T. Nicholson excavated two thick-walled, highly vitrified kilns

[146] “Glass-working” and “glassmaking” theoretically can be worked at the same place, but Freestone disagrees with this by referring to the trade of 175 glass ingots found in the Uluburun shipwreck, which dates to the late 14th century (Freestone et al. 2002).

together with black slag, which was argued as an indication of glass production (Nicholson 1997, 2007) though it was challenged by other scholars for not necessarily signifying glass making (Shortland 2009). Associated with them, a pottery kiln was found as well (Nicholson 1997, 2007). This archaeological evidence supports the argument that glass and pottery production areas can be interconnected or closely related. Though no scientific research was done on these black slag containing vitrified kilns and pottery kilns of Amarna, further examinations hopefully will clarify the relation of pottery and glass production in this workshop.

Finally in Qantir-Pi-Ramesse (1250–1200 BC), on the eastern Nile delta, over 1,000 glass fragments with rich debris of glass materials were recovered (Rehren and Pusch 1997, 2005, 2007; Rehren et al. 2001). The forty crucibles analyzed by T. Rehren shows that this site was specialized for making only red-colored glass, which indicates that even coloring and working glass is processed in different workshops (Rehren 1997).

As outlined above, both Mesopotamia and Egypt were in an advanced stage in glass production technology in the Late Bronze Age. However, which culture initiated this industry is not clearly understood yet. Egyptian “glassmaking” and “glass-working” sites have not found a counterpart in Anatolia or the Levant. Despite that, analytical studies have established different raw materials and chemical compositions among the glass artifacts of Egypt and other sites (Brill 1999 a-c; Shortland and Eremin 2006; Degryse et al. 2010). These scientific results indicate the existence of local production areas around Anatolia and the Levant. Even though, production units or workshop areas have not yet been excavated either in Anatolia or the Levant, these scientific examinations disprove the hypothesis that glass originated only from Egypt.

Regarding the scientific results highlighted in Chapter IV, Alalakh *Phase 1a* craft quarter Installation 5 now contributes unique archaeological evidence to local vitrified material/glass production areas excavated outside Egypt. SEM, XRD, and XRF analysis applied on several samples prove a vitrified material/glass-related activity was practiced in this installation. The chemical composition of Alalakhian vitrified material slag samples as well as a glass vessel fragment among the Woolley depot finds (Level IV), are distinguished from finds at other sites by high iron and aluminum concentrations (Tables 5–7). These high levels of iron may have originated from Orontes sand,[147] which has the greatest potential of being a raw material for Alalakh crafts.

Comparable typological and compositional data to Alalakh's glass was obtained from Tell Brak and Nuzi. Tell Brak, located in the Upper Khabur region in northeastern Syria, has Late Bronze Age levels contemporary to Alalakh Level I. Area HH, Level 2 (early 13th century) was the latest occupation of the Mitannian palace and temple in Tell Brak. This level yielded over seventy-three pieces of glass beads together with fragments of core-molded polychrome glass vessels, glass ingots, and pieces of a cullet (Oates et al. 1997: 81). The abundance of glass in palatial, temple, and domestic contexts signify the existence of local glass production at the site and the presence of a cullet confirms that manufacture had already started around the 15th century at Tell Brak (Oates et al. 1997).

Tell Brak and Nuzi glass assemblages show Mitannian characteristics in their typology, but can be distinguished by microscopic examination. Even though Tell Brak glass samples share similar chemical compositions and trace element concentration with Nuzi (Shortland and Eremin 2006), strontium (Sr) and neodymium (Nd) isotopic analysis show clear differences between Tell Brak and Nuzi glass samples. Sr ratios depend on the plant ash used in glass production and reflect the geological origin of soil (Freestone et al. 2003).

[147] For the iron in the Orontes, see Yener 2010b: 189.

Neodymium originates from the variations in the non-quartz mineral content of silica, simply marking the silica source (Banner 2004). The Late Bronze Age Nuzi glass has high Sr and low Nd ratios whereas Tell Brak has intermediate Sr and high Nd ratios, designating different sources of raw material and most probably production areas as well (Degryse et al. 2010). However, neither the excavations in Tell Brak nor in Nuzi can assign or associate any installation or production unit to glass production.

In conclusion, Anatolia and the Levant on one side, and Egypt on the other, flourished as two production spheres of glass in the 2nd millennium BC. Alalakh, Nuzi, and Tell Brak were prominent settlements reflecting Mitannian characteristics in their glass assemblages and showed distinguishable chemical characteristics from Egypt. Without a doubt, there was a material and cultural interconnection between these regions, which probably also included technological knowledge. The Late Bronze Age installation of Tell Atchana/ancient Alalakh provides essential information to reconstruct linkages in 2nd millennium BC glass production. To establish a comprehensive picture of glass production, further archaeological and archaeometric studies in this field is obviously required.

CHAPTER VI

CONCLUSIONS

This MA thesis investigated eight pyrotechnological installations unearthed in Area 2 at Tell Atchana/ancient Alalakh. With the aid of a set of scientific methods composed of OM, SEM, XRD and XRF, three out of eight pyrotechnological installations were examined. A final data-set covering instrumental results and a secure archaeological context were used to find answers to the research questions briefly explained in Chapter I.

To answer the major research question of identifying the functional and typological characteristics of the installations, 15 samples were analyzed with SEM and 54 microstructural images (figs. 4.1-4.54) were taken to estimate the firing temperatures of the installations. Furthermore, five samples were analyzed with XRD (figs. 4.55-4.59) to decipher the crystalline structure of the samples which provide further evidence for the firing temperatures. Additionally another set composed of five samples were analyzed with XRF (Tables 5 and 6) to determine the chemical compositions of the materials. Besides these five XRF samples, two glass samples from the Woolley Depot were analyzed (Tables 7 and 8) to set as a standard comparative for the glass analysis conducted for this research.

Scientific analyses show that the *Phase 1b* Installations 1 and 2 were used as pottery kilns. Estimated firing temperatures showed that Installation 1 was processed around 900 °C whereas Installation 2 reached almost 1100 °C. The almost 200 °C difference in the process temperature is an indication of a divergence in the technological process. As I discussed in detail in Chapter IV, this variation in the firing temperatures should be considered deliberate and may have been connected to the type or quality of the goods produced in the kilns.

Phase 1a Installation 5 is confirmed as a multifunctional kiln. This installation contains all the features of a vitrified material most probably glass production unit, yet it is hard to verify that this installation was only used as 'glass working' or 'glass making' or what sort of vitrified material/glass objects were being produced, but at this stage it can confidently be proposed that vitrified material/glass production was among the activities that took place in the installation. These results provide brand-new evidence for the discussion on local production units that scholars have anticipated finding at sites like Alalakh for the LBA. With the discovery of this thus-far unique pyrotechnological installation, vitrified material/glass production can now be verified at a site other than the famous Egyptian centers discussed in Chapter V.

Besides functionality, determined through scientific investigations, the typology of the installations and comparative examples from Syria and the Levant were summarized in Chapter V. Similarities and differences in these comparative pyrotechnological installations provide insights for interpreting continuous traditions and intercultural relations in production technologies. Comparative studies showed that LBIIa Alalakh's pyrotechnological installations, and thus the production technology, were still under the influence of Mitannian culture even though political control of the capital shifted to the Hittite Empire some time during the LBIIa.

Syria and the Levant in the Late Bronze Age had a strong connection to Mitannian culture, which left its marks not only in Alalakh but also other 2nd millennium BC settlements like Tell Afis and Aleppo. The people of Alalakh adopted various cultural elements in their own way and harmonized them to create idiosyncratic methods of production. Craft productions in these local workshops, like the craft quarter in Area 2, were processing the local natural resources as effective as possible. The high iron contents discovered both in glass chemical compositions and locally produced Nuzi/Atchana Wares (Erb-Satullo et al.

2011) most probably result from using local Orontes sand, which contains almost 25% iron in the form of magnetite (Yener 2010b), in glass and pottery production. The Orontes River, which likely ran around the mound in the Middle and Late Bronze Ages, offered a good reserve of sand and water and was most probably a frequent resource used by the Alalakh craftspeople. Here I also want to propose that Alalakh artisans were almost certainly using their own recipes for pottery and glass production since dealing with sources containing high amounts of iron requires higher processing temperatures. This subject is also discussed at the end of the next section 6.1.5.

While the purpose of instrumental analysis was to determine the technology of, and the types of products being made in the installations of Area 2 a complimentary research question was examining the socio-economic structure of Alalakh through the organization and management of these pyrotechnological installations and the workshops that contained them. Even though the production of pottery or glass had an economic value, these economic considerations were directly linked to the social systems of society. The production of the materials will provide clues to understanding the administrative control of the palace over production (if any) and the level of specialization and intensification of production.

6.1. Archaeological Theory and the Interpretation of the Craft Quarter

This section evaluates the socio-economic systems of this LBIIa craft quarter and its internal dynamics throughout its lifespan with reference to the theory of anthropological archaeology. In Chapter I, a brief overview of the anthropology inspired from technology and craft specialization was given. In summary, the following variables were identified as significant to the mode of production: *location, concentration, scale, and intensity* (Costin 1991). In examining these variables in the Area 2 workshops, the greater socio-economic and political organization of the city may be revealed.

6.1.1. Location

The location of production helps to identify *context* of production (Costin 1991). In attached production, patrons of the production generally locate the activity area of the specialists around their elite architecture. These allocations provide elites to oversee the committed activities and check the access of the workshops more easily. This structure, not only give patrons a broad control of the craft quarter but also provide an atmosphere to manifest their power and wealth physically. Existence of such supervision sometimes declares itself by administrative artifacts like seals and documents that are indications of a controlling power. Despite that, independent producers commonly locate their workshops in the vicinity of domestic areas. In the absence of political control, access to independent production areas is neither restricted nor controlled, unlike the attached production areas. These domestic and simple constructions make identification of independent production areas more difficult for the archeologist due to the generally low quality and quantity of remains (Costin 1991:25-27).

The location of the Alalakh craft production spaces in Area 2is important for interpreting the *context* of production. The production area is located at the northeastern side of the mound close to the Late Bronze Age city walls, about 150 m away from the Level IV palace of Alalakh as far as it can currently be determined. Between the IV palace and the Area 2 excavations are a number of elite structures defined by Woolley as ‘Private Houses’ (Woolley 1955). Woolley proposes that these ‘Private Houses’ were used by elites and high status citizens of Alalakh. Based on Costin’s argument, a location for production contexts close to the palace and elite residences is a sign of attached production. If the Alalakh palatial administration and elites chose a nearby area for keeping production easily under control, the craft spaces in Area 2 should be considered the domain of ‘attached specialists’. The textual records referring to four social statuses of the Alalakh society and their relation to the specific crafts (von Dassow 2008) do reveal that there was a class of craft specialists and these might have been the workers who used the Area 2 facilities. This assumes an administrative control over the craft production in Area 2 during the time of its existence. While no texts, seals or bulla that might designate administrative control were recovered in the craft area itself, this may simply be because such things were not used in the vicinity of the kilns but rather in the areas where for example finished products might have been brought and stored.

6.1.2. Concentration

Concentration describes the distribution patterns of the producers in a specific regional setting. The distribution model also affects the association between specialists and their customers. Specialists are influenced by the characteristics and requirements of their social, cultural, and natural surroundings. This distinctiveness links *concentration* to the *context* of production since the landscape will be shaped according to the degree of control over production (Costin 1991:13). The organization of production, whether attached or independent, manipulates the distribution of craft specialists and location of activity areas. For example, because independent producers want to make use of resources more efficiently, they may locate their activity areas close to necessary resources (water, fuel, raw materials) that are generally scattered around the landscape (Arnold 1985, Rice 1981, Costin 1991:13, 14) or alternatively may be positioned to cater for specific neighborhoods. On the other hand, attached production areas are generally concentrated to some degree depending on the patrons' power and control over raw materials and distribution of finished goods (Smith 1975, Sinopoli 1988, Costin 1991:14, 15).

To identify *concentration* in archaeological context requires a broad study around the site and its environs. Production debris plays a critical role for determining concentration. If production remains are found in many points around the region, it suggests a dispersed distribution of craft specialists. A limited number of locations with production debris suggest a nucleated center of production (Costin 1991:27-29).

In Alalakh Area 2, the activity areas including eight pyrotechnological installations and open courts serving most probably for drying, cooling, storing and finishing of products, were accumulated in this one region of the site. The excavation of this area is currently limited to four 10 x 10 m trenches which represent only 400 m^2. Further excavations planned in this spot of the mound will probably extend the area of the craft quarter and reveal the linkage of the open-court areas. Currently the craft quarter yields 400 m^2 of activity areas in two phases of occupation with more than one installation in each phase and with an almost centralized arrangement in the area (figs. 3.2 and 3.8). Referring to the distribution of the specialists in the regional setting, the *concentration* of Alalakh's craft quarter also designates attached production.

6.1.3. Scale

Scale refers to size and content of the activity areas. Size can change from small spaces in household production to large workshops, which also affects the amount and quality of work. For independent production, efficiency of production shapes the *scale* of production (Costin 1991:16). In contrast, for attached production, size and composition of work spaces are determined according to the requests of the patrons (Costin 1991:15). For example, attached production generally happens in larger workshops instead of small and family based production units, because control of a large unit in one area is easier and more efficient than the control of small ateliers in distributed locations (Goody 1982, Costin 1991:16).

Determining the parameter *scale* is related to the *context* of the archaeological site. The production capacity of the production unit depends on its size. Small scale, family based production generally happens near domestic complexes whereas industrialized workshops sponsored by elites are attached around nonpublic structures (Costin 1991:29). Using the information of *context* and *concentration*, Alalakh craft quarter can be defined as a large workshop. Instead of locating around domestic complexes, this area locates in a large sized area which is another indication of large *scale* attached production. Furthermore, the craft quarter was recovered in two local phases (*Phase 1b* and *1a*) without a discontinuity in the stratigraphy. Archaeological evidence provided evidence for abandonment of some *Phase 1b* pyrotechnological installations rather than a destruction though the activity area itself was not abandoned. It continued to be used for production but most probably with a new organization. The excavated areas put forward a variation in type and size of the installations and the scientific results proposed the production of glass which was not found in evidence in the earlier phase of the craft quarter. These new arrangements might also indicate a further step in the advancement of the *size* of the craft quarter.

6.1.4. Intensity

The last parameter for determining the organization of production, *intensity,* describes the amount of time that craft specialists must have spent at work. A specialist can be a full-time or part-time worker (Costin 1991: 16-18). In this respect, *intensity* is directly related to the efficiency of the production. It is obvious that full-time work is more efficient than part-time activity (Costin 1991: 16-18). In addition, an efficient full-time activity brings the accustomed and standardized production that forms the bedrock of mass production. On the other hand, the efficiency of the activity and the quality of the goods are also related to the training, skill, and technological knowledge of the specialists. Concerning that, since artifacts generated by attached specialists require significant skills and knowledge, it is more logical for patrons to employ full-time professionals instead of more part-time workers (Costin 1991: 16-18).

Identification of time in archaeological contexts is not easy (Costin 1991:16-18, 30). Scholars have different methods to shed light on the parameter of *intensity*. Torrence proposes to consider the amount of production debris and to calculate time required for this accumulation (Torrence, 1986). Although debris accumulation gives an idea about consumed time by the workers, the number of workers is disregarded in this study. For example, debris accumulated at the end of a three-hour work of an employee will be equal to one-hour work of three employees in one hour.[148] According to Costin, *intensity* is also correlated to the type of production. Intensity affected whether the production is household or individual. Independent or attached production styles are also decisive for the determinability of time (Costin 1991:30, 31). However, none of these is enough to conclude an accurate result for *intensity*. In the case of Alalakh, defining how much time the craftspeople spent in the workshop or answering the question of their being of part-time or full-time workers is partially possible. Concerning the fact that this craft space was an attached production area with high *concentration* and *scale*, it will be logical to think that the artisans should be full-time instead of part-time. Unfortunately, neither archaeological findings nor textual records provide evidence clearly identifying *intensity*.

6.1.5. General Remarks

The Area 2 of Alalakh described with the terminologically loaded term ‘craft quarter’ provided evidence for using this term and as hypothesized in Chapter I was an ‘attached production’ unit. Besides its proximity to the elite quarter, the location of the craft quarter in the landscape of the mound has advantages to process pyrotechnology related activities. The position of the complex near city walls may enable separation of production from the city itself. Due to the geography of the Amuq Valley and the Amanus Mountains, an atmospheric

[148]Working capacity (amount of work done and quantity of debris accumulated) of the employees is assumed as identical.

temperature gradient is produced that causes a strong daytime wind blowing from west to east (the local border crossing is known as Bab al-Hawa, 'gate of the winds'). Given that the workshops are located along the eastern edge of the city, this directional wind (likely not different in the Late Bronze Age) would have helped to carry smoke and toxic gases away from the city rather than into the settlement itself. This windy situation is not only helpful for disposal of fire-smoke, but also helps obtain higher temperatures in the pyrotechnological installations. Air-circulation created by the west-east wind would have worked as a catalyst and helped craftsperson to reach higher firing temperatures with ease (rather than rely on bellows or tubes). This strong wind would have also helped the craftsperson to reach higher temperatures with less labor therefore would have caused a decrease in fuel consumption which is the most desired cost of craftsperson. Rice argues that kilns (as opposed to pits or open hearths) were needed to obtain higher temperatures with more control over production and more economical use of fuel (Rice 1987:153).

All the scientific investigations done on the pyrotechnological installations of the LBA Alalakh provide a depth for the anthropological theories of technology and craft specialization. The analytical results showed that the craft quarter in Area 2 was used for both ceramic and vitrified material/glass production at the same time at one point during its existence. This multipurpose usage brought another aspect to the anthropological theories in terms of specialization. The production of both ceramics and vitrified materials/glass would suggest that in *Phase 1a* there is indeed specialized pottery production but there was also vitrified materials/glass production. This may also suggest that besides specialized pottery production, artisans were also experimenting with other luxury goods. This hypothesis led me further suggest that the attached production area was specialized but there was also experimentation and perfection of new techniques of production. However, this hypothesis needs further investigations of the possible production areas both in Alalakh and the neighboring regions. Therefore it will be a part of future research.

6.2. Concluding Remarks

This interdisciplinary MA thesis investigated a LBIIa craft space from Tell Atchana with scientific methods, contextual analysis, and interpretation based on archaeological theory. Linking the knowledge of chemistry, material science and geology into the field of archaeology opens a new door to understanding socio-economic systems in a Late Bronze Age capital. Using Tell Atchana/ancient Alalakh as a case, various aspects of pyrotechnology, production, crafts, craft specialization and their relations within the social, political, cultural and environmental dynamics of a capital city were investigated. Of course, more answers bring more questions to light. With new rounds of well-structured excavations not only at Alalakh but also around the region, together with collaborative work among different social and scientific disciplines, our knowledge of ancient societies will continue to improve.

APPENDIX A

TABLES

Registration number	Definition in the Original Label	S.Q	LOCUS	LOT	Relation to Installation
R04-421		44.80	04-2039	132	fill inside instl. 5
R04-560	ceramic slag	44.80	04-2039	209	fill inside instl. 5
R04-452	ceramic slag	44.80	04-2039	147	fill inside instl. 5
R04-428	ceramic slag	44.80	04-2032	138	fill floor related to instl.5
R04-607	slag	44.80	04-2048	?	Instl. 2.
R04-698		44.80	04-2038	?	Instl. 2 or 5
R04-378		44.80	04-2032	108	fill floor related to instl.5
R04-538	slag	44.80	04-2051	199	related to instl. 5 and 2
R04-472		44.80	04-2038	168	related to instl. 5 and 2
R04-534	ceramic slag	44.80	04-2013	196	related to instl.6 or 2
R04-581	sample of plaster and mudbrick	44.80	04-2048	228	Installation 2
11474		44.69	03-2044		Installation 1
R04-328		44.80	04-2002	78	Installation 2
R04-349		44.80	04-2032	94	Installation 5
11475	Vitrified mud-brick	44.80	04-2071		fill inside combustion chamber of instl. 2

Table 1: List of Analytic Samples

Sample	Installation number	Vitrification Level	Firing Temperature
AT 11474-Bulk#1	Installation 1	NV	<750
AT 11474-Bulk#2	Installation 1	V	850-1080
AT 11474-Bulk#3	Installation 1	TV	> 1080
AT 11474-Bulk#4	Installation 1	V	850-1080
AT 11474-Bulk#5	Installation 1	IV/NV	750-800
AT 11474-Bulk#6	Installation 1	TV	> 1080
AT 11475-Bulk#1	Installation 2	TV	≥1150
AT 11475-Bulk#2	Installation 2	TV	≥1150
AT 11475-Bulk#3	Installation 2	TV	≥1150
R04-581	Installation 2 plaster sample	IV	750-800
R04-607	Installation 2 plaster sample	IV	750-800
R04-560	Installation 5	TV	1150-1200
R04-452	Installation 5	TV	1100
R04-428	Installation 5	TV	1100
R04-538	Installation 2 or 5	TV	1100

Table 2: Vitrification Levels and Proposed Firing Temperatures for Installations 1 and 2

NV	no vitrification
V	extensive vitrification
TV	total vitrification
IV	incomplete vitrification

Sample	Definition of Sample
AT 11474-Bulk#1	Combustion chamber fragment, red in color
AT 11474-Bulk#2	Combustion chamber fragment, black in color
AT 11474-Bulk#3	Combustion chamber fragment, red in color
AT 11474-Bulk#4	Plaster fragment of the floor between combustion chamber and firing chamber
AT 11474-Bulk#5	Combustion chamber fragment, grey in color
AT 11474-Bulk#6	Combustion chamber fragment, green and grey in color

Table 3: SEM samples of Installation 1

Sample	Definition of Sample
AT 11475-Bulk#1	Combustion chamber fragment, green-light green in color
AT 11475-Bulk#2	Combustion chamber fragment, green in color
AT 11475-Bulk#3	Combustion chamber fragment, green in color
R04-581	Plaster and mudbrick fragment
R04-607	Plaster of floor fragment

Table 4: SEM samples of Installation 2

	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	NiO	SrO	SO_3	ZnO	Pd	ZrO_2	Cl	CuO	Ru	TOTAL
R04-349	51.10	19.62	12.96	7.14	4.52	2.54	1.59	0.81	0.38	0.15	0.08	0.05	0.04	0.04	0.02	0.01	0.01	nd	nd	nd	101.06
R04-378	50.63	22.02	10.86	6.80	4.63	2.36	0.81	0.76	0.62	0.15	0.07	0.04	0.04	0.12	0.01	nd	0.01	0.12	0.09	0.01	100.06
R04-421	44.66	15.00	11.30	6.54	3.75	1.72	0.62	0.72	0.44	0.14	0.05	0.04	0.03	0.06	0.01	nd	0.01	0.03	0.01	nd	85.13

Table 5: XRF results of Installation 5

	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	NiO	SrO	SO_3	ZnO	Pd	ZrO_2	Cl	CuO	BaO	Ru	TOTAL
R04-698	29,40	21,10	5,92	6,67	2,86	0,53	1,10	0,66	0,45	0,17	0,07	0,04	0,11	0,24	0,02	nd	0,01	0,07	nd	nd	nd	69.38
R04-472	52,44	22,27	10,26	6,90	4,41	0,58	2,33	0,76	0,98	0,15	0,09	0,06	0,09	0,26	0,01	nd	0,01	0,04	0,01	0,07	nd	101.72

Table 6: XRF results of Installation 2 or 5

*nd stands for Not Determined.

Formula	Concentration	Formula	Concentration
SiO_2	71,2	Si	33
Al_2O_3	6,02	Al	3,27
PbO	2,72	Pb	2,04
CaO	2,6	Ca	1,7
Fe_2O_3	2,32	Fe	1,4
MgO	1,64	Mg	1,04
K_2O	1,02	K	0,788
P_2O_5	0,66	P	0,28
SO_3	0,42	Sb	0,222
BaO	0,3	Ba	0,22
Sb_2O_3	0,301	Cu	0,202
CuO	0,296	Na	0,18
TiO_2	0,25	Cl	0,18
Na_2O	0,22	S	0,16
Cl	0,19	Ti	0,14
SrO	0,0962	Sr	0,0697
Cr_2O_3	0,058	Os	0,037
Os	0,033	Cr	0,035
ZrO_2	0,0049	As	0,0294
		Zr	0,0044
		Ir	0,0036
		O(matrix)	55
TOTAL	90,3491	TOTAL	100,0011

Table 7: Oxide and Elemental Composition of glass goblet fragment obtained by XRF

Formula	Concentration	Formula	Concentration
SiO_2	70,8	**Si**	33,1
CaO	5,97	**Ca**	3,83
MgO	2,64	**Mg**	1,74
CuO	1,41	**Cu**	0,941
Na_2O	0,86	**Na**	0,73
K_2O	0,86	**Cl**	0,718
Cl	0,775	**K**	0,66
Al_2O_3	0,77	**Al**	0,43
P_2O_5	0,5	**Fe**	0,265
Fe_2O_3	0,456	**P**	0,21
SO_3	0,44	**S**	0,17
SrO	0,028	**Sr**	0,0206
ZnO	0,01	**Zn**	0,007
Rb_2O	0,003	**Rb**	0,003
ZrO_2	0,001	**Zr**	0,001
		O(matrix)	57,1
TOTAL	85,523	**TOTAL**	99,9256

Table 8: Oxide and Elemental Composition of opaque dark-blue glass obtained by XRF

Analyzed Point / Element %	O	Si	Ca	Fe	Cu
Point #1(top left)	60.36	37.99	nd.	1.48	0.17
Point #2 (inside)	52.22	22.08	18.57	7.13	nd.
Point #3	56.19	0.14	43.56	0.11	nd.
Point #4 (red crecent inside)	74.56	8.61	14.18	1.74	0.91
Point #5 (above cracky part)	59.37	28.93	6.43	5.26	nd.
Point #6	0.98	0.51	92.55	5.95	nd.

Table 9: SEM results of the glass slag A03-1313 (Hissett 2004 *unpub*.).

Analyzed Point/Element%	O	Mg	Al	Si	Ca	Fe	Mn	Sr
Bulk #1	46.0	2.81	4.00	24.43	10.25	8.83	0.23	0.04
	Ti	**P**	**K**	**Ni**	**Zr**			
	0.64	0.41	2.27	0.10	0.02			

Table 10: XRF results of R04-503

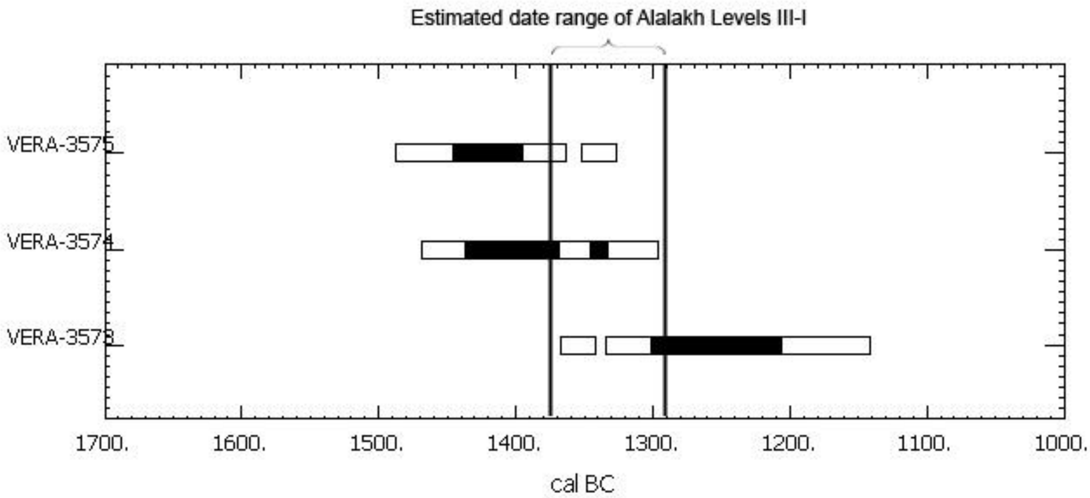
Analyzed Point/Element%	O	Al	Si	Cl	Fe	Cu	As	Sn
Surrounding residue of Prill Bulk	41.69	4.22	19.9	0.24	2.73	21.49	2.87	6.87
Linear reading Point #1	37.28	nd.	0.11	0.03	nd.	62.64	nd.	0.08
Linear reading Point #2	53.96	6.96	29.89	0	0.92	6.9	0.39	0.97
Linear reading Point #3	28.52	0.01	2.75	0.12	0.33	47.46	1.85	18.96
Linear reading Point #4	35.32	0.13	11.38	nd.	0.42	23.38	0.61	28.85
Linear reading Point #5	35.25	7.59	24.41	0.09	3.41	18.9	2.73	7.62
Linear reading Point #6	34.11	7.39	17.94	0.07	2.92	28.85	2.25	6.48
Linear reading Point #7	35.84	0.06	0.29	0.05	0.05	62.84	0.39	0.47
Linear reading Point #8	37.86	6.18	25.32	0.05	5.09	7.28	6.99	11.22
Linear reading Point #9	38.58	8.27	24.24	0.05	6.28	0.73	7.56	14.29

Table 11: SEM results of the interior slag of the crucible A03-R1937(Unverferth 2004, *unpub*.).

Analyzed Point/Element%	O	Mg	Al	Si	Ca	Fe	Cu	Sn
Bulk #1	49.33	2.00	4.71	20.03	7.4	3.62	12.55	0.37
Bulk #2	53.81	2.13	5.49	21.55	10.44	4.85	1.74	nd.
Bulk #3	56.61	1.86	4.96	20.92	11.41	4.25	nd.	nd.

Table 12: SEM results of the crucible bulk A03-R1937 (Unverferth 2004, *unpub*.).

Reg Number	GRID/SQ	PHASE	LOCUS	Type	CONTEXT	Lab Number	^{14}C Age
R04-527	44.79	Local Phase 1	L04-2041	Charcoal	Street/ditch	VERA-3573	3002+-27BP
R04-594	44.80	Local Phase 2	L04-2055	Charcoal	Occupation debris	VERA-3574	3117+-38BP
R04-658	44.80	Local Phase 2	L04-2055	Charcoal	Occupation debris	VERA-3575	3140+-31BP



CALIB; 50 year moving average; black =1σ, white =2σ

Table 13: Re-calibration of theRadiocarbon Samples and their Contexts

APPENDIX B

FIGURES

Figure 2. 1: The Middle and Late Bronze Age Sites in the Amuq Valley and the Levant (courtesy of Murat Akar 2009).

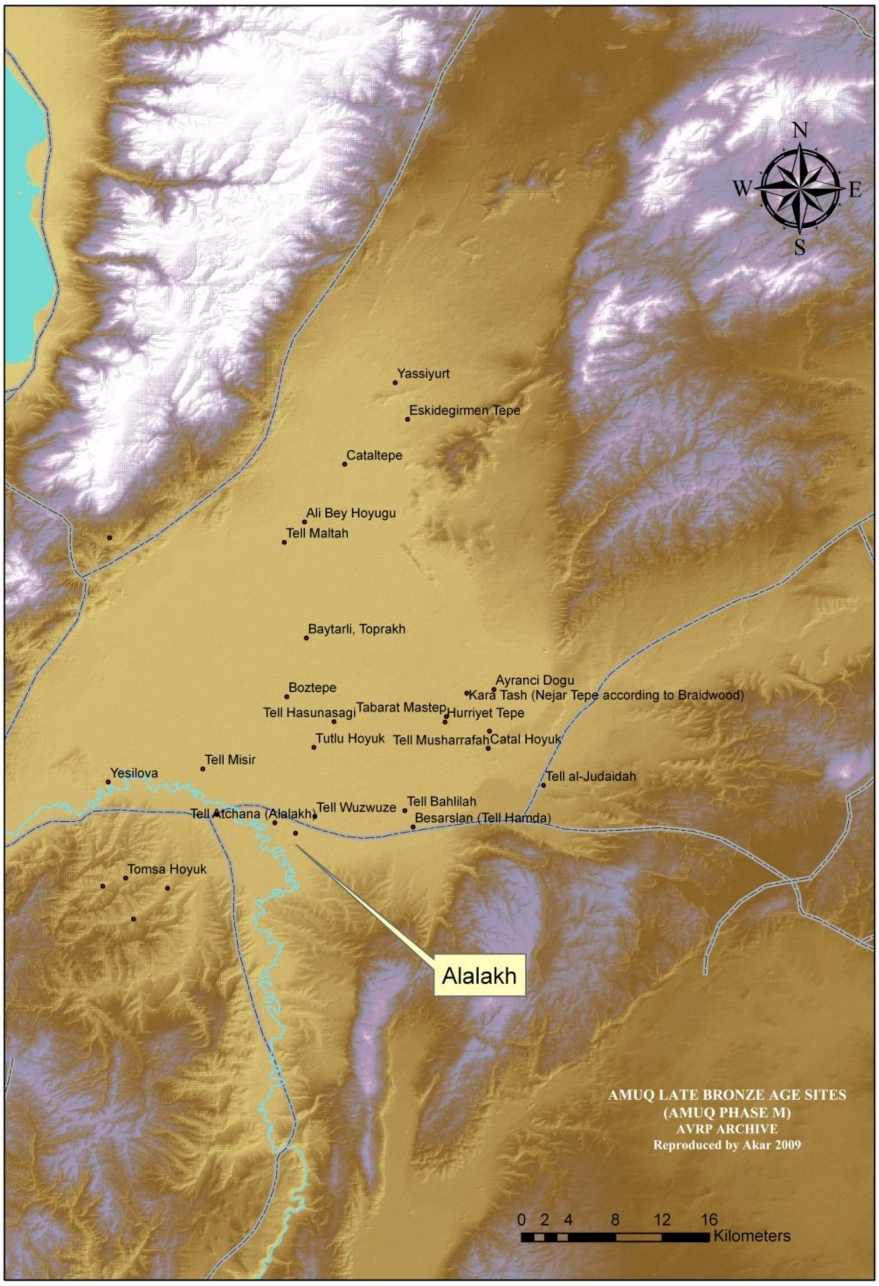


Figure 2. 2: The Late Bronze Age Sites in the Amuq Valley and location of Tell Atchana/Ancient Alalakh (courtesy of Murat Akar 2009).

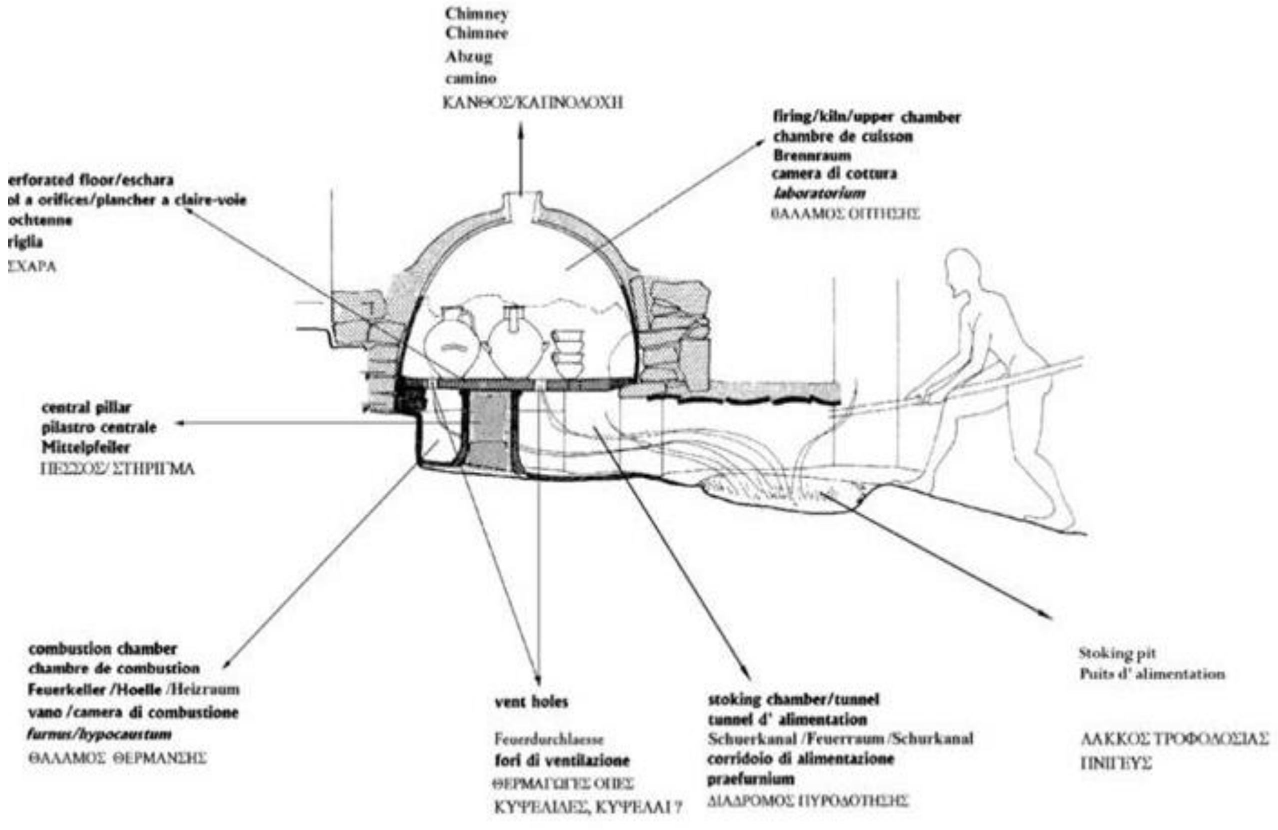
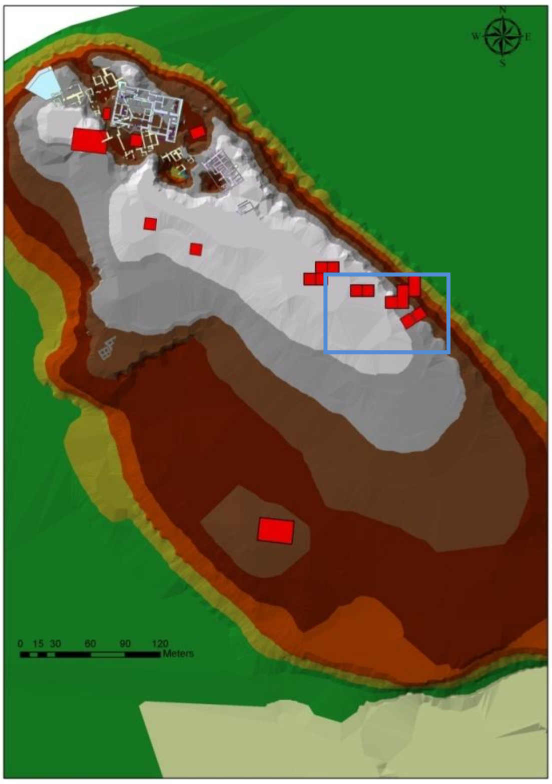


Figure 3. 1: Compartments of a pottery kiln (Hasaki 2002).



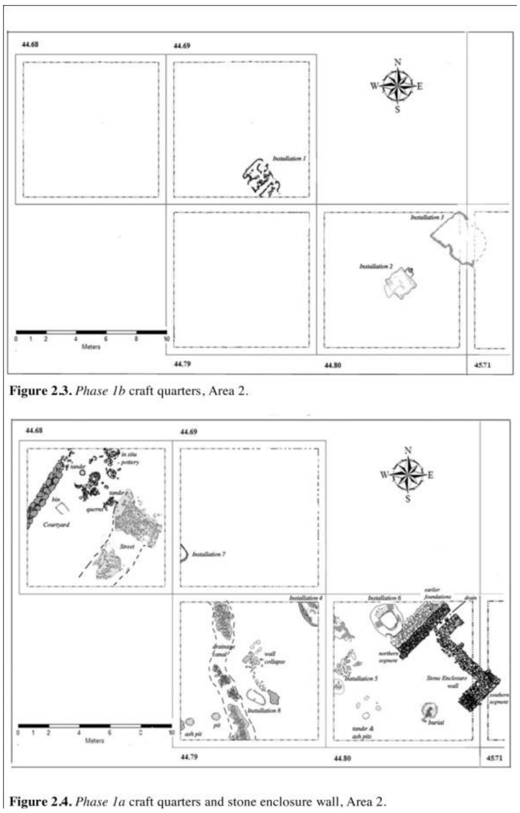


Figure 3. 2: Architectural plan of the craft quarter district in Phase 1b and Phase 1a (Yener and Yazıcıoğlu 2010:36).

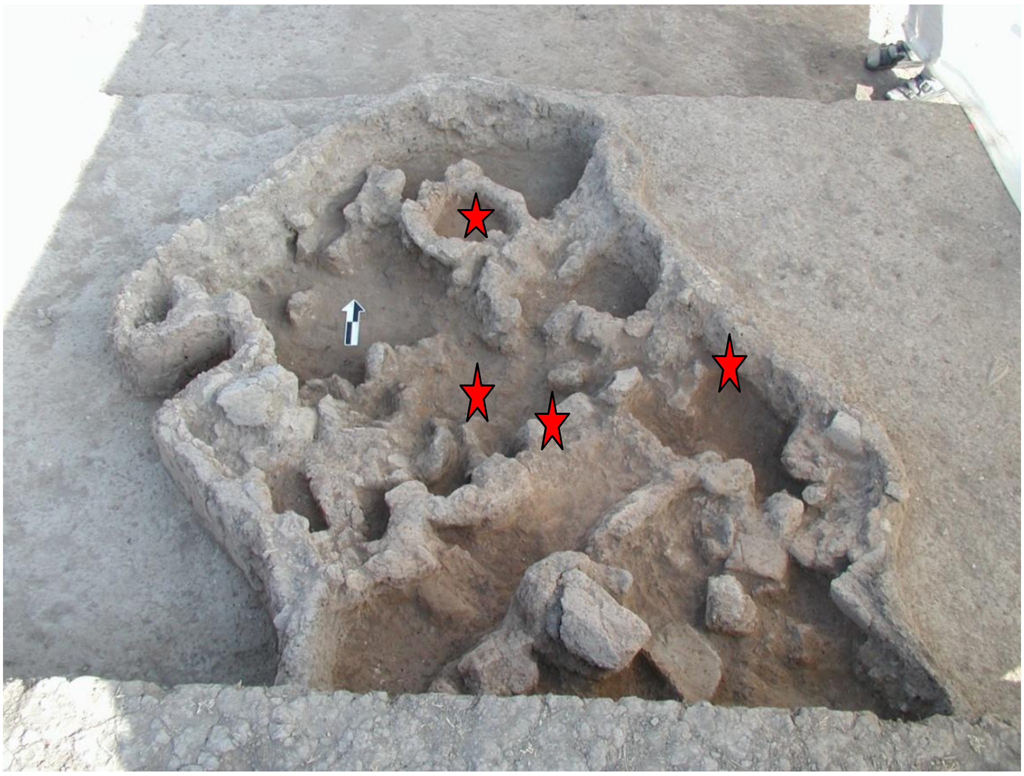


Figure 3. 3: Installation 1 (Atchana Archives).Stars show the sample locations.

Figure 3. 4: Installation 2 upper deck floor (Atchana Archives).

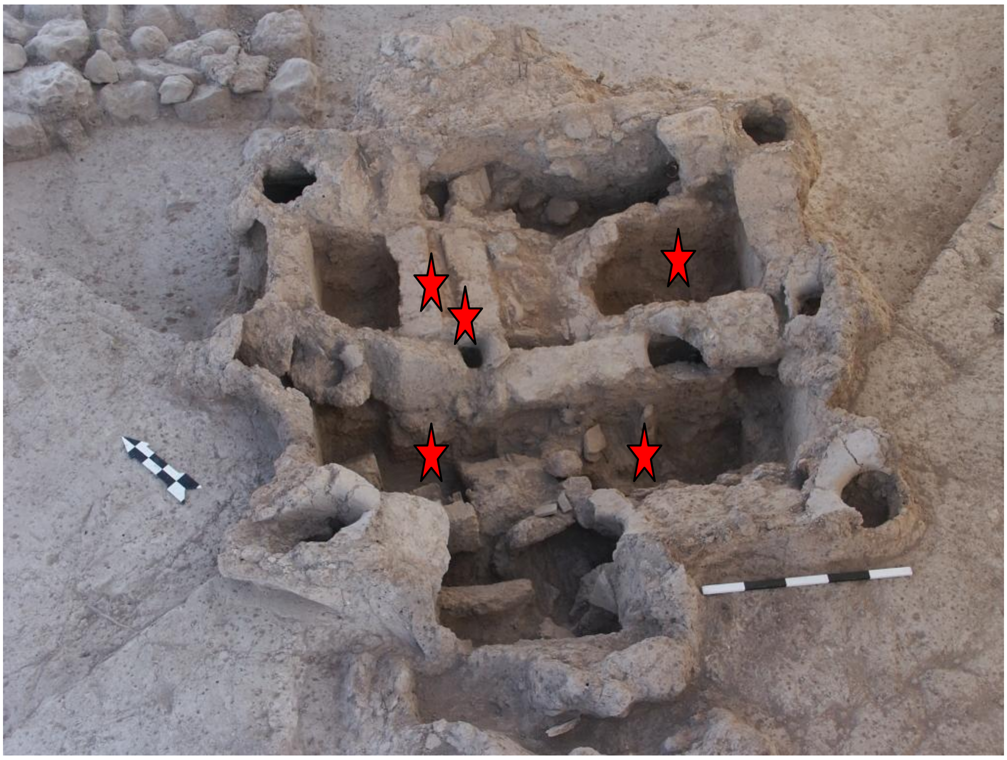


Figure 3. 5: Installation 2 lower deck (Yener and Yazıcıoğlu 2010:41). Stars show the sample locations.

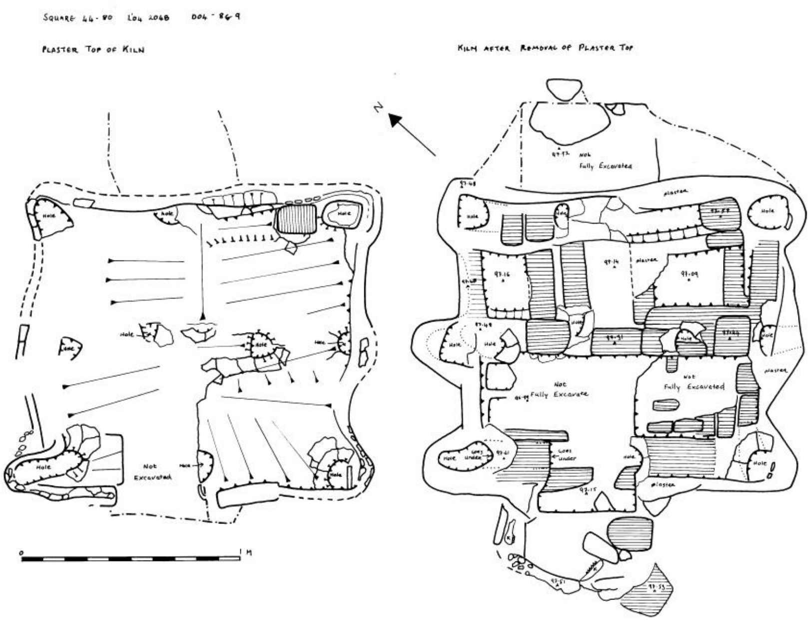


Figure 3. 6: Architectural plan of the Installation 2. Upper chamber on the left, lower chamber on the right (Yener and Yazıcıoğlu 2010:40, fig. 2.11).

Figure 3. 7: Installation 3 (Atchana Archives).

Figure 3. 8: An Overview of *Phase 1a* craft quarter (Atchana Archives).

Figure 3. 9: Installation 4 (Yener and Yazıcıoğlu 2010:41, fig.2.12.4).

Figure 3. 10: Installation 5 at the bottom of the photograph. The upper structure is Installation 4 (Atchana Archives).

Figure 3. 11: Installation 5 (Atchana Archives).Stars show the sample locations.

Figure 3. 12: Installation 6 (Atchana Archives).

Figure 3. 13: Installation 6 interior view (Atchana Archives).

Figure 3. 14: Installation 8 (Yener and Yazıcıoğlu 2010:41, fig.2.12.4).

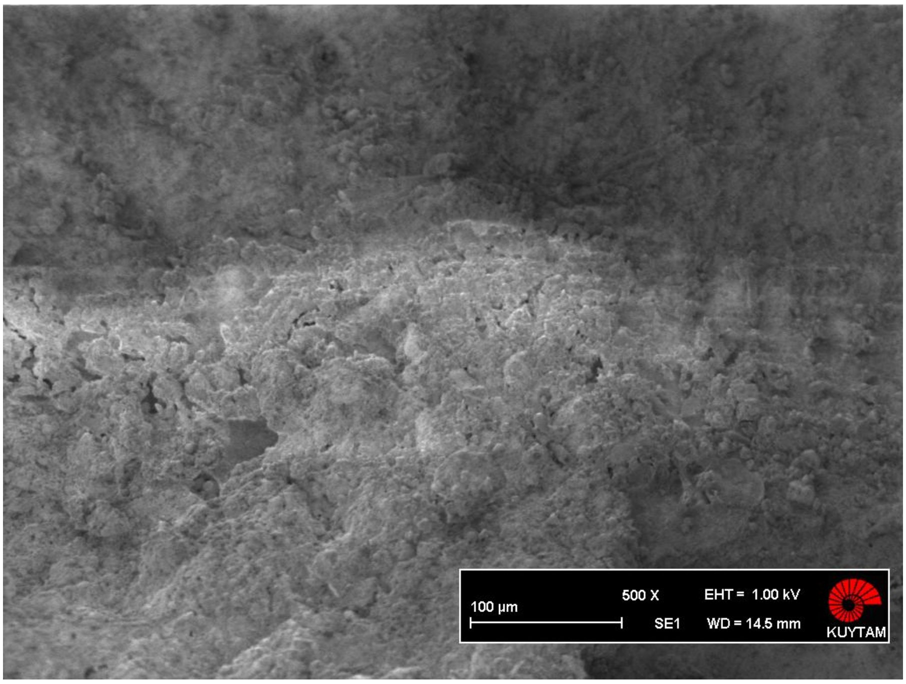


Figure 4. 1: Installation 1 SEM of AT 11474- Bulk #1, red colored combustion chamber fragment, NV, firing temperature <750°C.

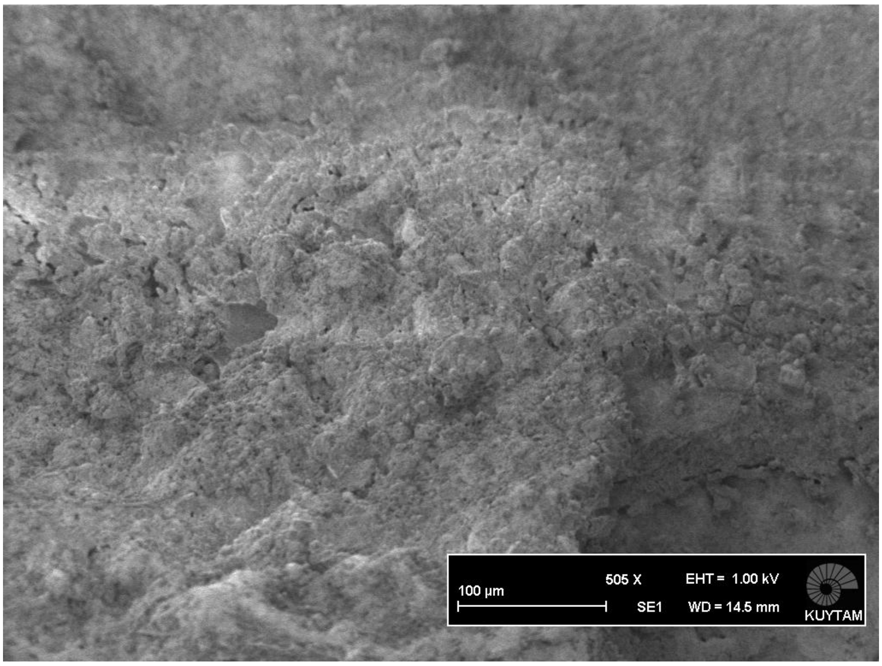


Figure 4. 2: Installation 1 SEM of AT 11474- Bulk #1, red colored combustion chamber fragment, NV, firing temperature <750°C.

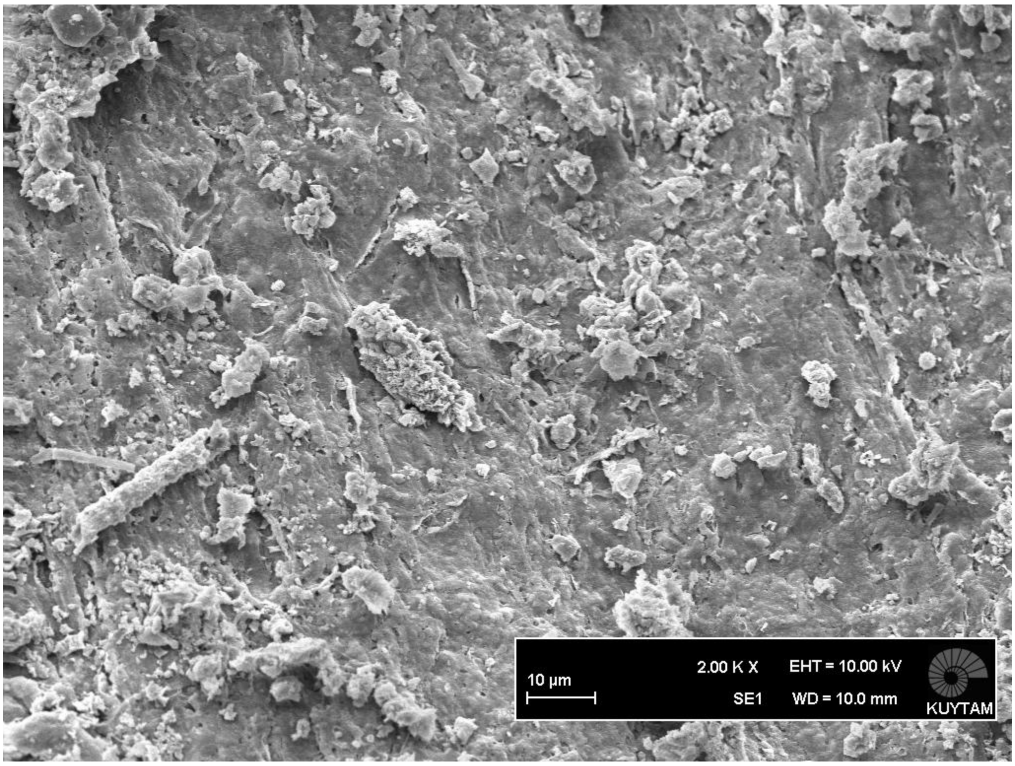


Figure 4. 3: Installation 1 SEM of AT 11474- Bulk #2, black colored combustion chamber fragment, V, firing temperature 850-1050 or 1050-1080°C.

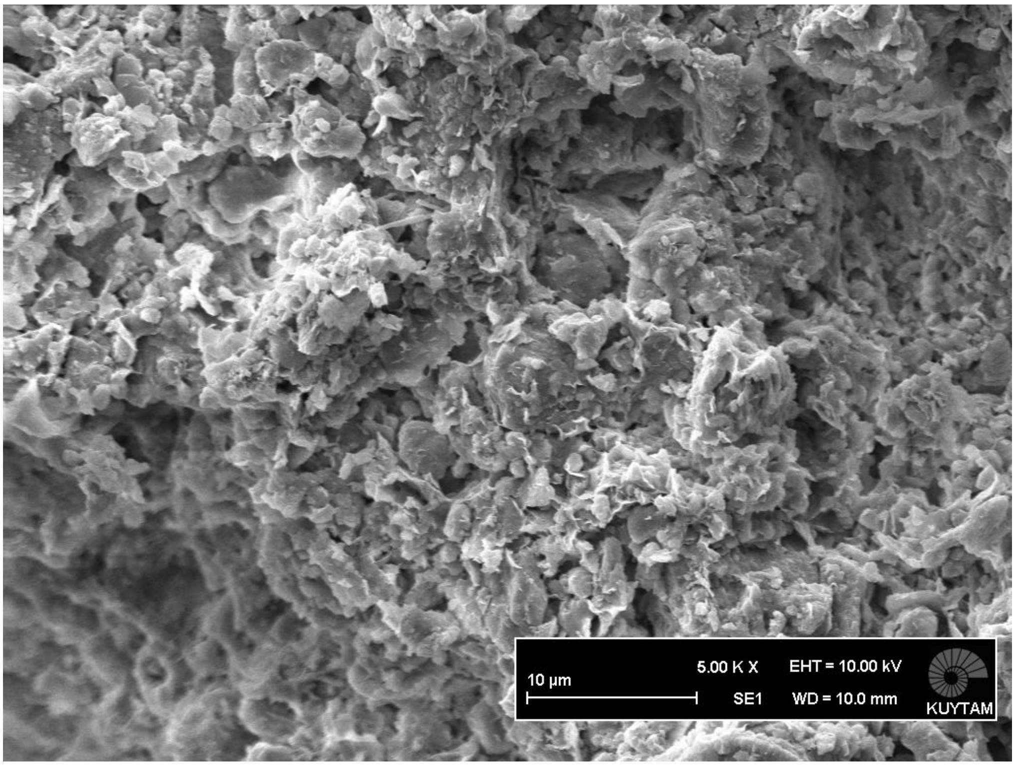


Figure 4. 4: Installation 1 SEM of AT 11474- Bulk #2, black colored combustion chamber fragment, V, firing temperature 850-1050 or 1050-1080°C.

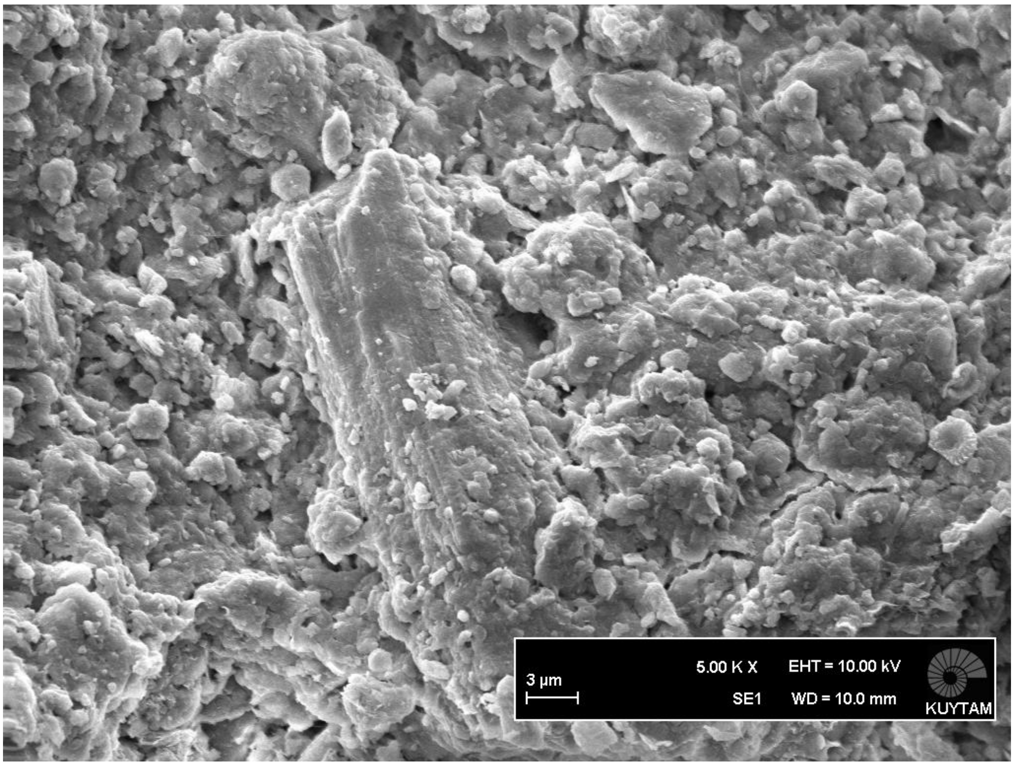


Figure 4. 5: Installation 1 SEM of AT 11474- Bulk #2, black colored combustion chamber fragment, V, firing temperature 850-1080 °C depending on the CaO content of the sample**.**

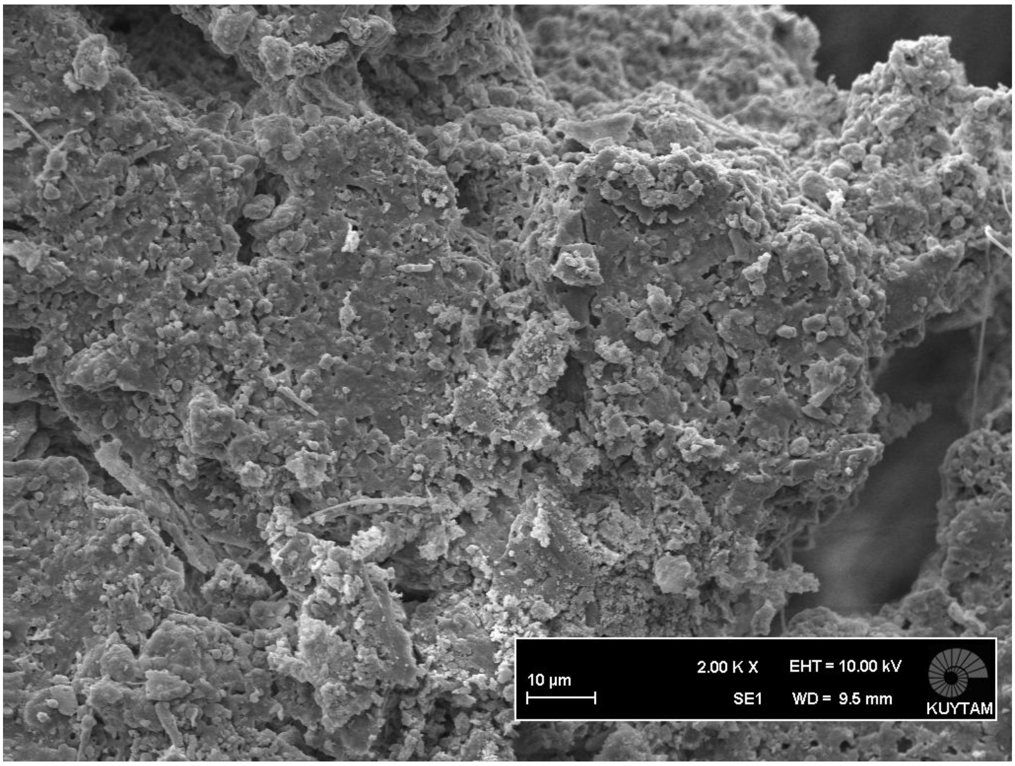


Figure 4. 6: Installation 1 SEM of AT 11474- Bulk #3, red colored combustion chamber fragment, TV, firing temperature > 1080°C.

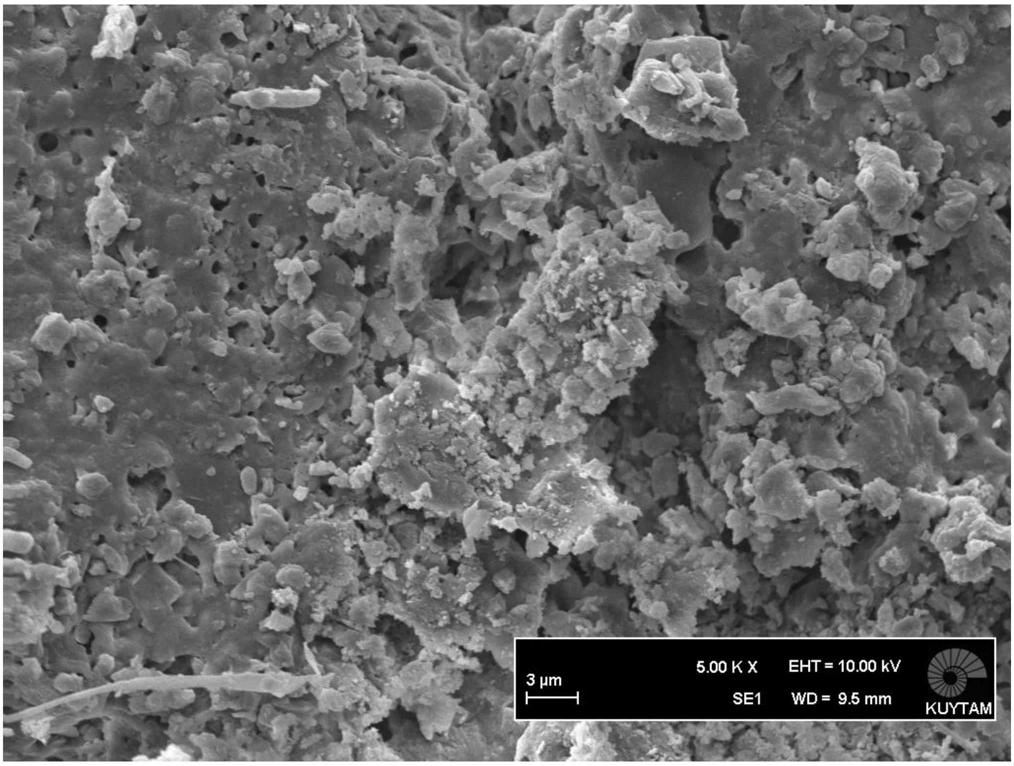


Figure 4. 7: Installation 1 SEM of AT 11474- Bulk #3, red colored combustion chamber fragment, TV, firing temperature > 1080°C.

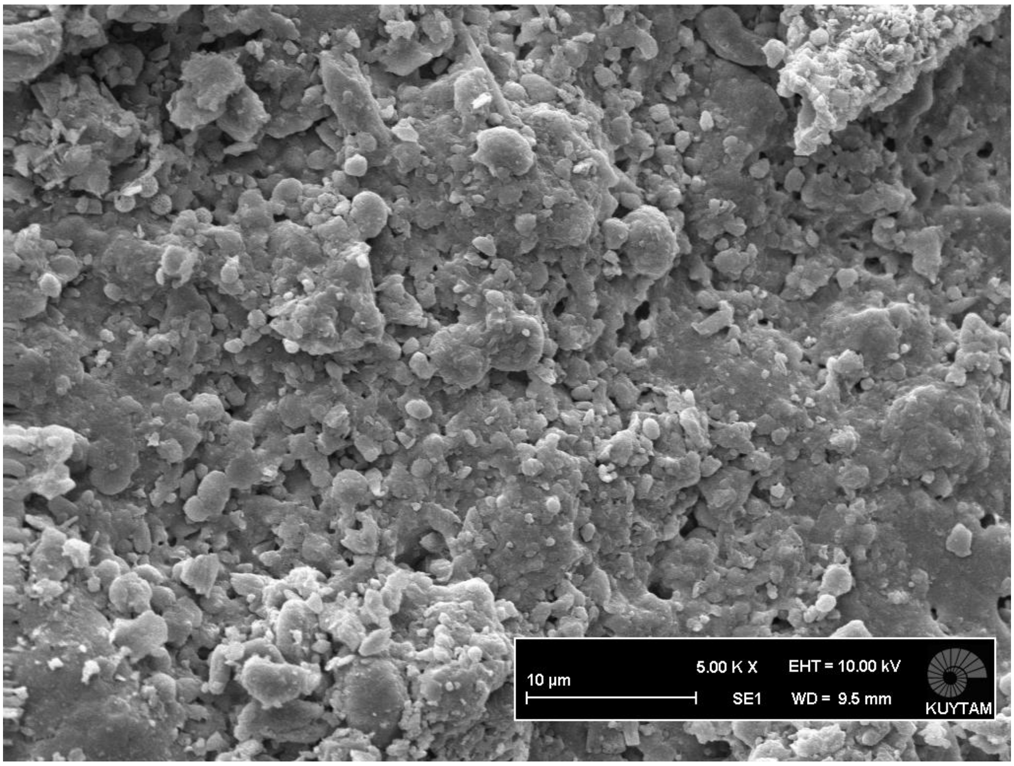


Figure 4. 8: Installation 1 SEM of AT 11474- Bulk #3, red colured combustion chamber fragment, TV, firing temperature > 1080°C.

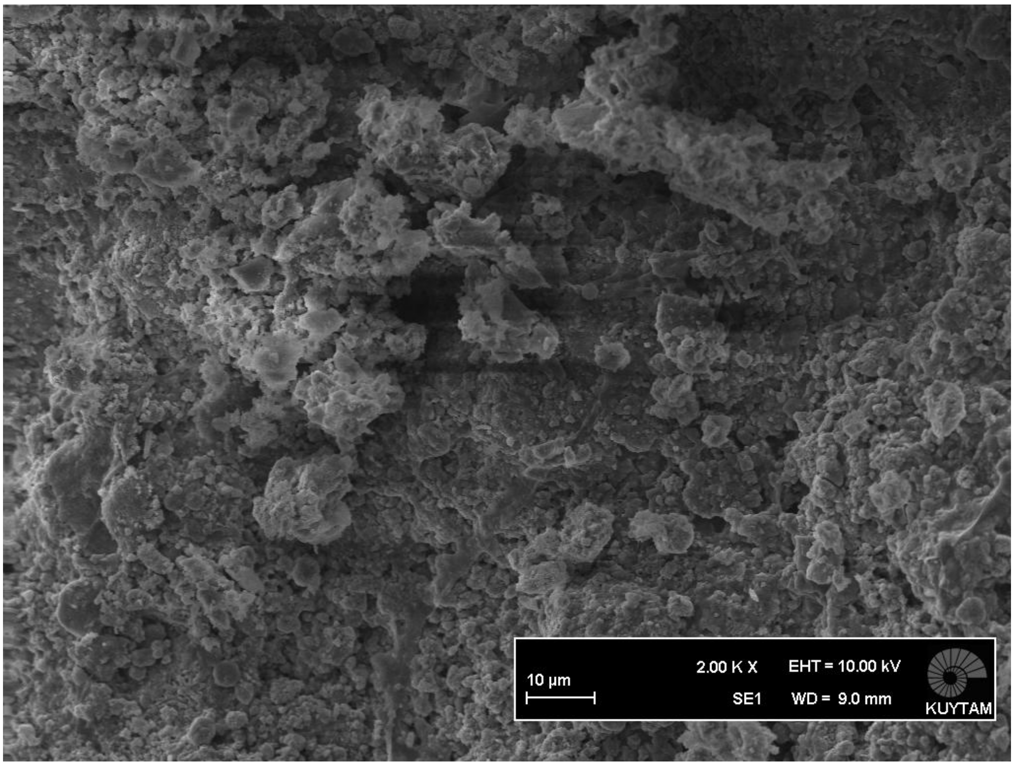


Figure 4. 9:Installation 1 SEM of AT 11474- Bulk #4, plaster fragment of floor separating combustion and firing chambers, V, firing temperature between 850 - 1080 °C.

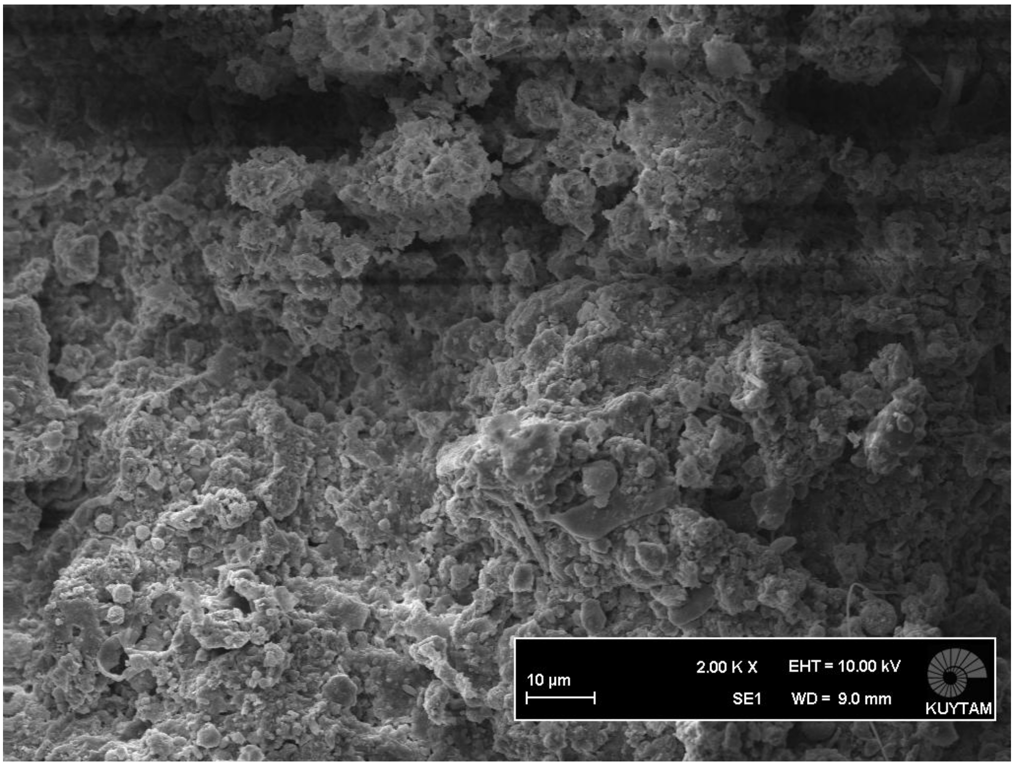


Figure 4. 10: Installation 1 SEM of AT 11474- Bulk #4, plaster fragment of floor separating combustion and firing chambers, V, firing temperature between 850 - 1080 °C.

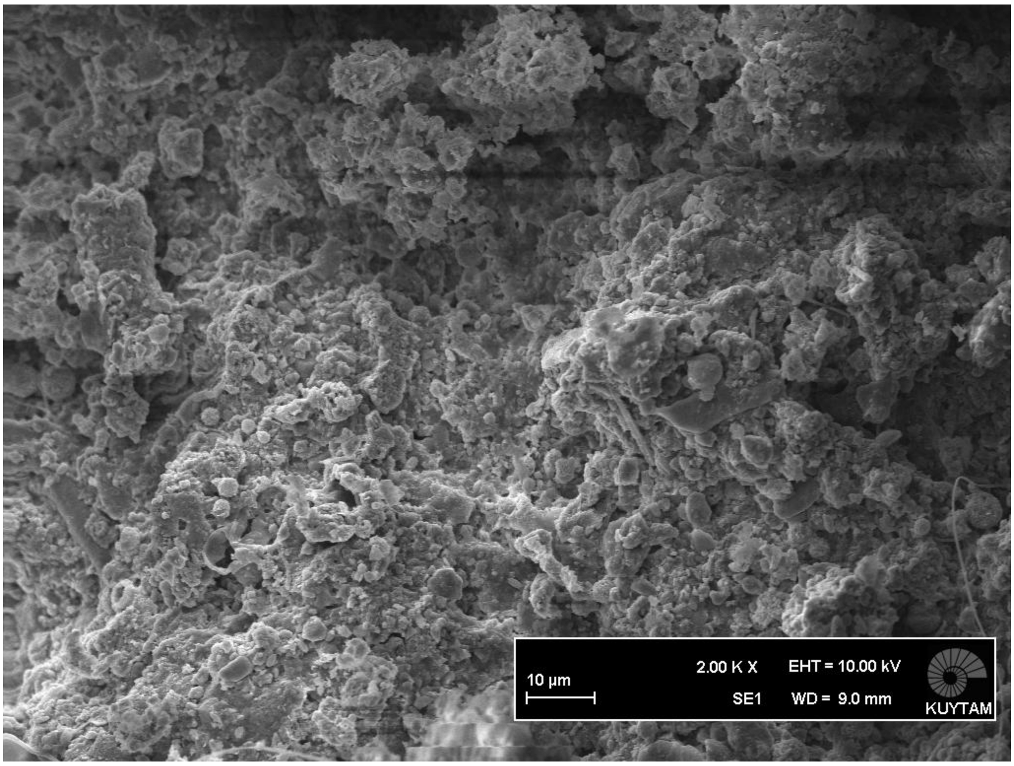


Figure 4. 11: Installation 1 SEM of AT 11474- Bulk #4, plaster fragment of floor separating combustion and firing chambers, V, firing temperature between 850 - 1080 °C.

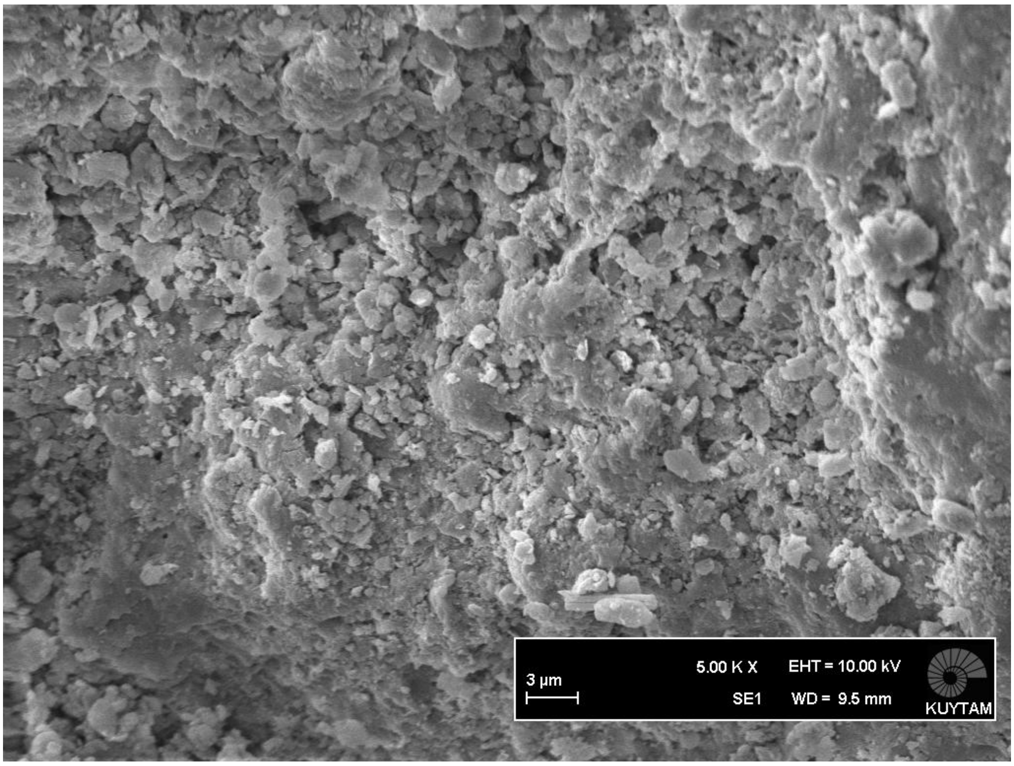


Figure 4. 12: Installation 1 SEM of AT 11474- Bulk #5, grey colored combustion chamber fragment, NV, firing temperature <750 °C.

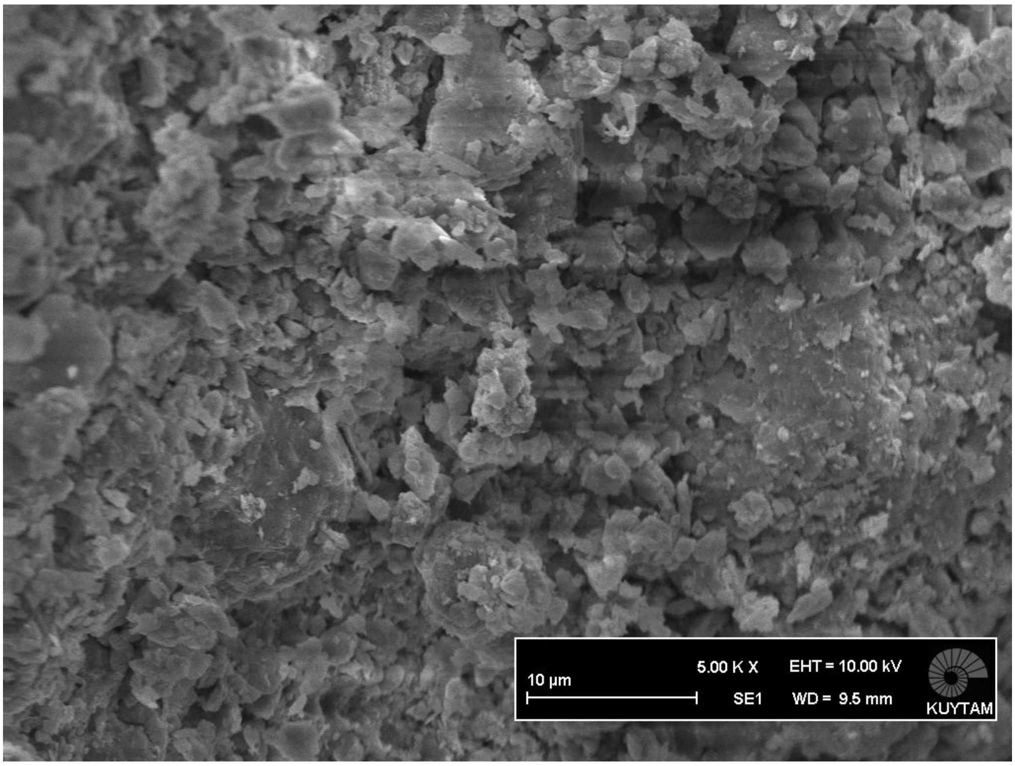


Figure 4. 13: Installation 1 SEM of AT 11474- Bulk #5, grey colored combustion chamber fragment, IV, firing temperature 750 - 800 °C.

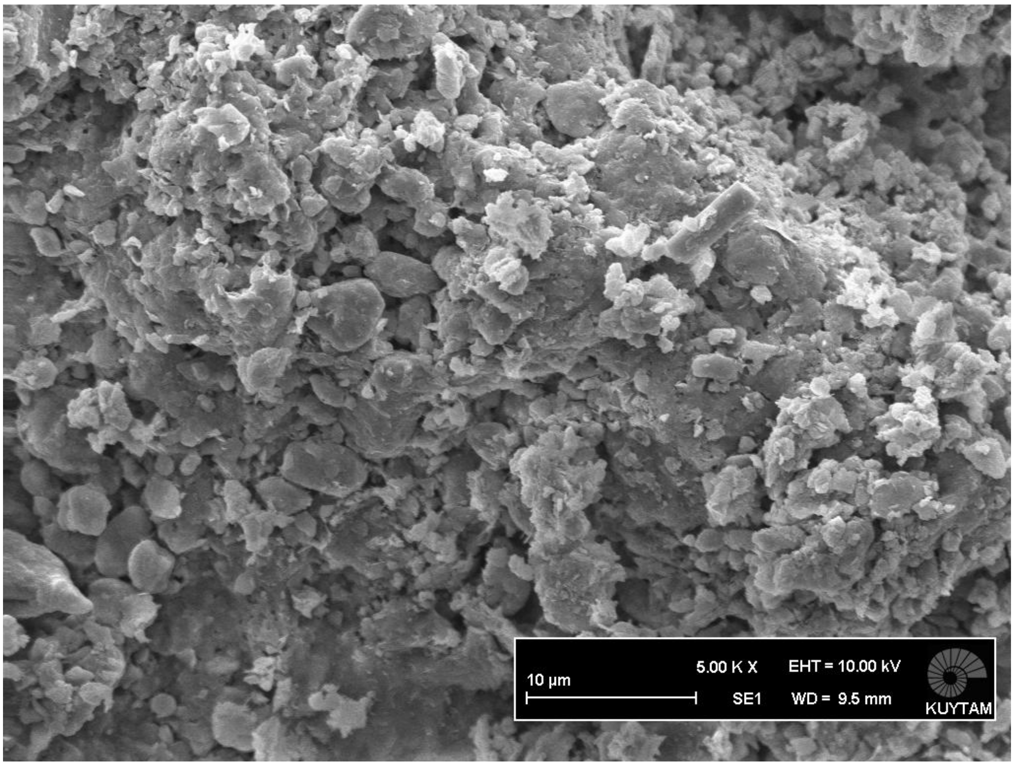


Figure 4. 14:Installation 1 SEM of AT 11474- Bulk #5, grey colored combustion chamber fragment.

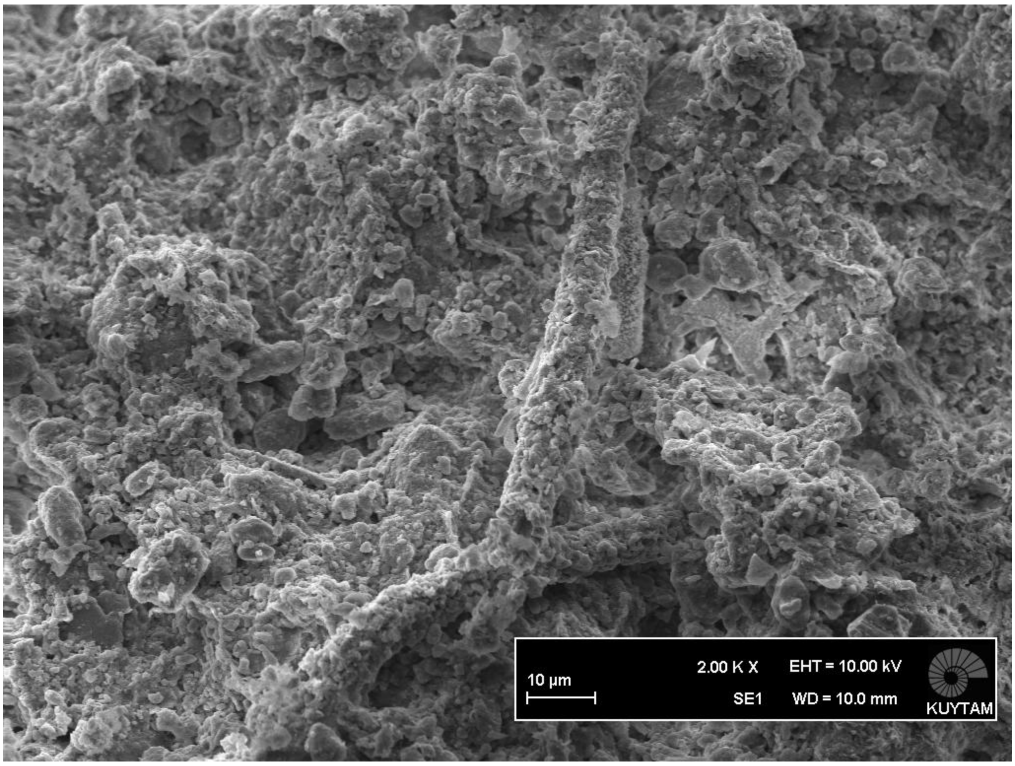


Figure 4. 15: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, TV, firing temperature over 1080 °C.

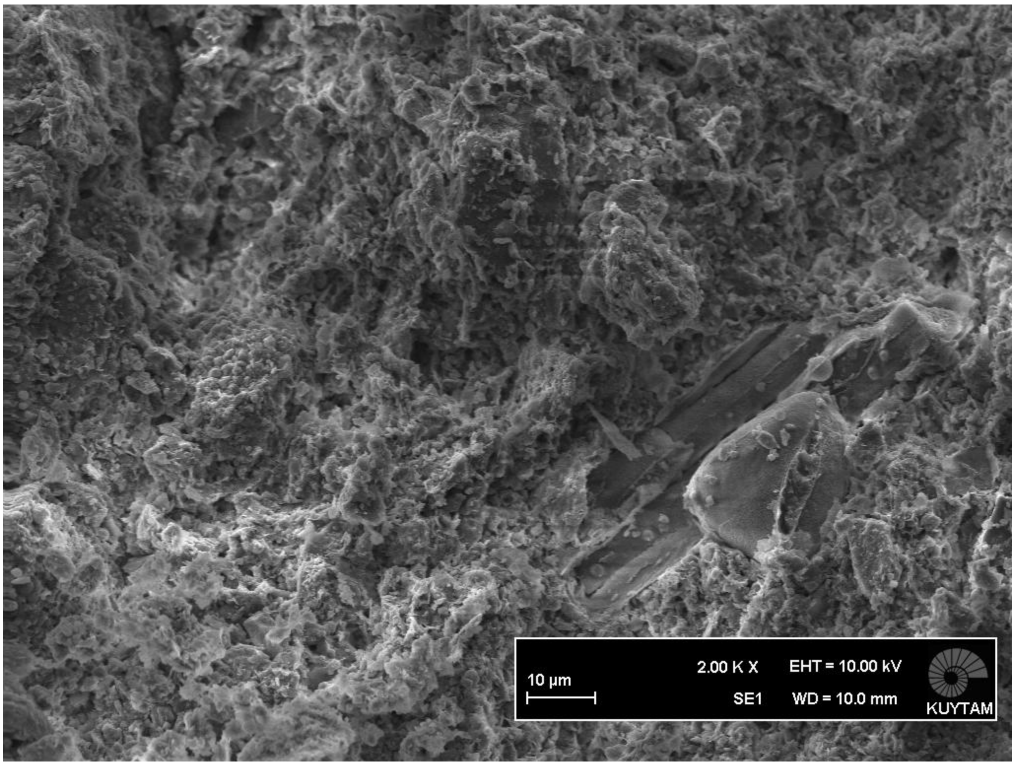


Figure 4. 16: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, TV, firing temperature over 1080 °C.

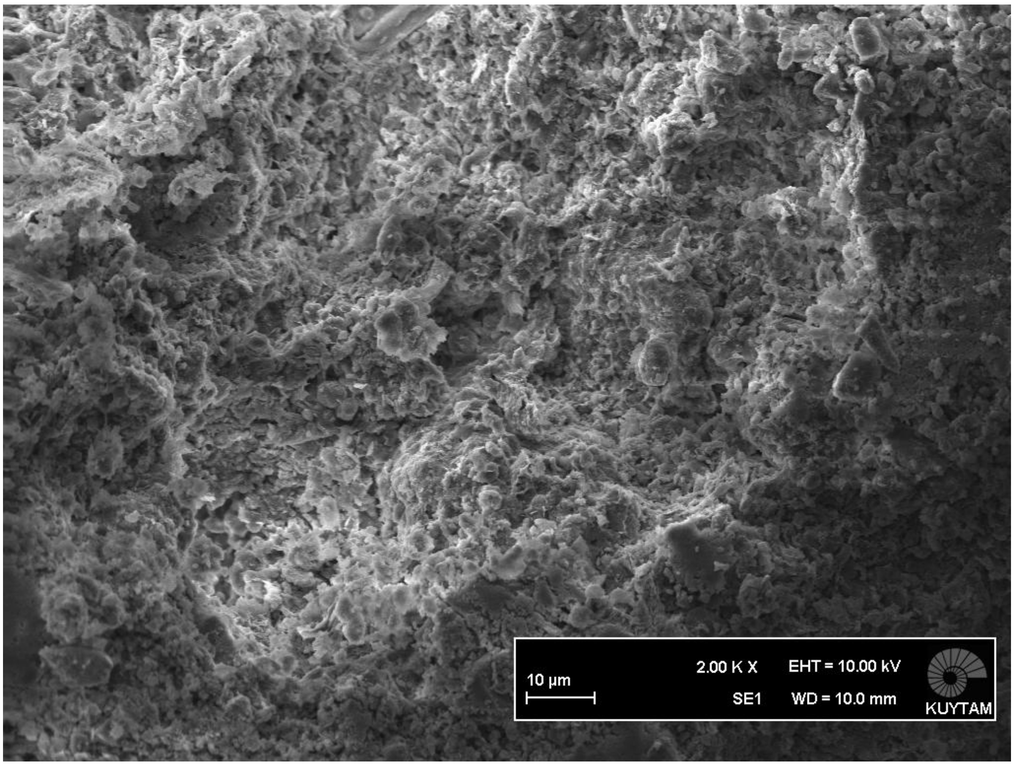


Figure 4. 17: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, V, firing temperature 850 - 1080 °C.

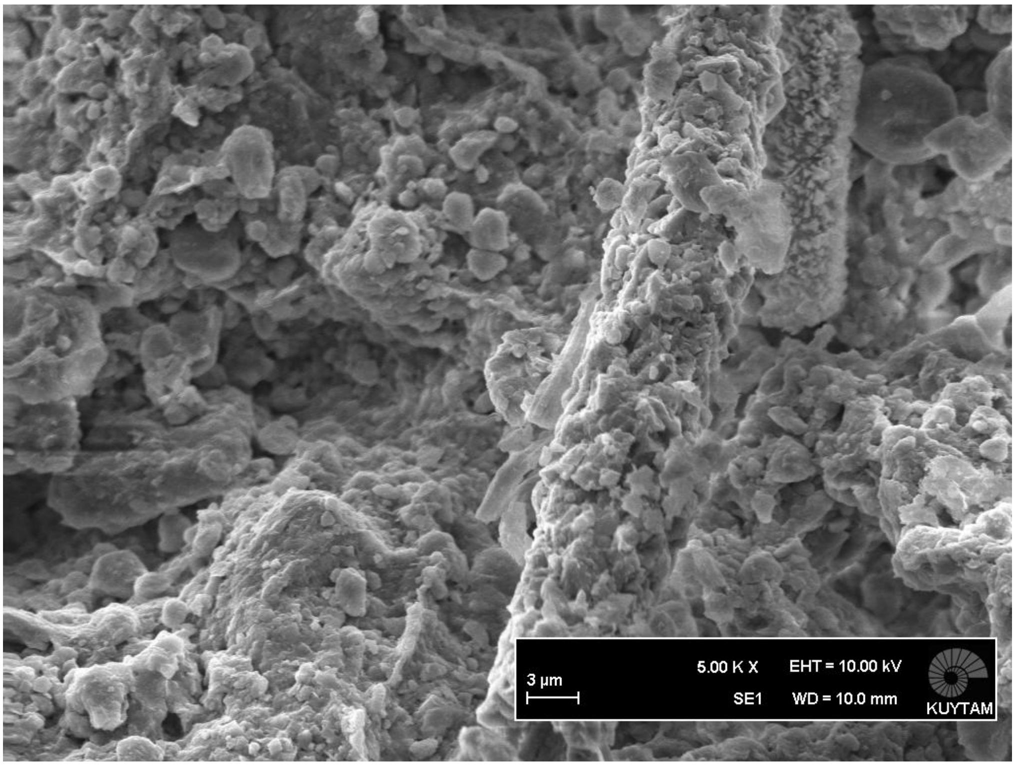


Figure 4. 18: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment.

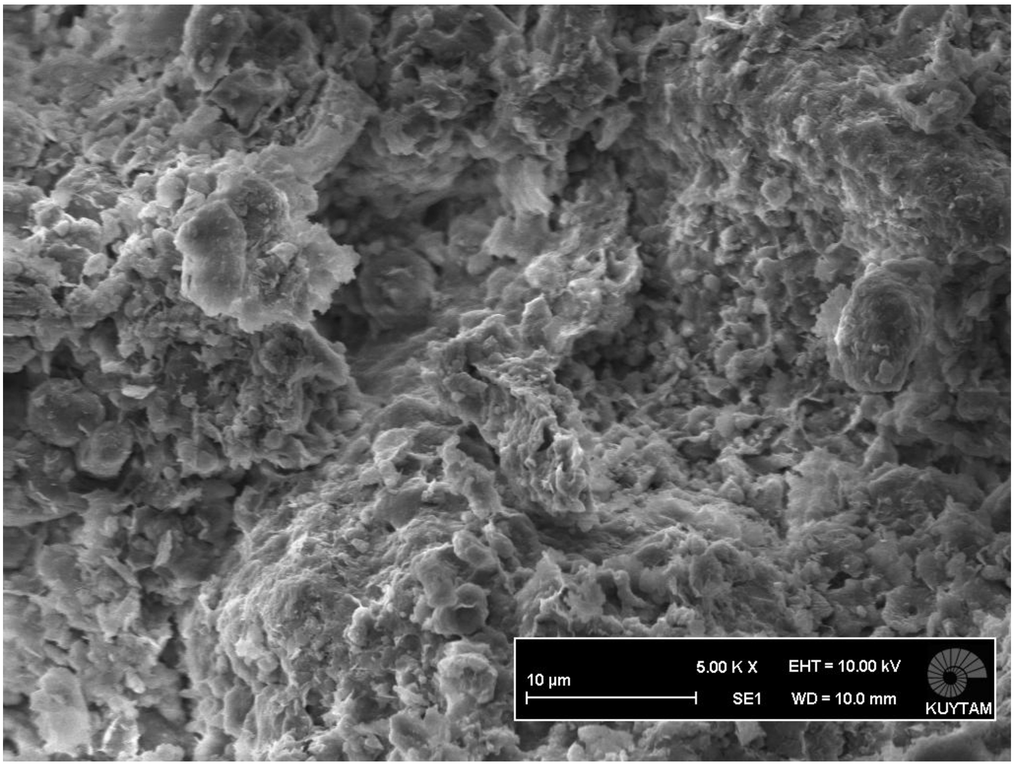


Figure 4. 19: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, TV, firing temperature over 1080 °C.

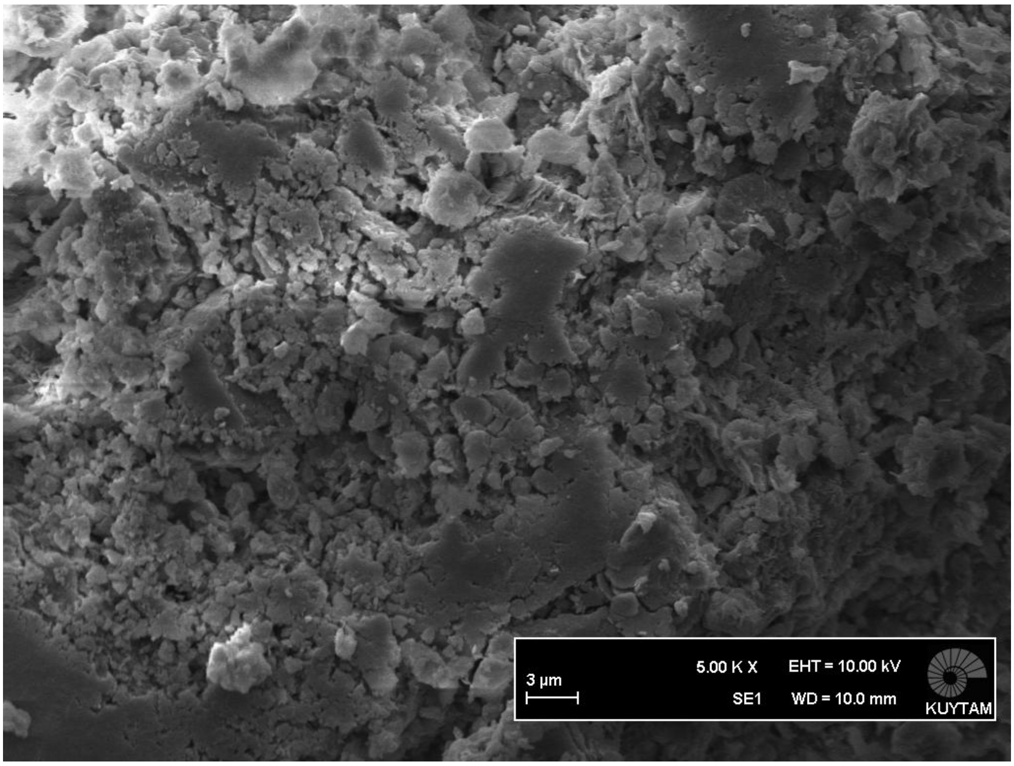


Figure 4. 20: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, TV, firing temperature over 1080 °C.

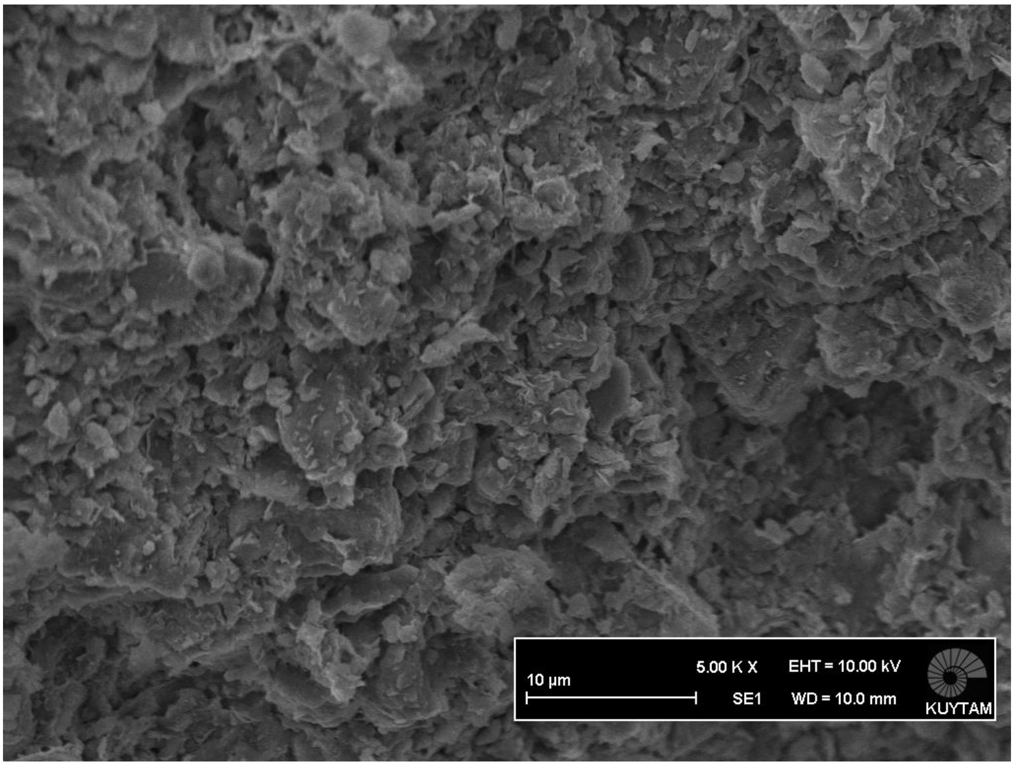


Figure 4. 21: Installation 1 SEM of AT 11474- Bulk #6, green-gray colored combustion chamber fragment, TV, firing temperature over 1080 °C.

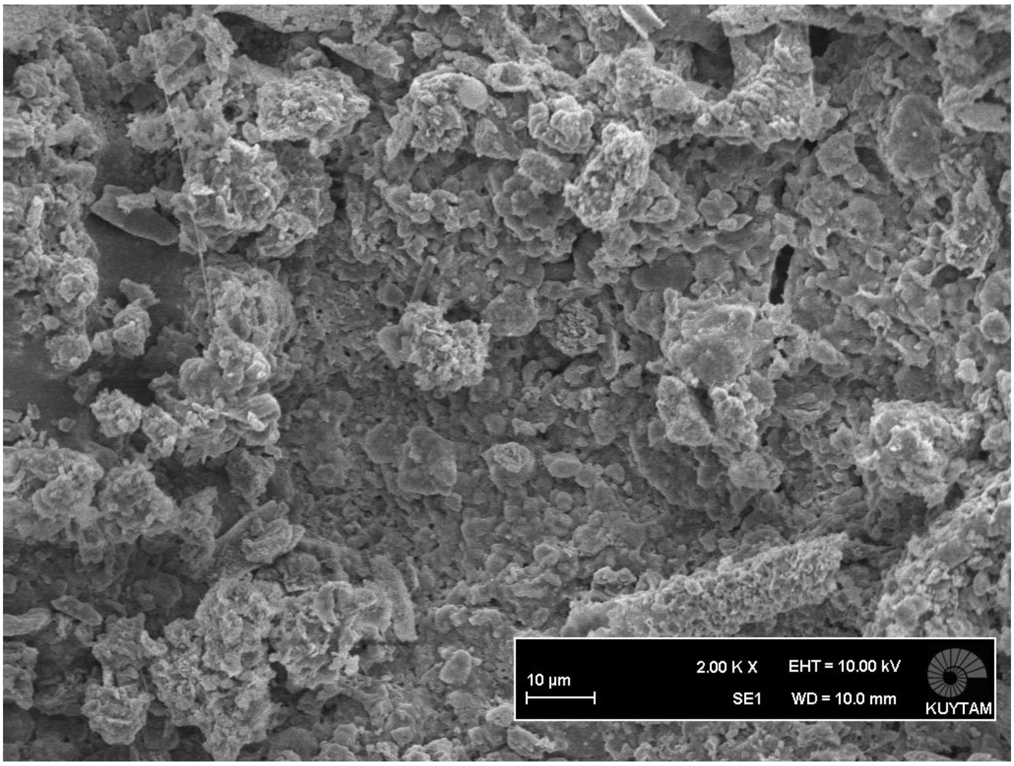


Figure 4. 22: Installation 2 SEM of AT 11475- Bulk#1, green-light green colored combustion chamber fragment, TV, firing temperature over 1080 °C.

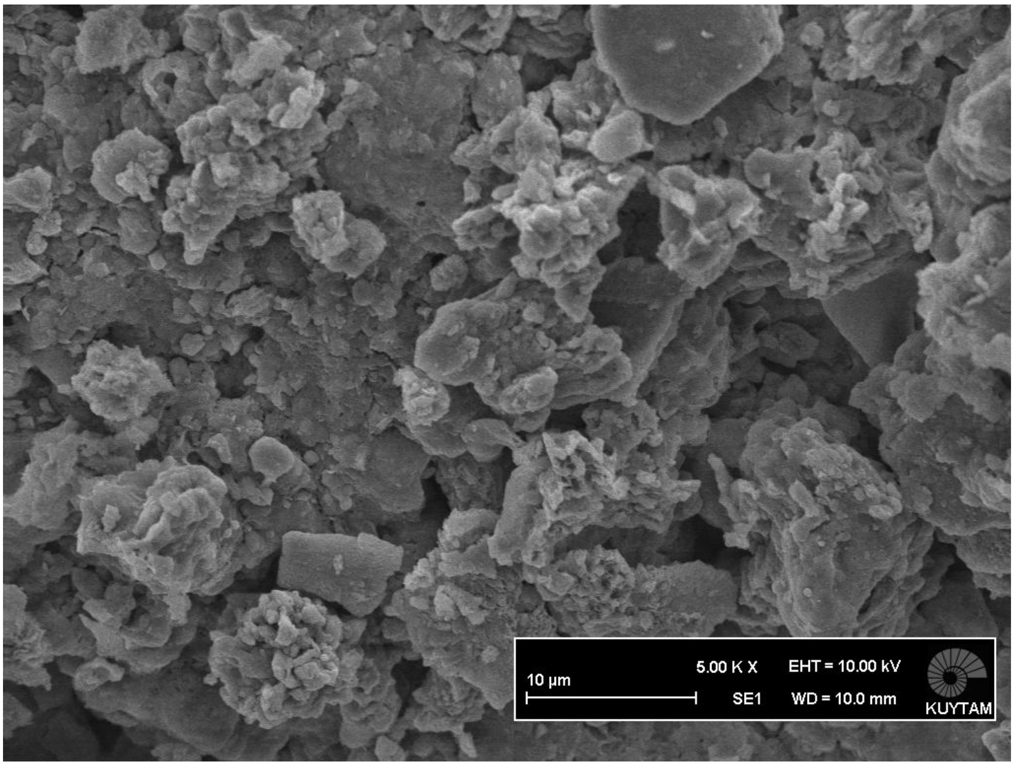


Figure 4. 23: Installation 2 SEM of AT 11475- Bulk#1, green-light green colored combustion chamber fragment, TV, firing temperature over 1080 °C.

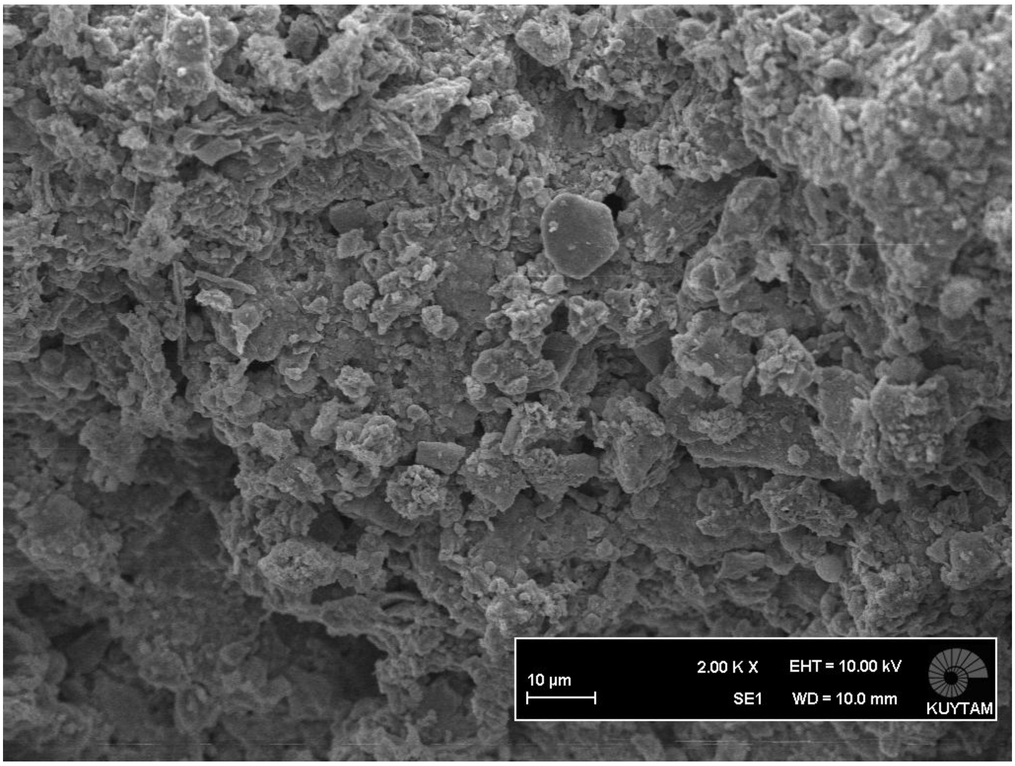


Figure 4. 24: Installation 2 SEM of AT 11475- Bulk#1, green-light green colored combustion chamber fragment, TV, firing temperature over 1080 °C.

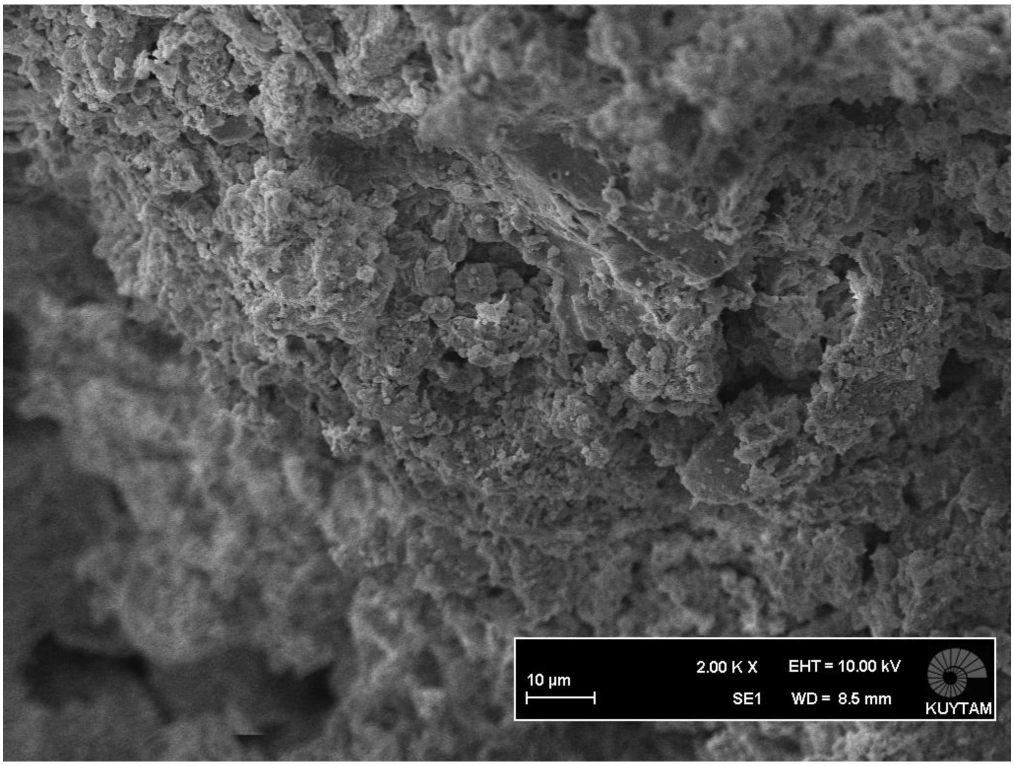


Figure 4. 25: Installation 2 SEM of AT 11475- Bulk#1, green-light green colored combustion chamber fragment , TV, firing temperature over 1080 °C.

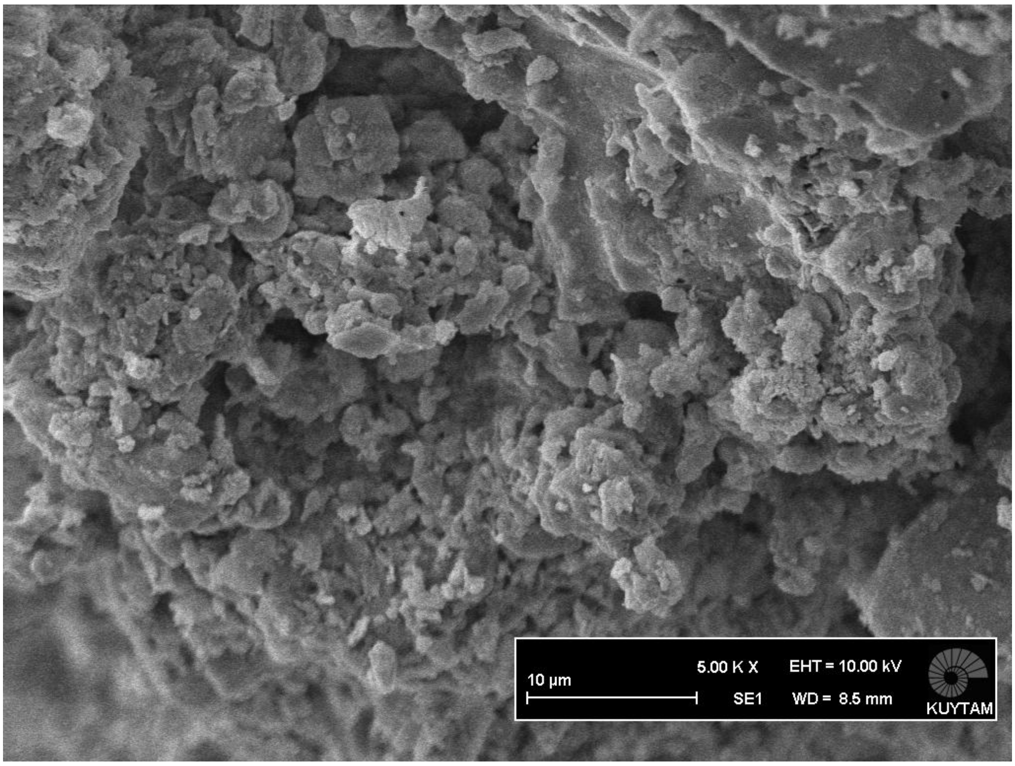


Figure 4. 26: Installation 2 SEM of AT 11475- Bulk#1, green-light green colored combustion chamber fragment, TV, firing temperature over 1080 °C.

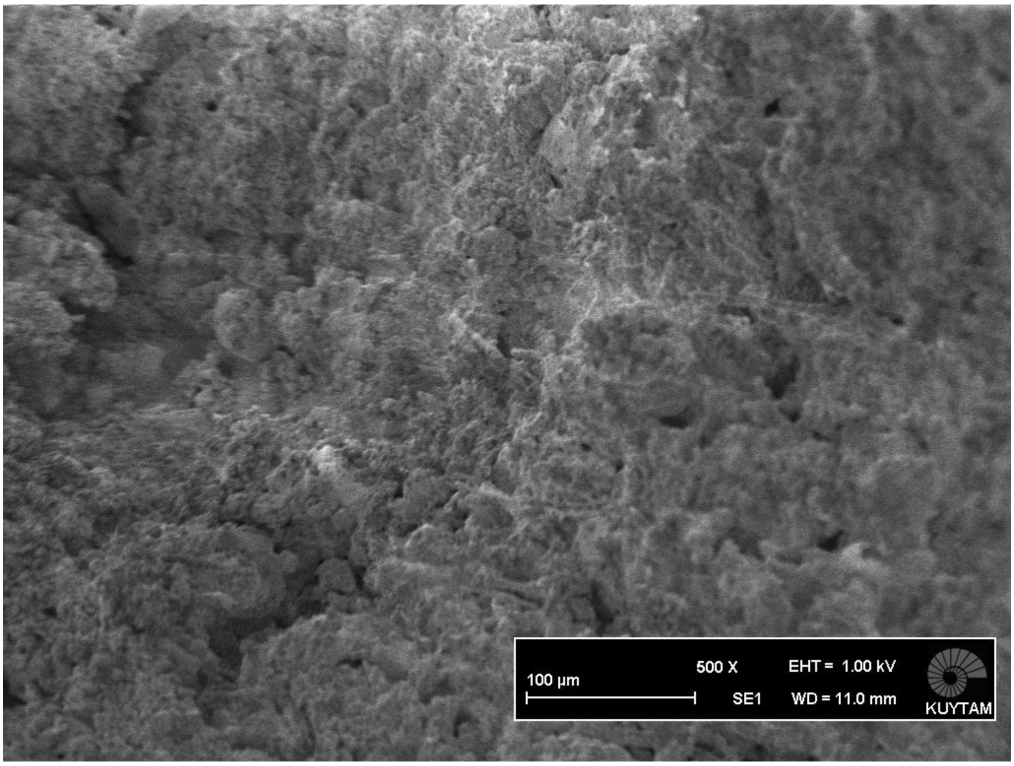


Figure 4. 27: Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment, V, firing temperature between 850 - 1080 °C.

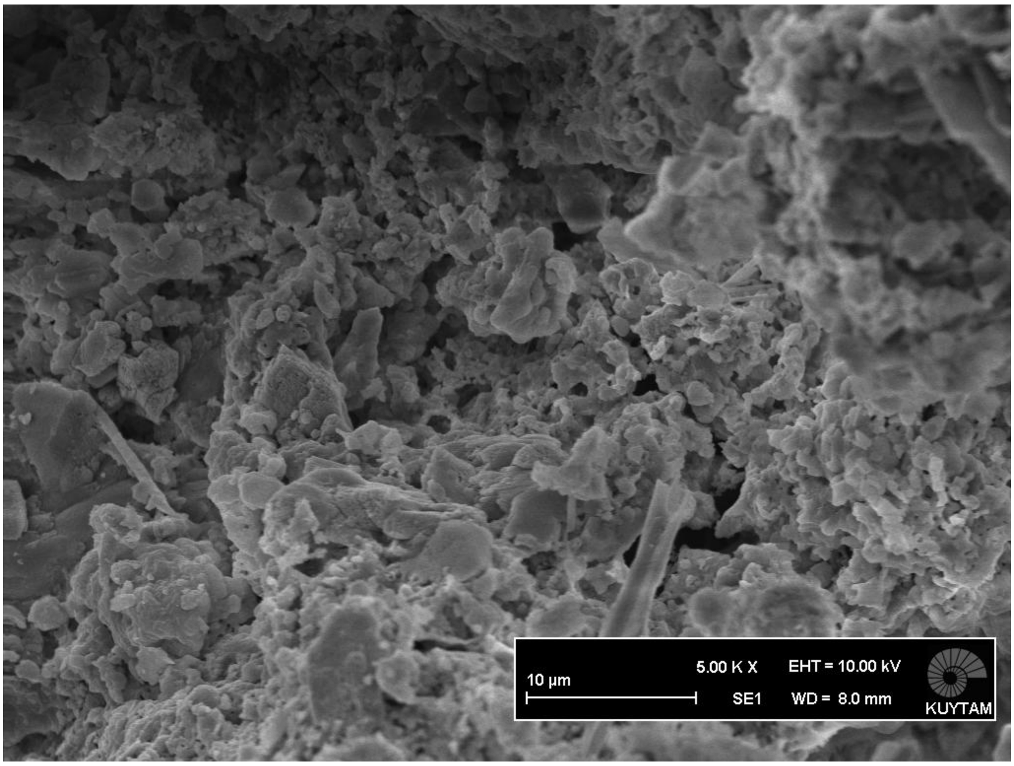


Figure 4. 28: Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment V, firing temperature between 850 - 1080 °C.

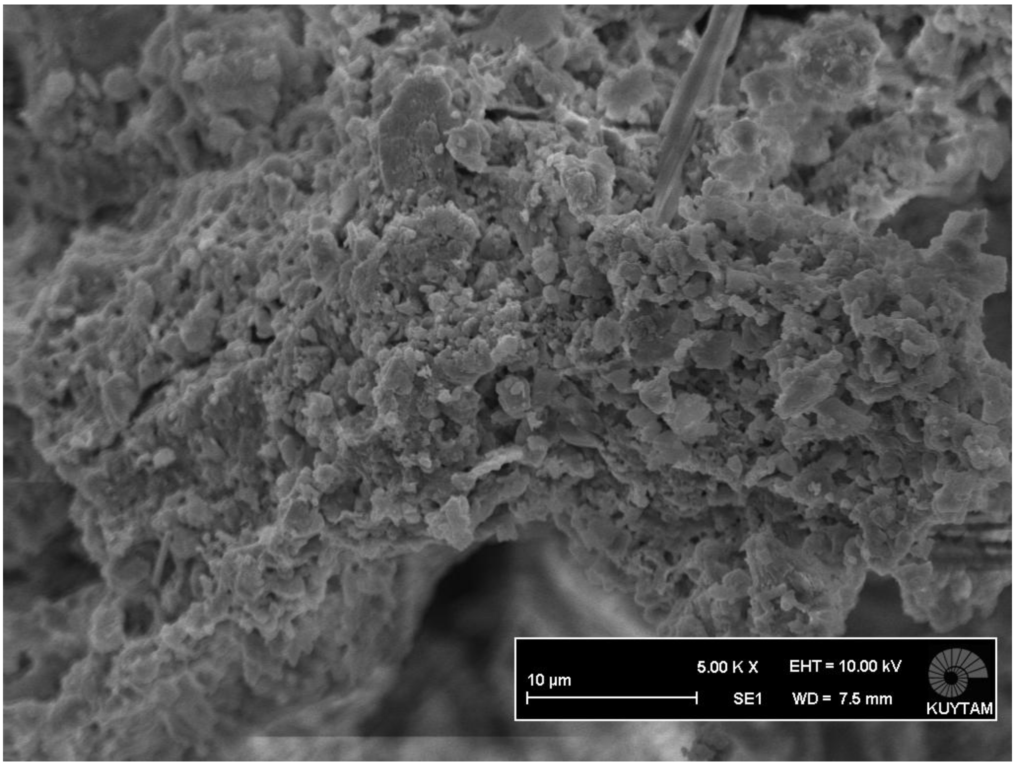


Figure 4. 29: Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment V, firing temperature between 850 - 1080 °C.

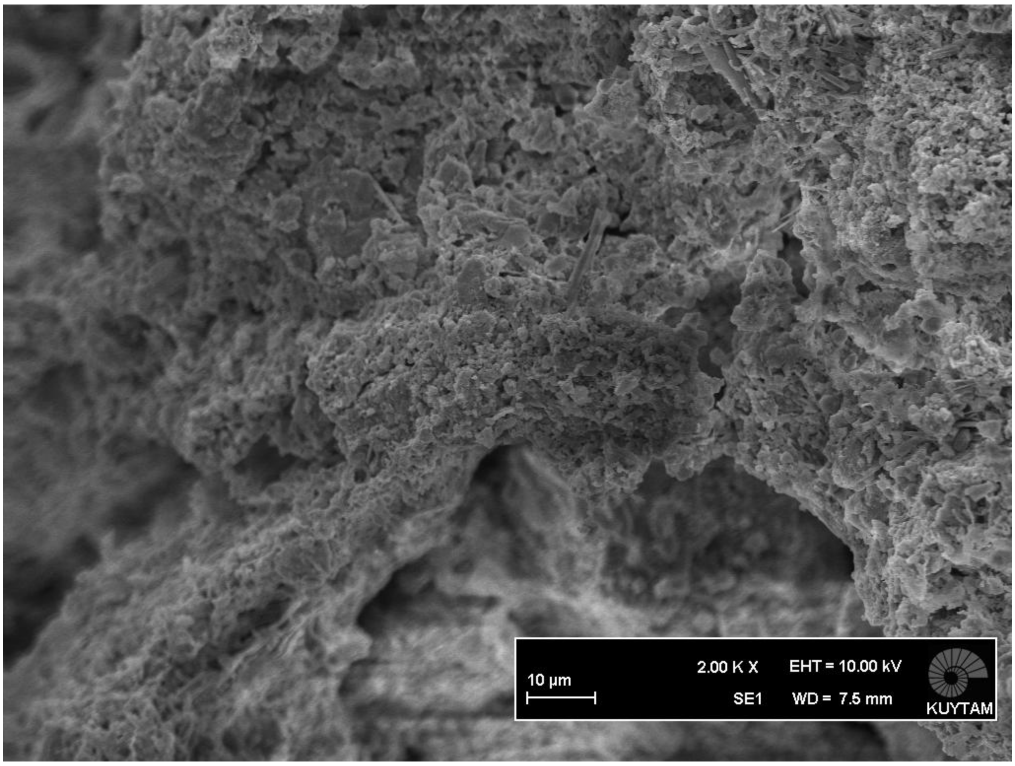


Figure 4. 30: Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment, V, firing temperature between 850 - 1080 °C.

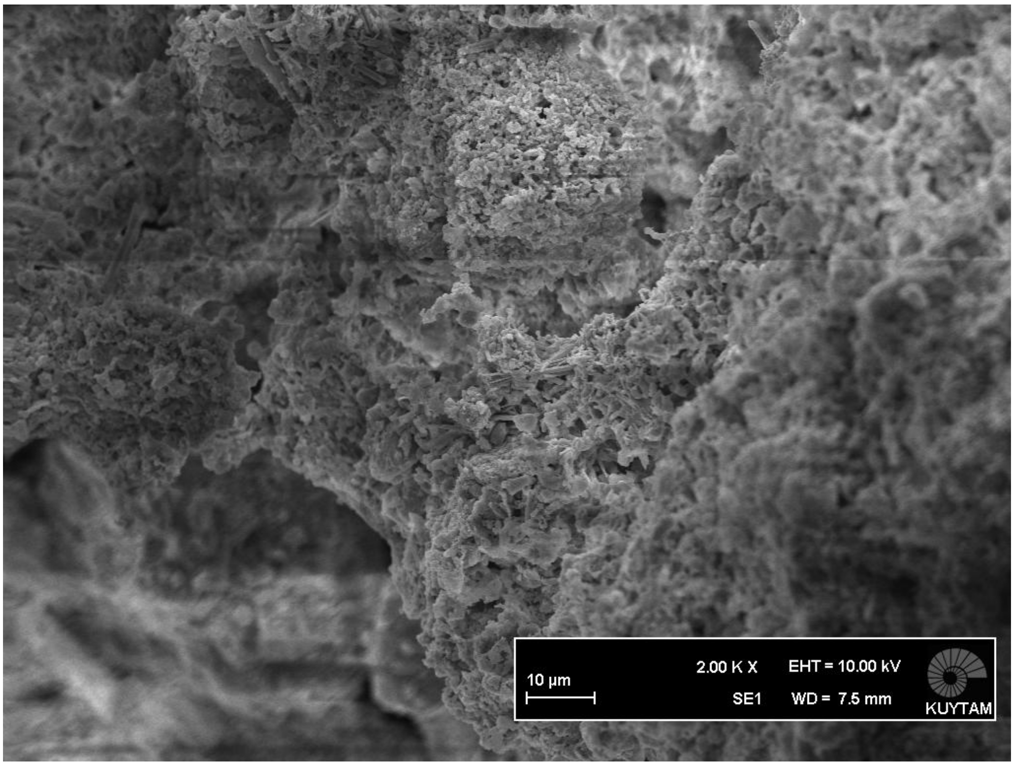


Figure 4. 31:Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment, V, firing temperature between 850 - 1080 °C.

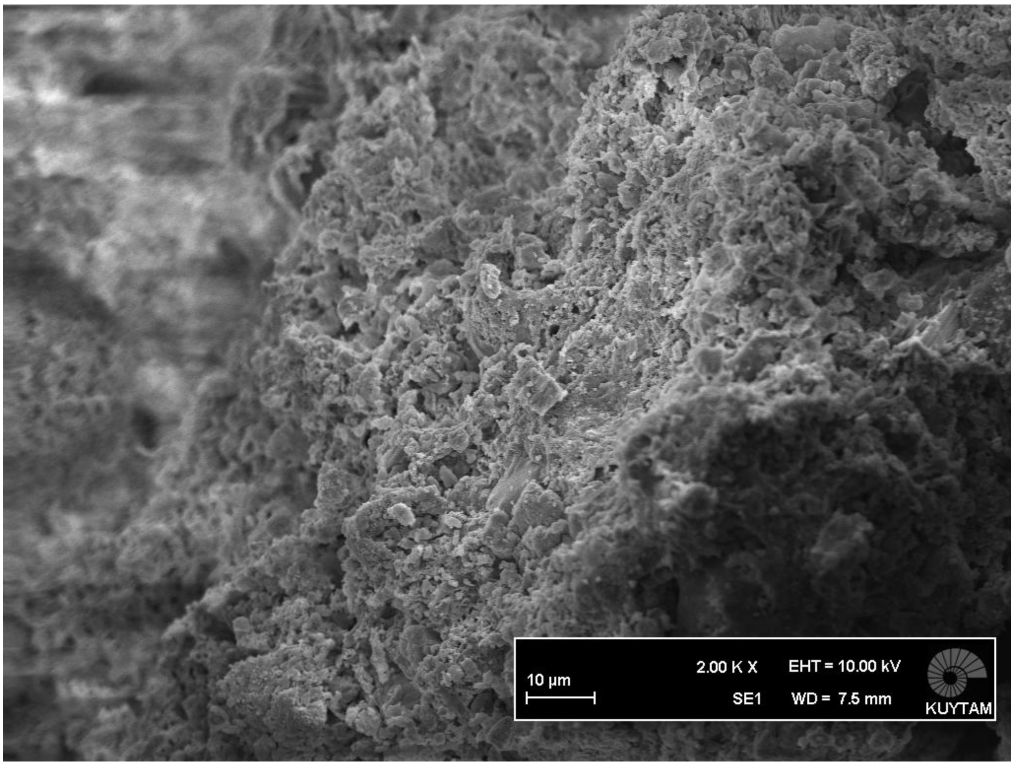


Figure 4. 32:Installation 2 SEM of AT 11475- Bulk#2, green colored combustion chamber fragment, V, firing temperature between 850 - 1080 °C.

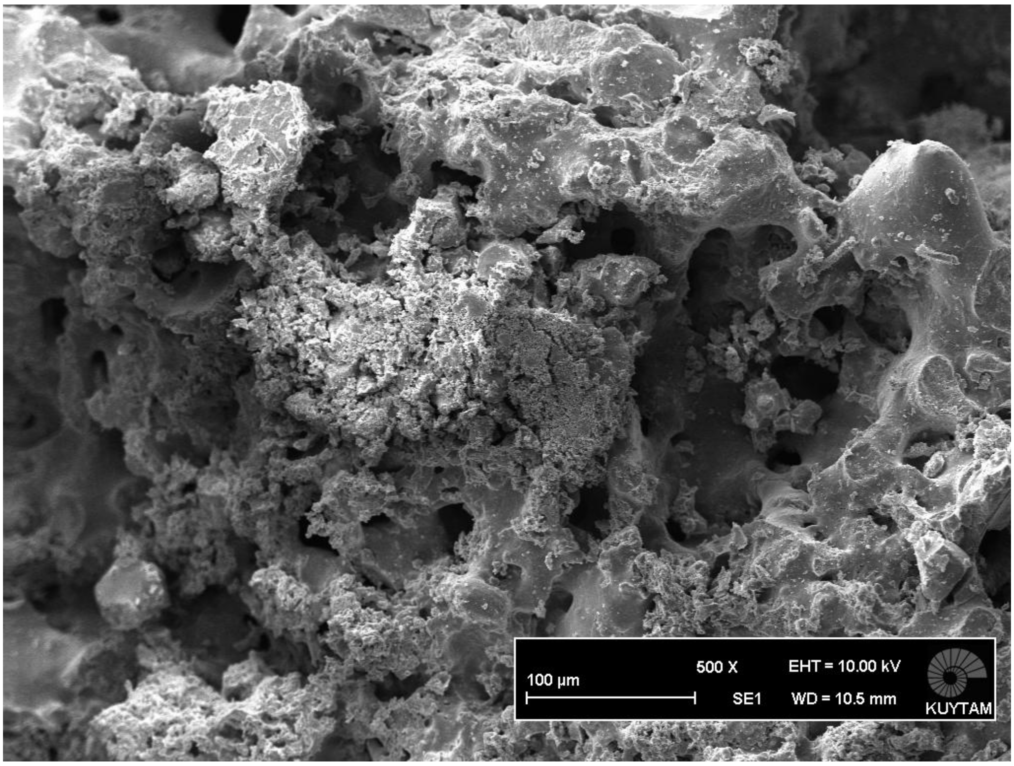


Figure 4. 33:Installation 2 SEM of AT 11475- Bulk#3, green colored combustion chamber fragment, TV, firing temperature 1150°C.

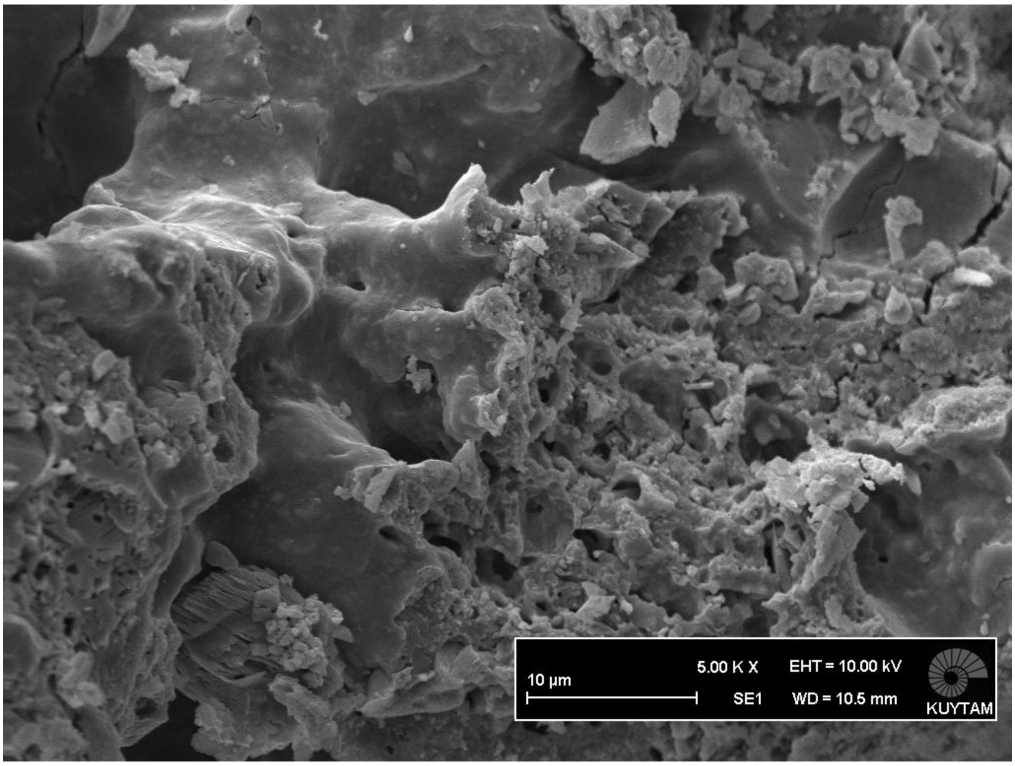


Figure 4. 34:Installation 2 SEM of AT 11475- Bulk#3, green colored combustion chamber fragment, TV, firing temperature 1150°C.

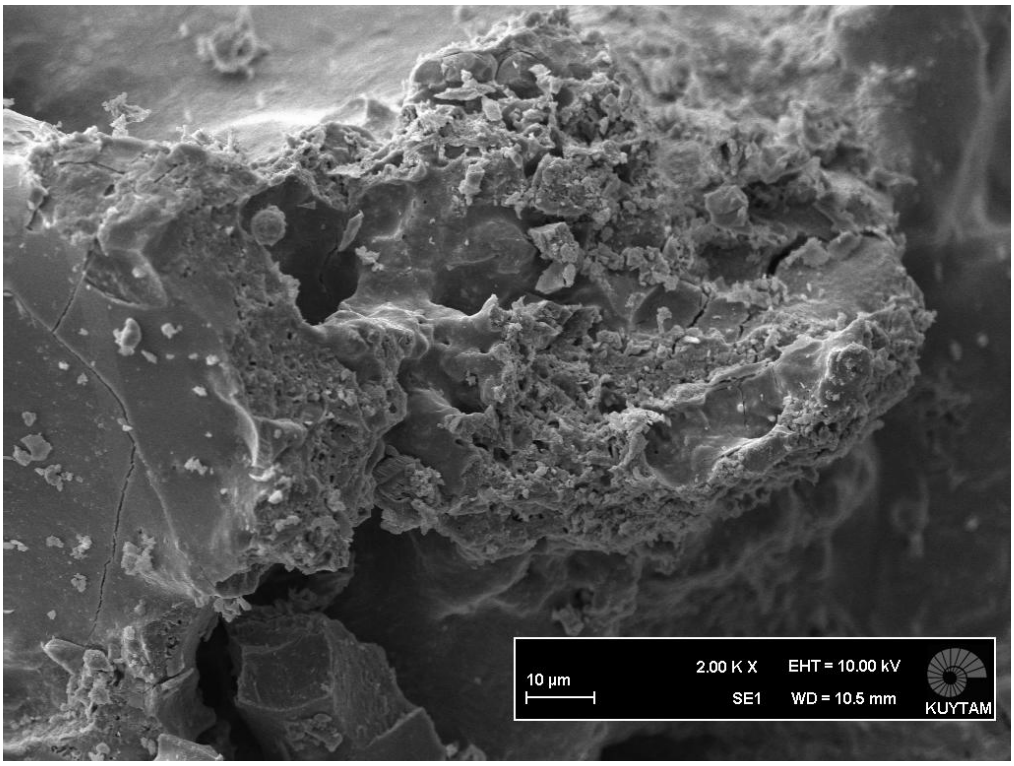


Figure 4. 35: Installation 2 SEM of AT 11475- Bulk#3, green colured combustion chamber fragment, TV, firing temperature 1150°C.

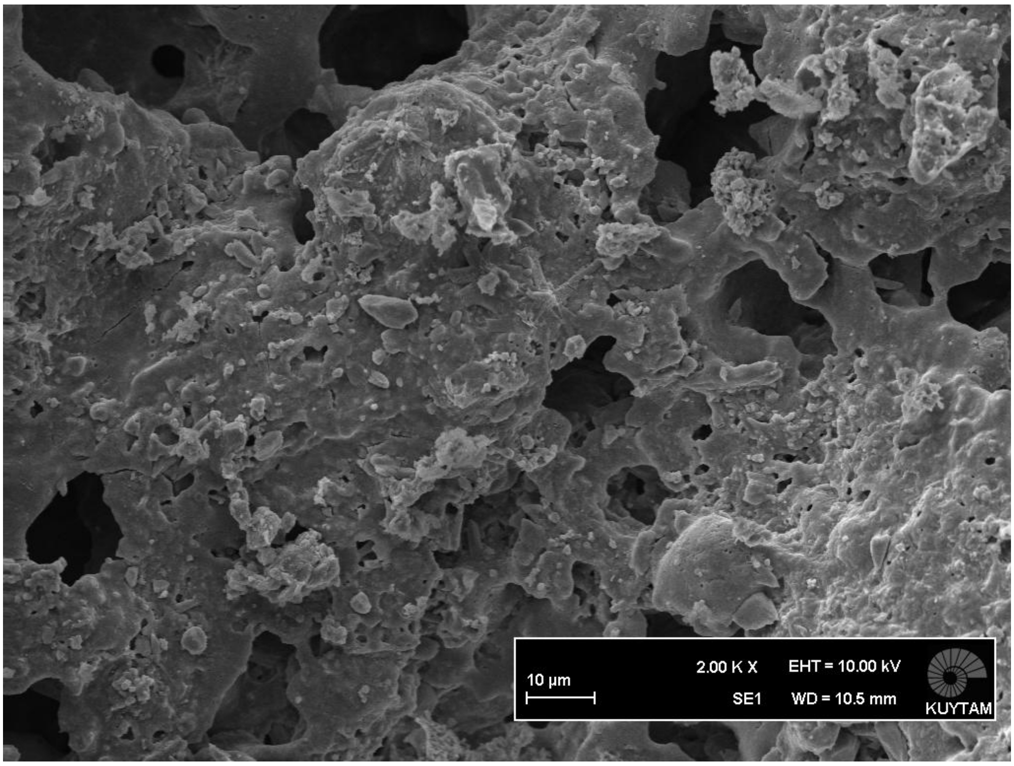


Figure 4. 36:Installation 2 SEM of AT 11475- Bulk#3, green colored combustion chamber fragment, TV, extensive formation of bloating pores, firing temperature 1150°C.

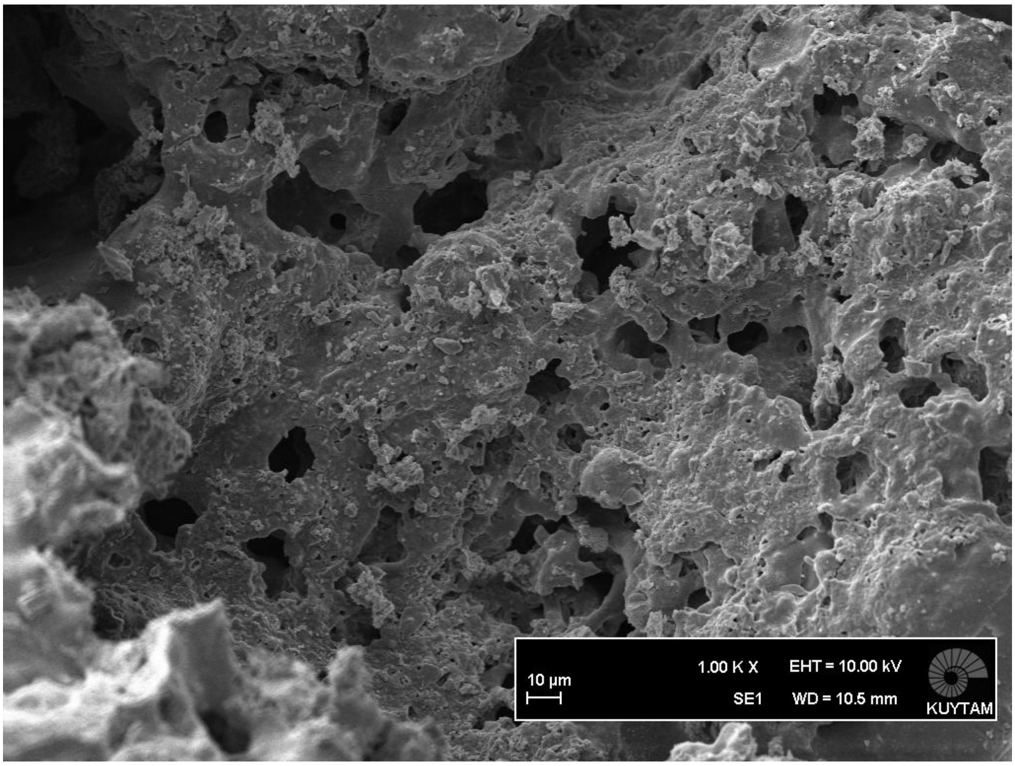


Figure 4. 37:Installation 2 SEM of AT 11475- Bulk#3, green colured combustion chamber fragment, TV, extensive formation of bloating pores, firing temperature 1150°C.

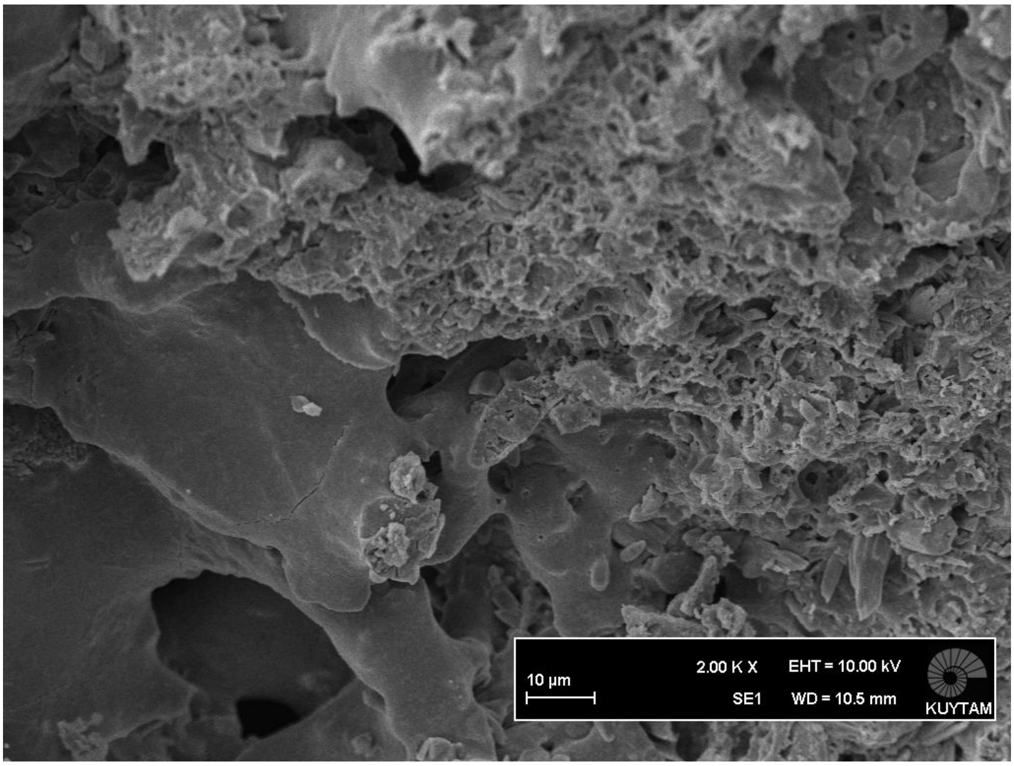


Figure 4. 38:Installation 2 SEM of AT 11475- Bulk#3, green colured combustion chamber fragment, TV, firing temperature 1150°C.

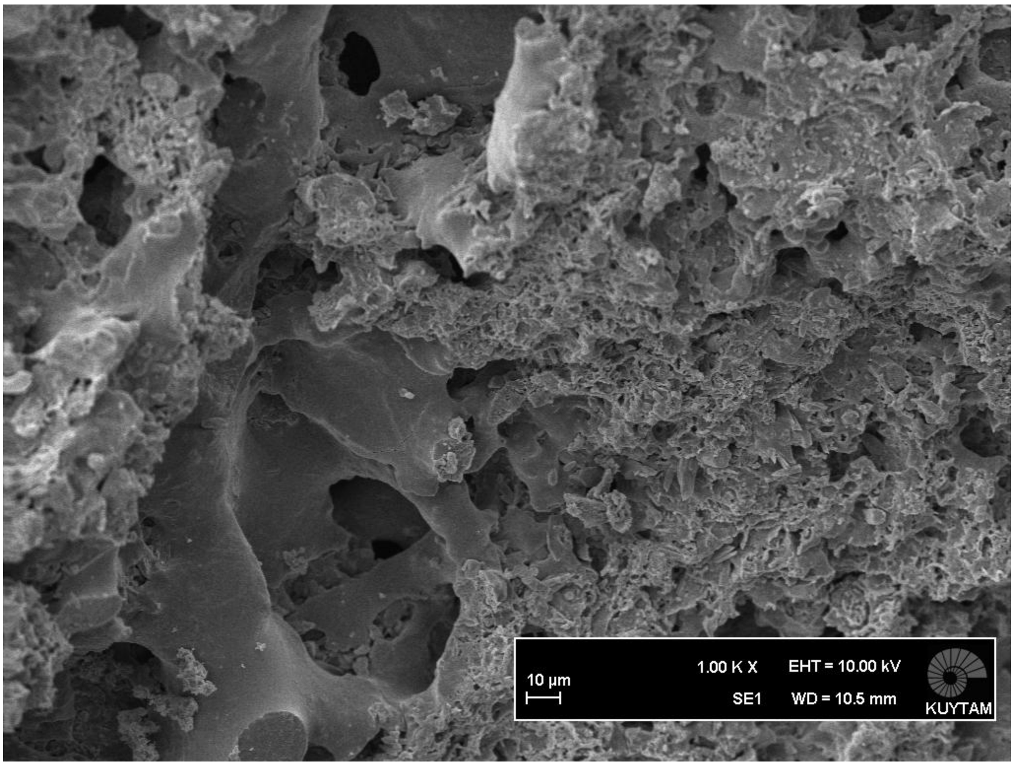


Figure 4. 39:Installation 2 SEM of AT 11475- Bulk#3, green colured combustion chamber fragment, TV, firing temperature 1150°C.

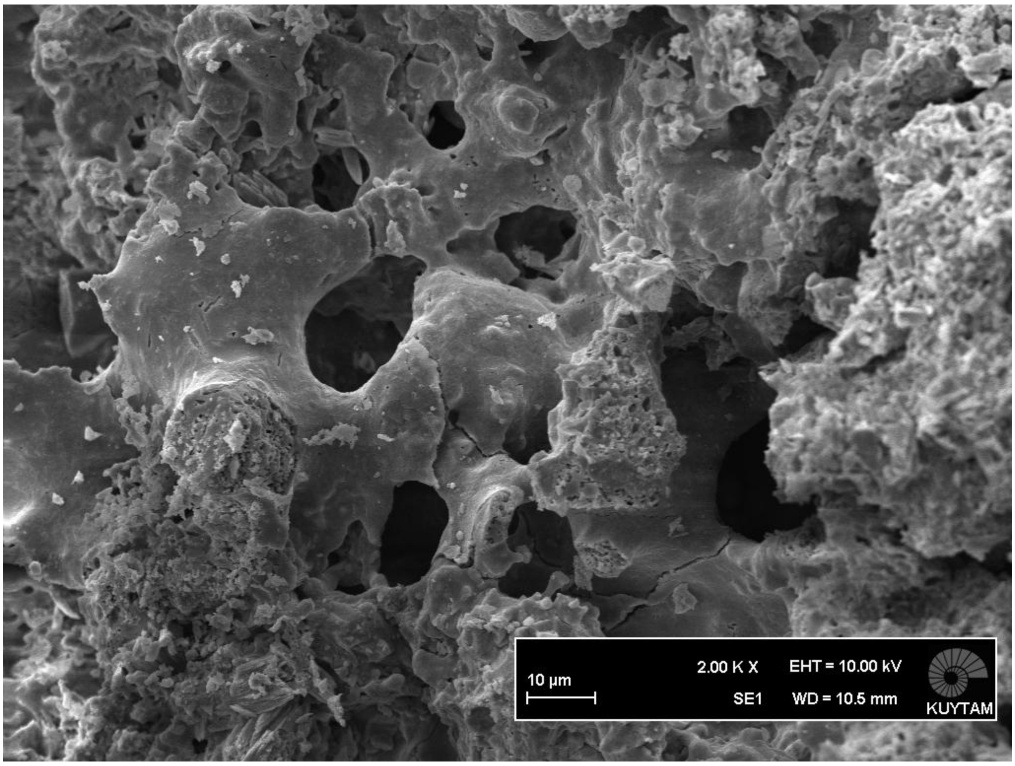


Figure 4. 40:Installation 2 SEM of AT 11475 Bulk#3, green colored combustion chamber fragment, TV, extensive formation of bloating pores, firing temperature 1150°C.

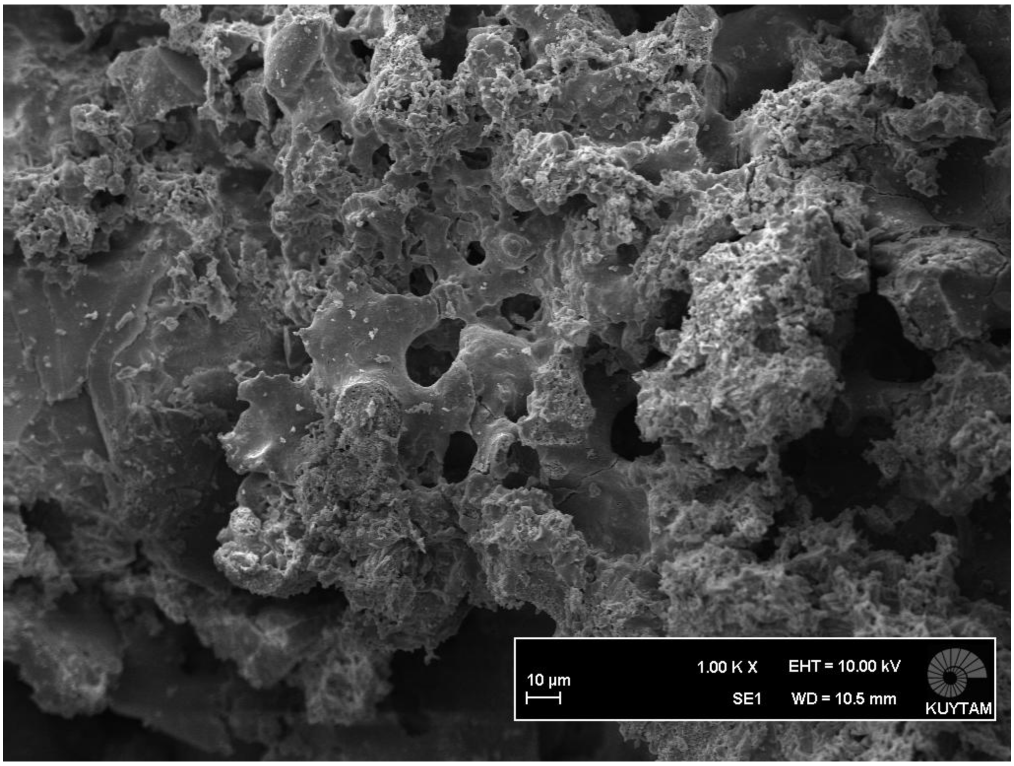


Figure 4. 41:Installation 2 SEM of AT 11475- Bulk#3, green colored combustion chamber fragment, 1000x magnified image of figure 40.

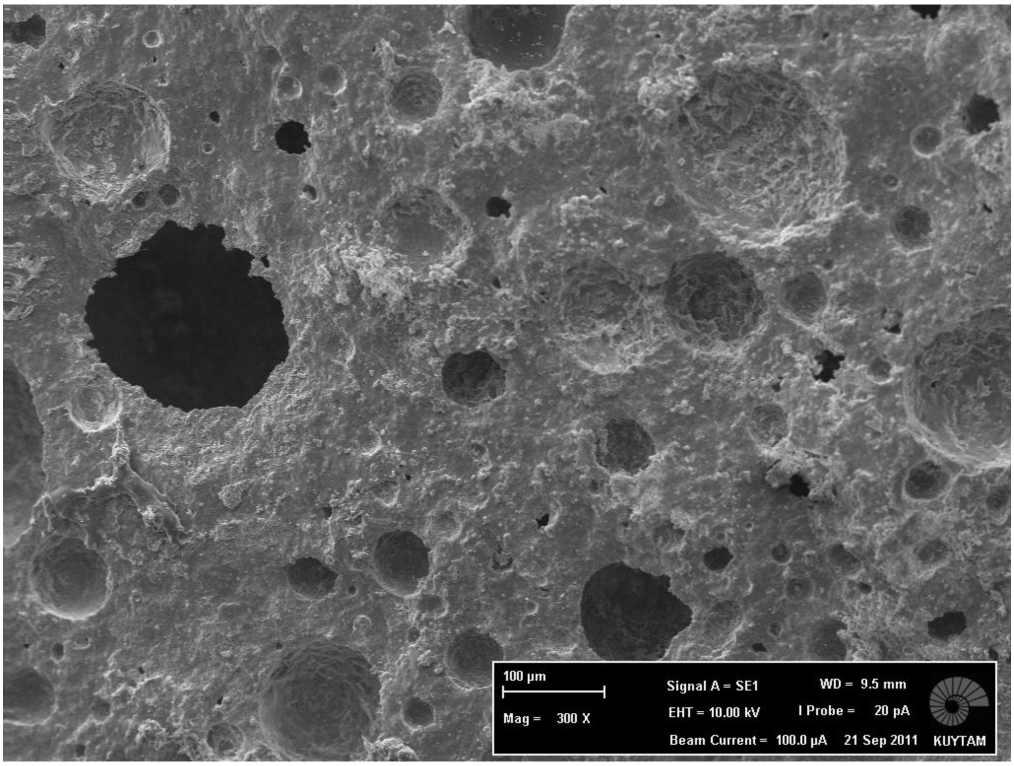


Figure 4. 42:SEM image of R04-328 showing the bloating pores, firing temperature 1150°C.

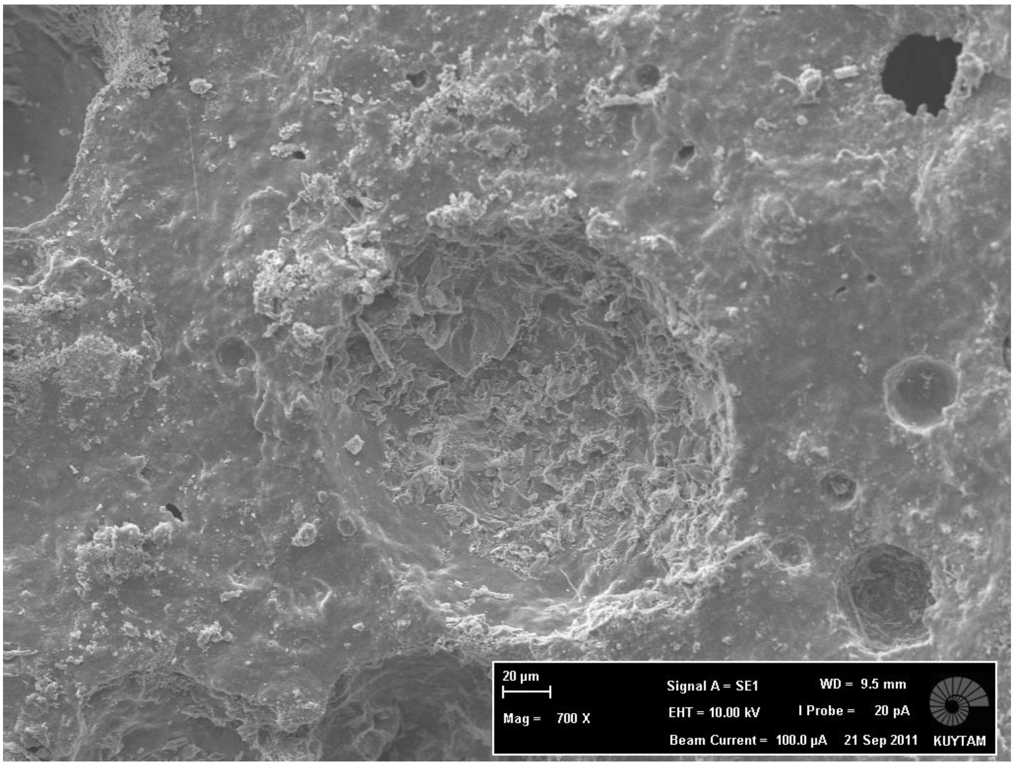


Figure 4. 43:Closer view to the microstructure of bloating pores of R04-328.

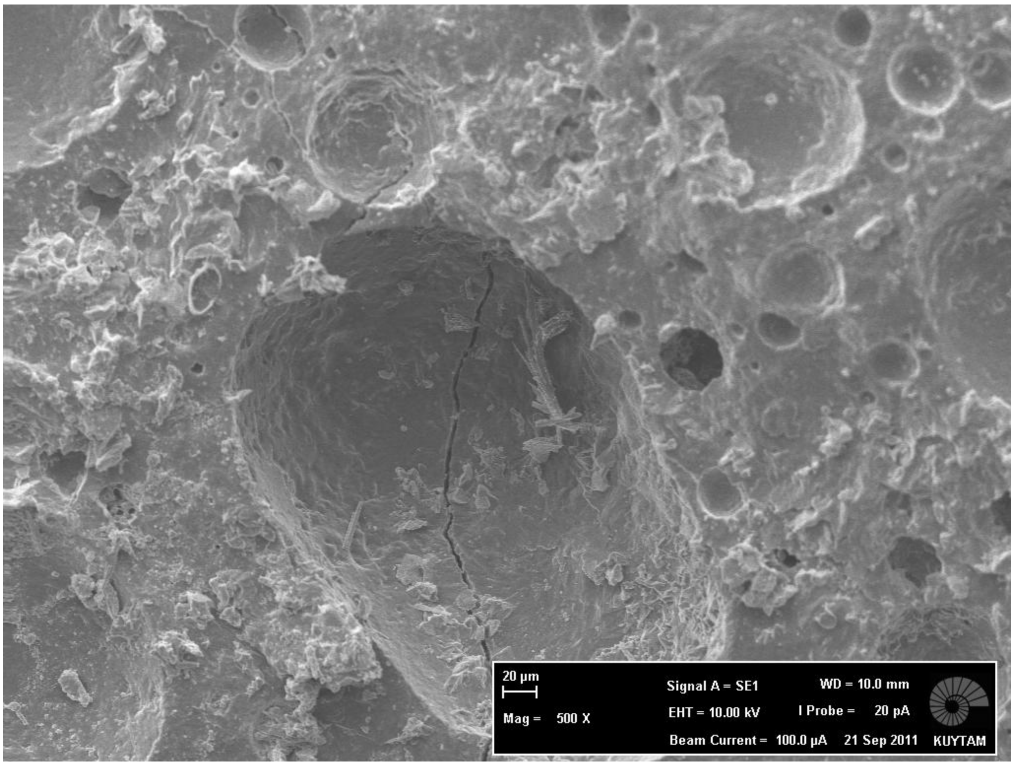


Figure 4. 44:Closer view to the microstructure of bloating pores of R04-328.

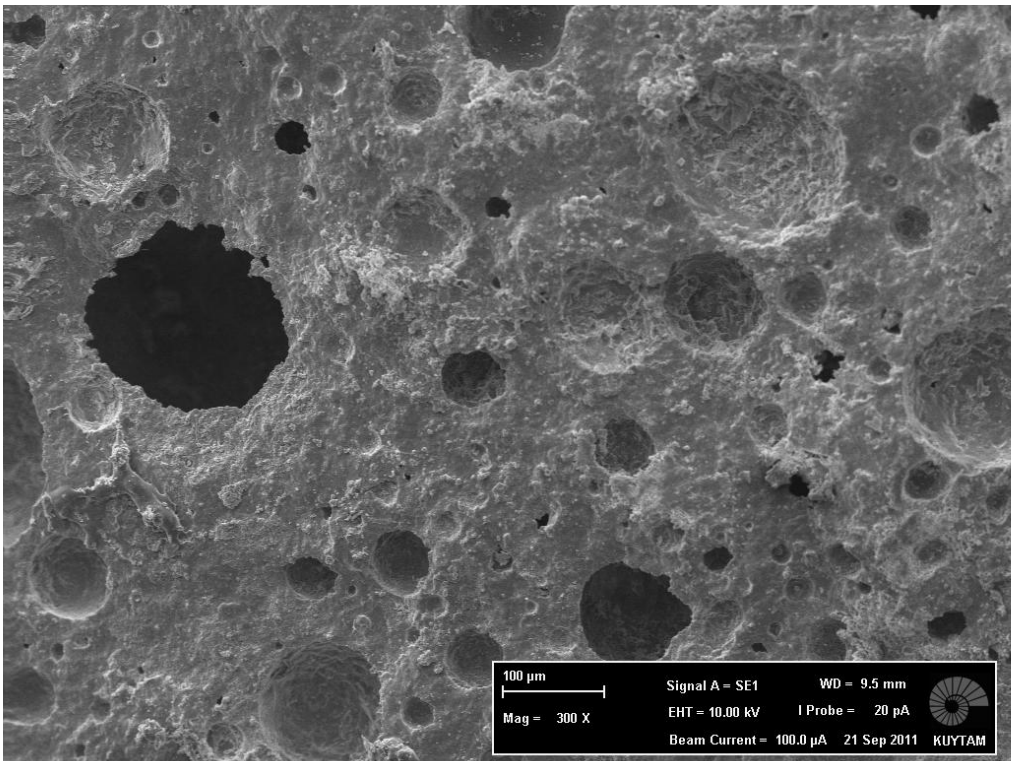


Figure 4. 45:SEM image of R04-534 showing the bloating pores, firing temperature 1150°C.

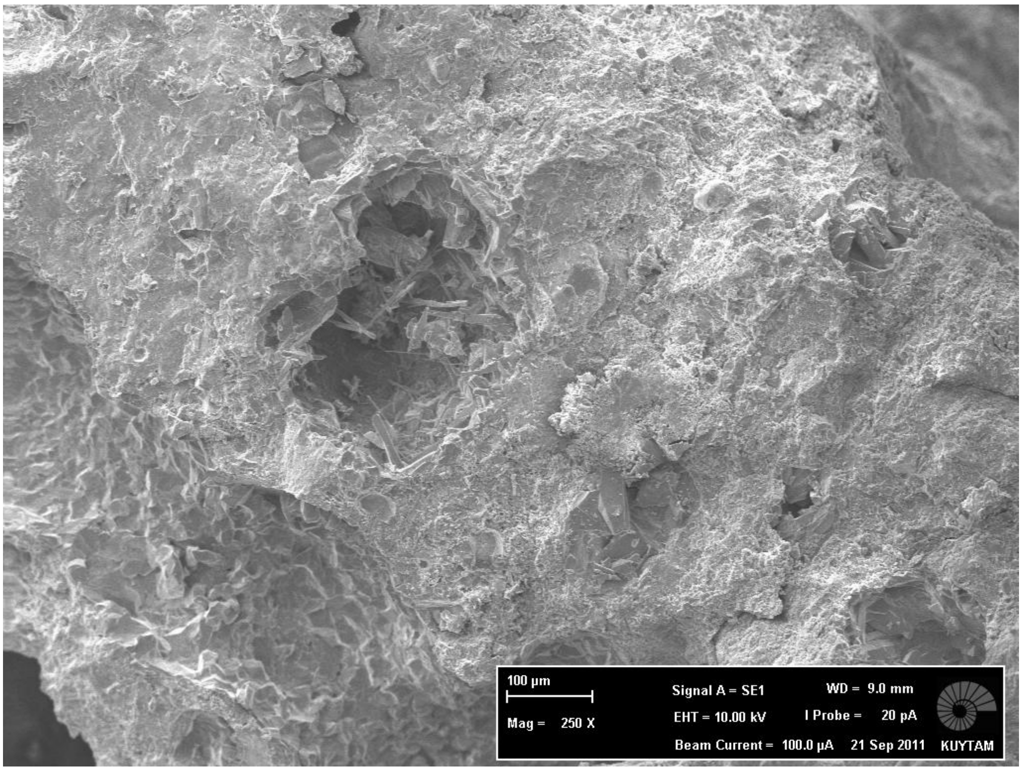


Figure 4. 46:250x magnified SEM image of R04-534.

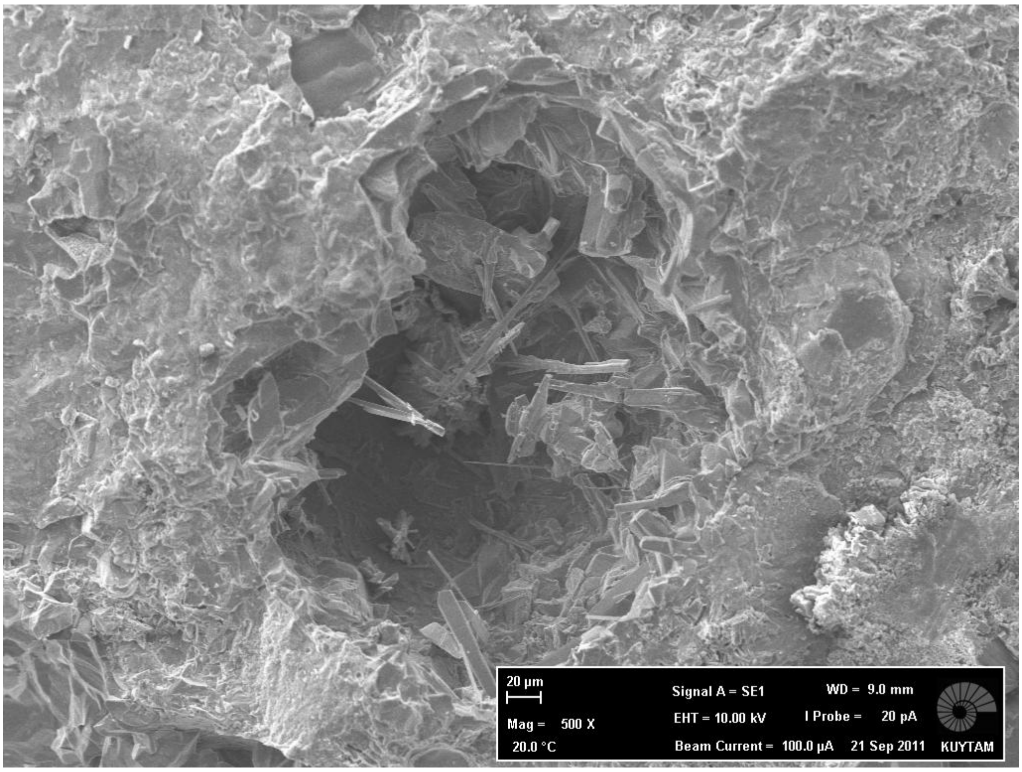


Figure 4. 47:500x SEM image of the feratures of R04-534.

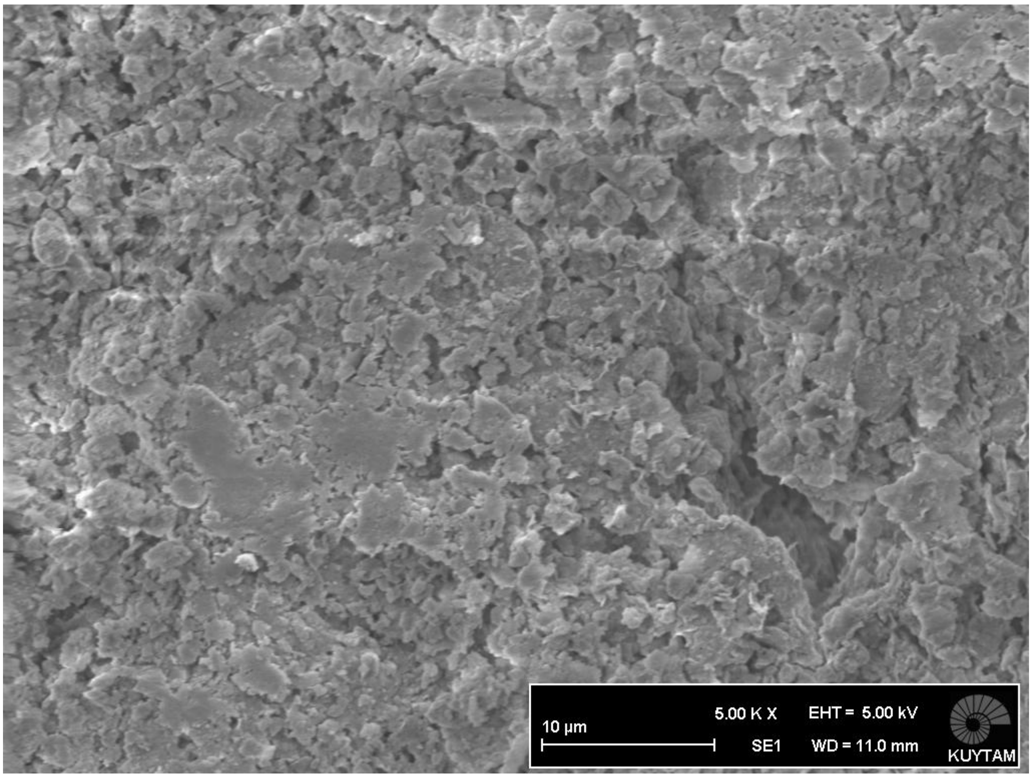


Figure 4. 48:SEM image of plasters sample R04-581 sample from Installation 2, IV, 750-800°C.

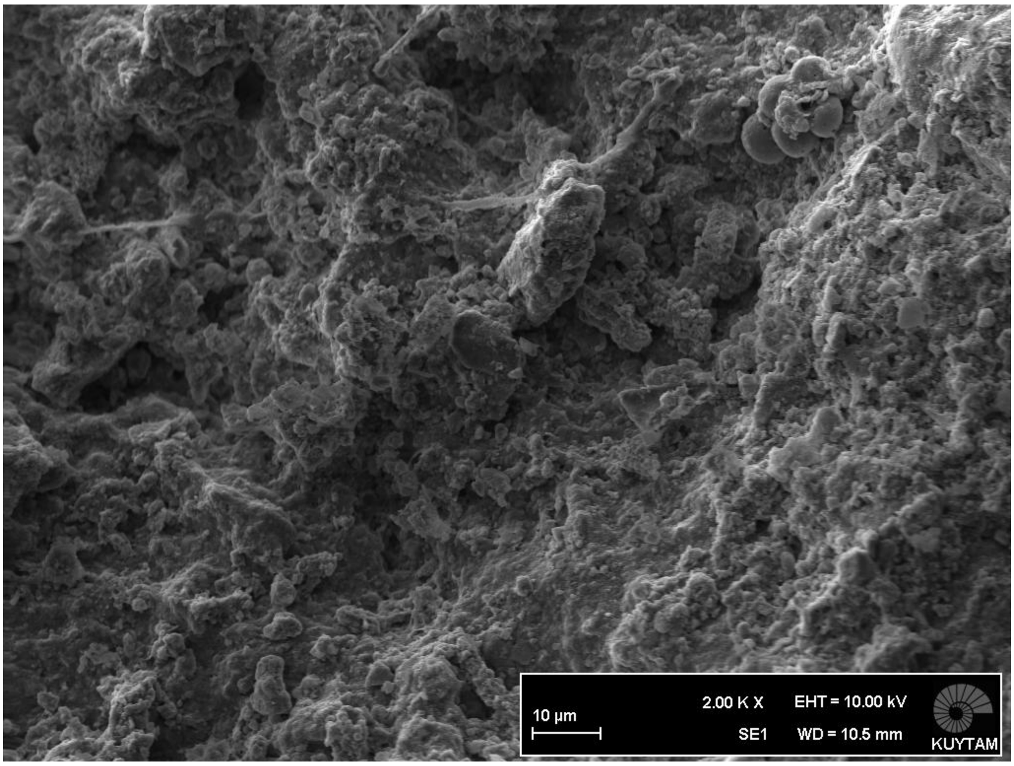


Figure 4. 49:SEM image of R04-607 sample from Installation 2, IV, 750-800°C.

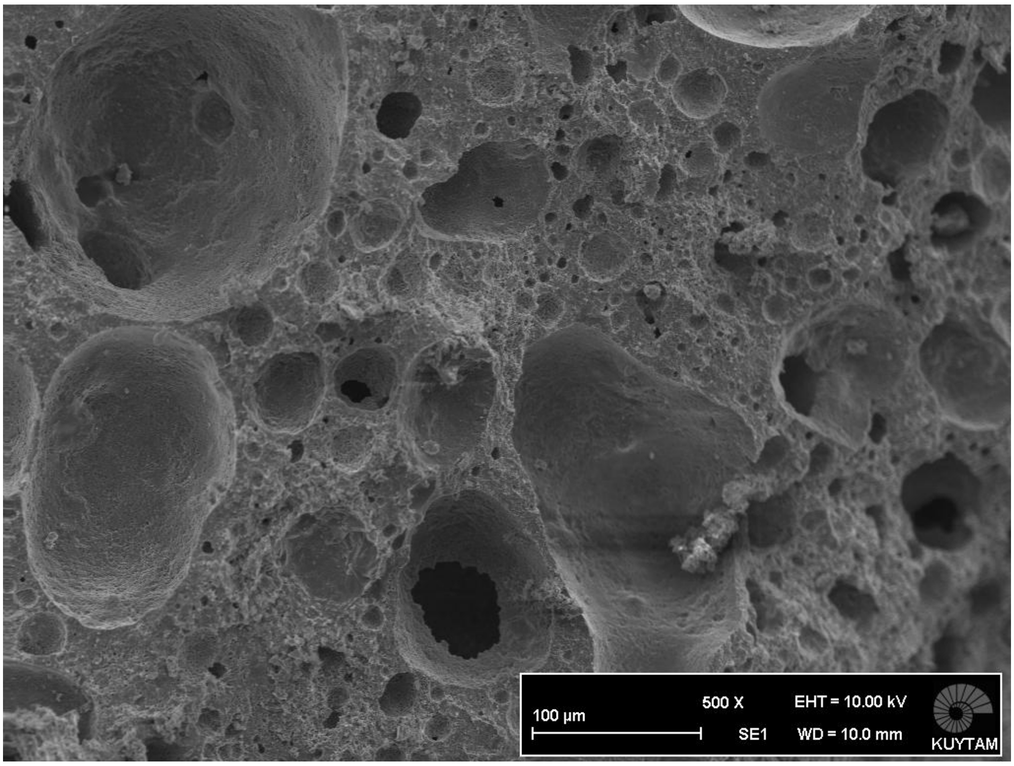


Figure 4. 50:SEM image of Installation 5 sample R04-560, TV, estimated firing temperature 1150-1200 °C.

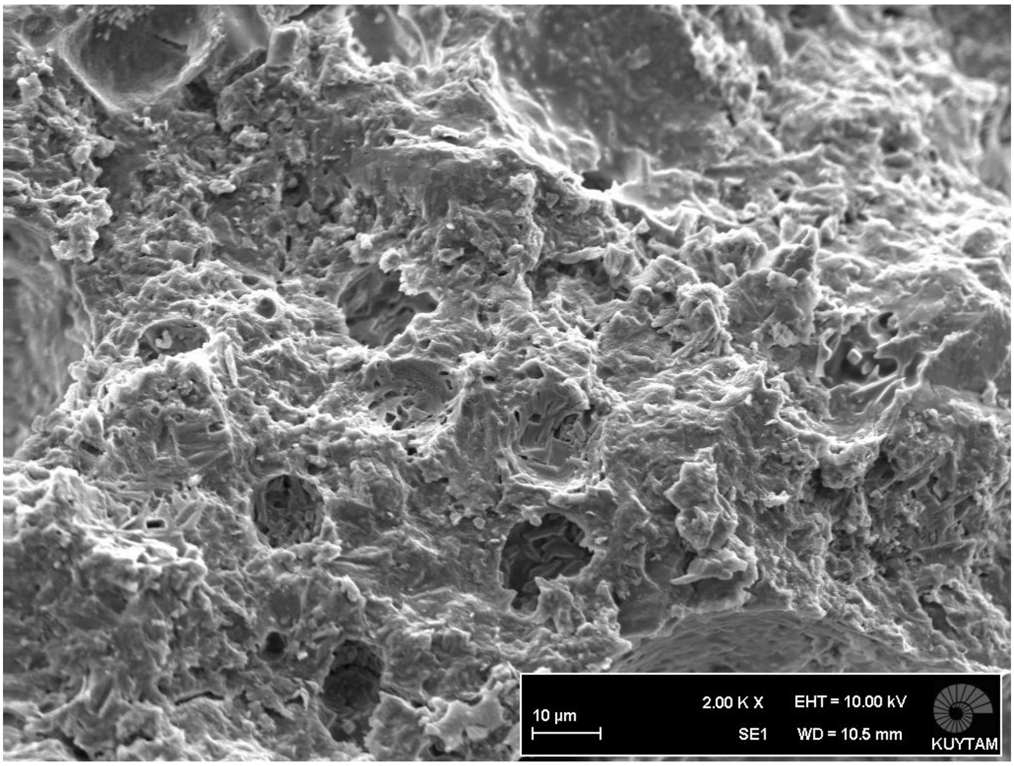


Figure 4. 51:SEM image of Installation 5 sample R04-452, TV, estimated firing temperature 1100°C.

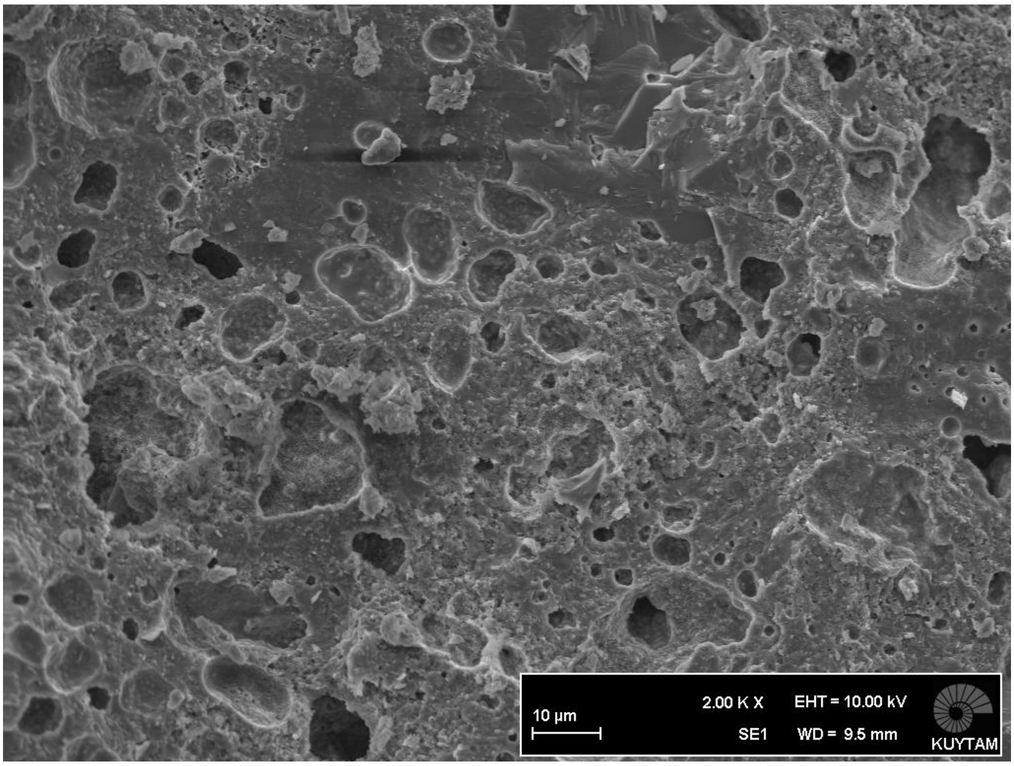


Figure 4. 52:SEM image of Installation 5 sample R04-428, TV, estimated firing temperature 1100°C.

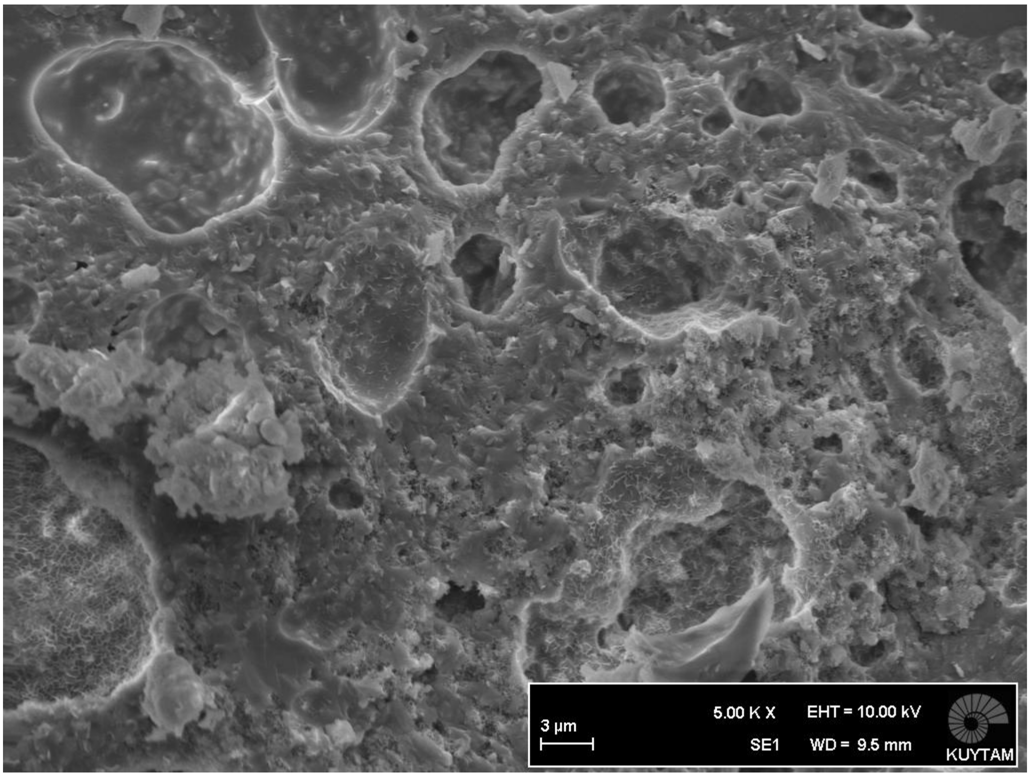


Figure 4. 53:SEM image of Installation 5 sample R04-428, TV, estimated firing temperature 1100°C. Closer view to the bloating pores.

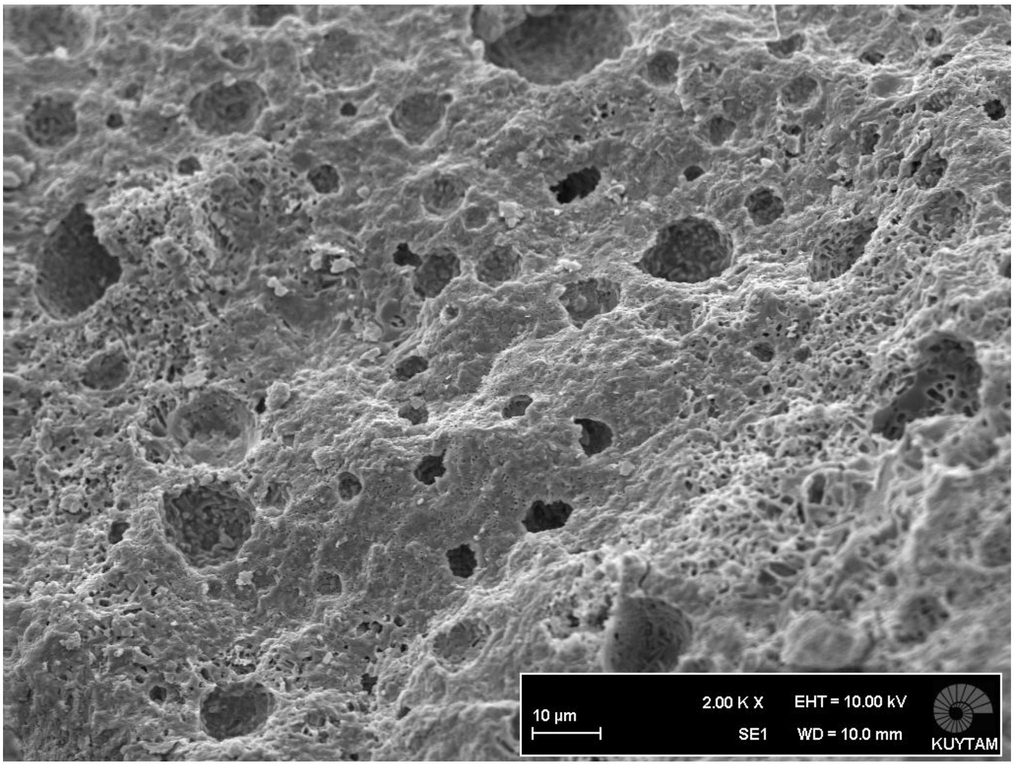


Figure 4. 54:SEM image of Installation 2 or 5 sample R04-538, TV, estimated firing temperature 1100°C.

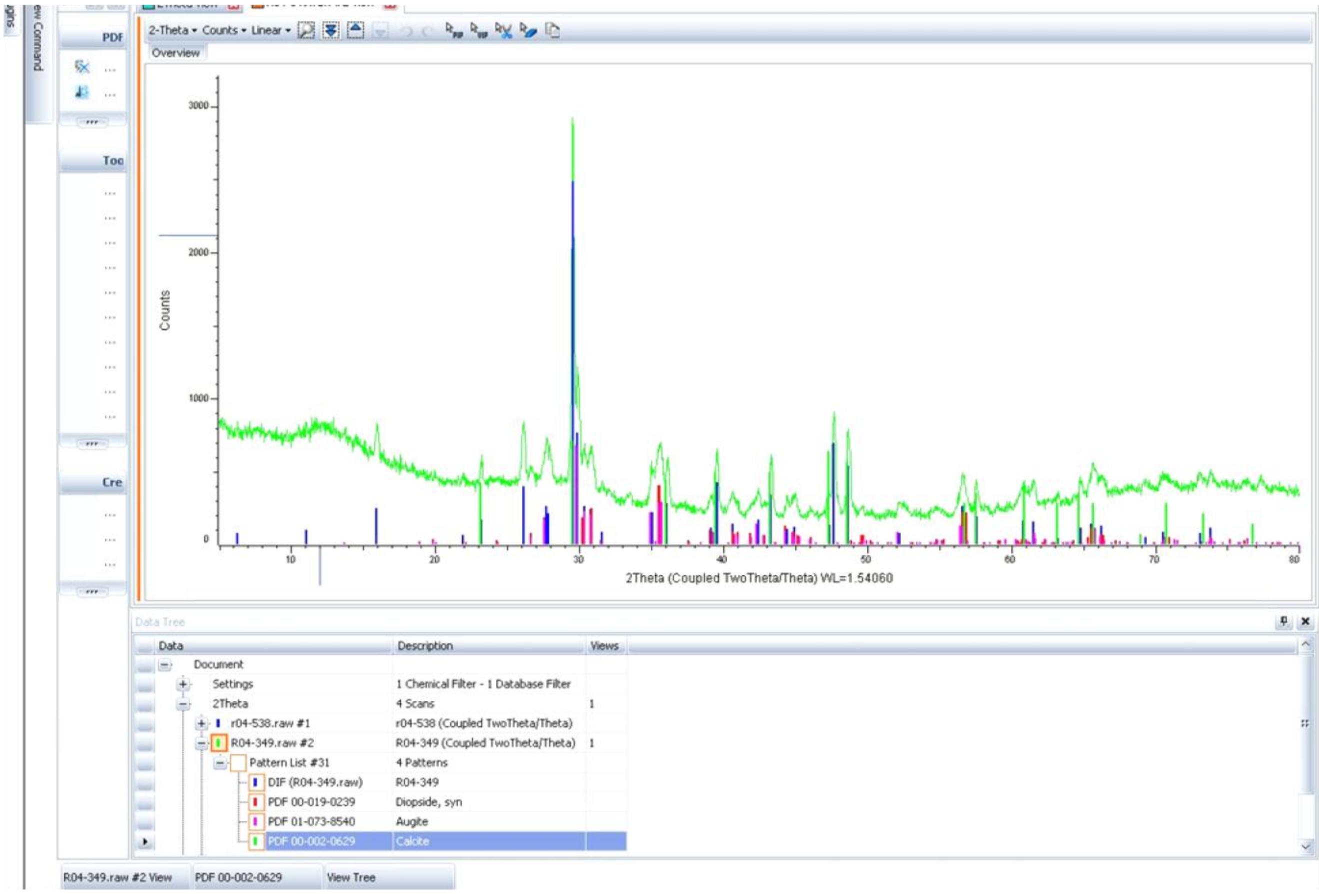


Figure 4. 55:XRD Diagram of R04-349.

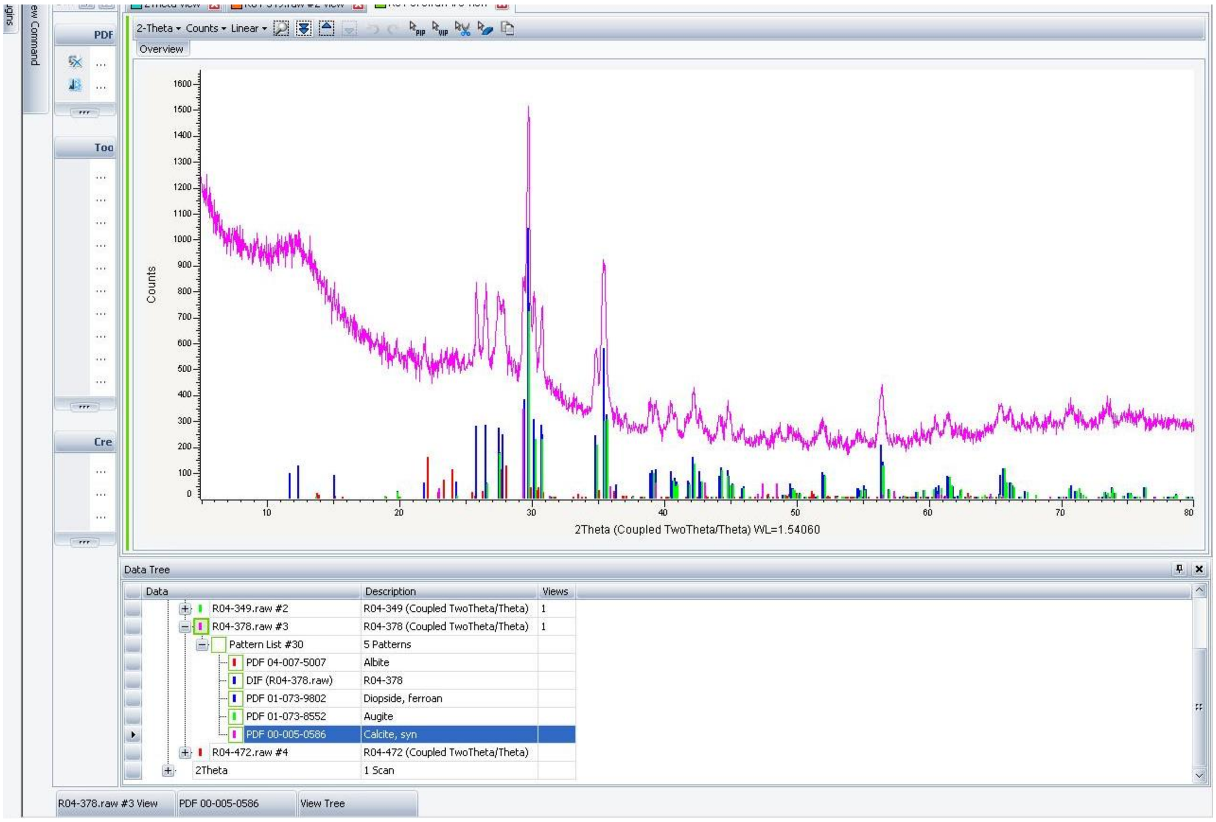


Figure 4. 56:XRD Diagram of R04-378.

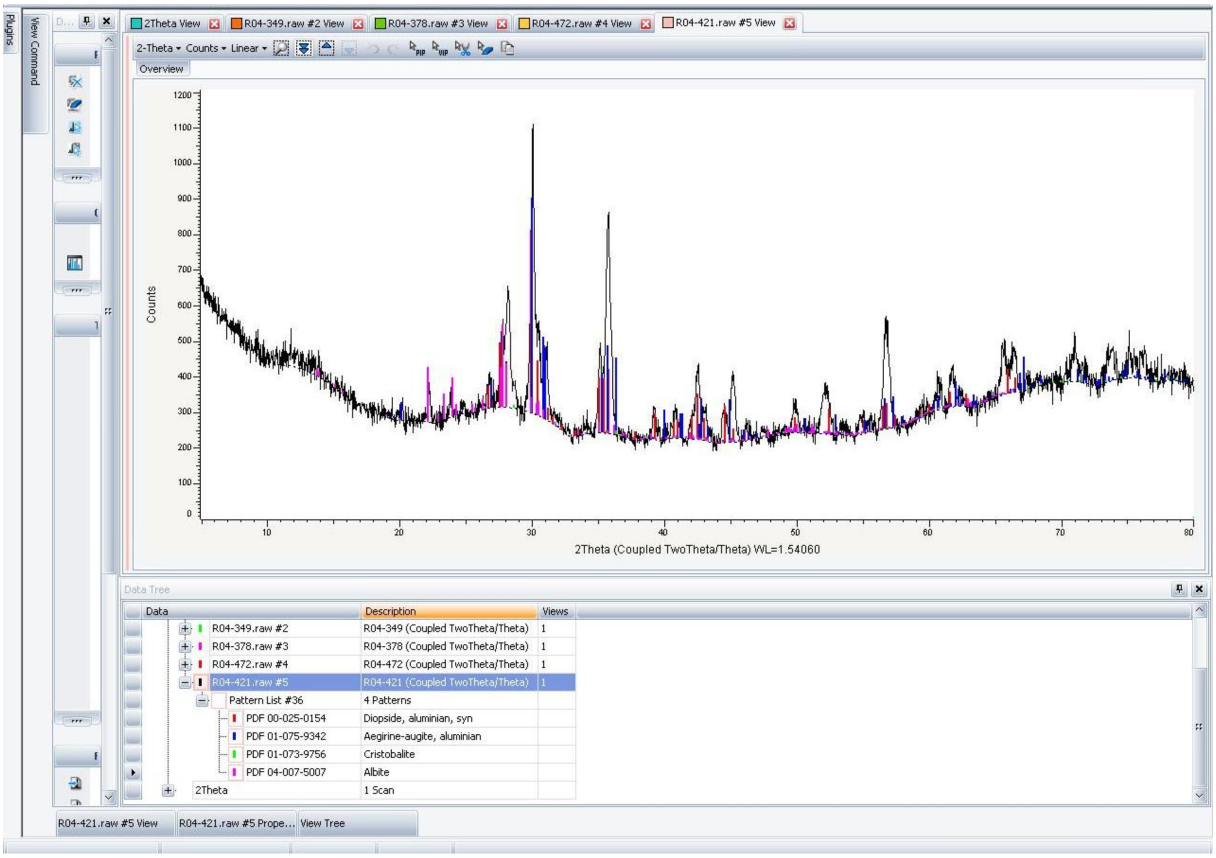


Figure 4. 57:XRD Diagram of R04-421.

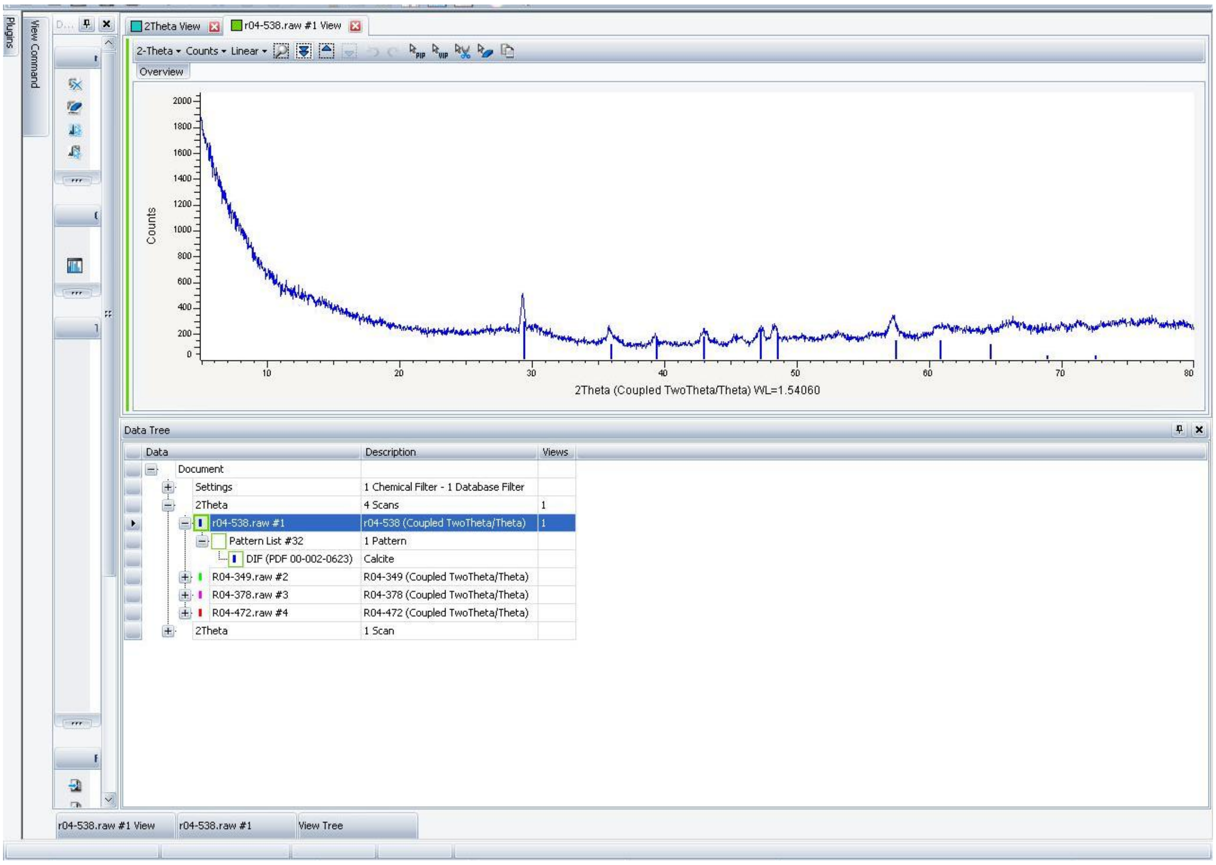


Figure 4. 58:XRD Diagram of R04-538.

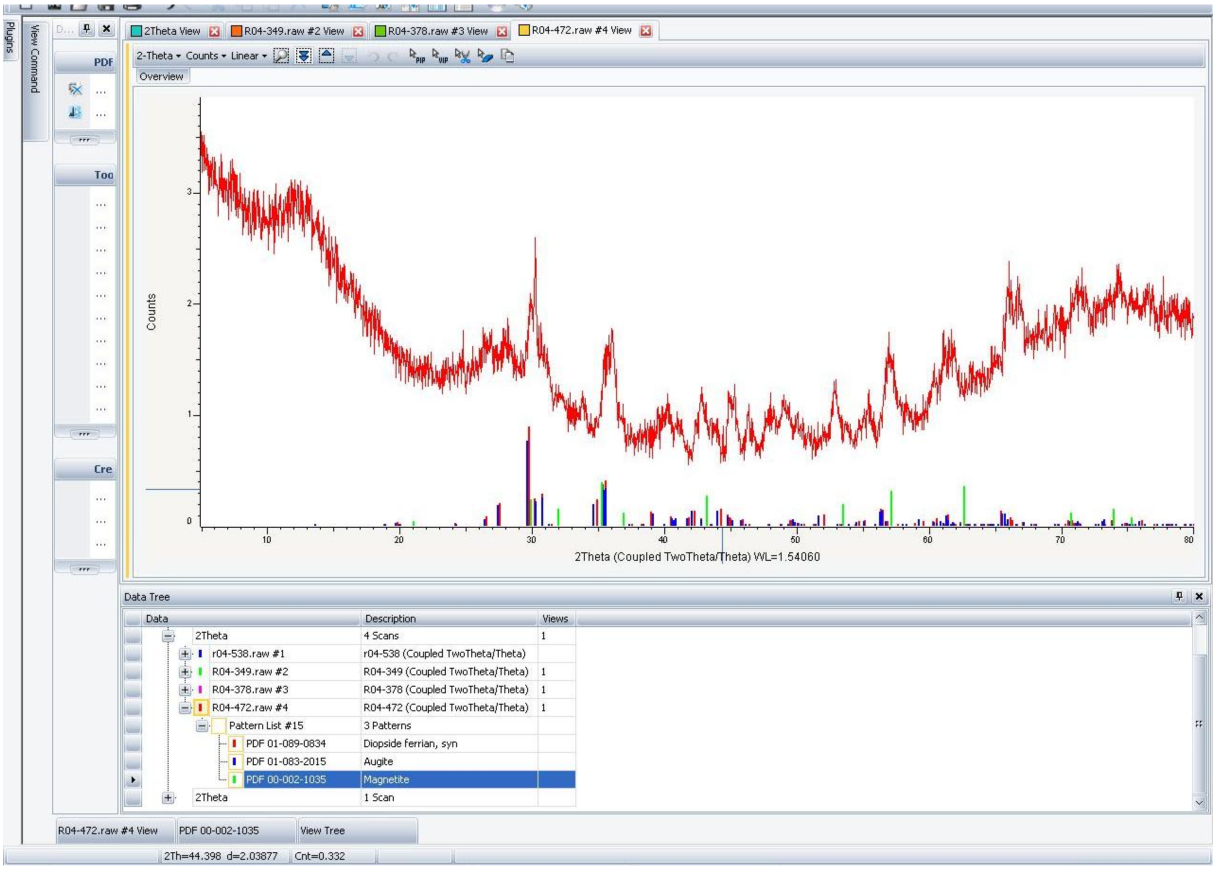


Figure 4. 59:XRD Diagram of R04-472.

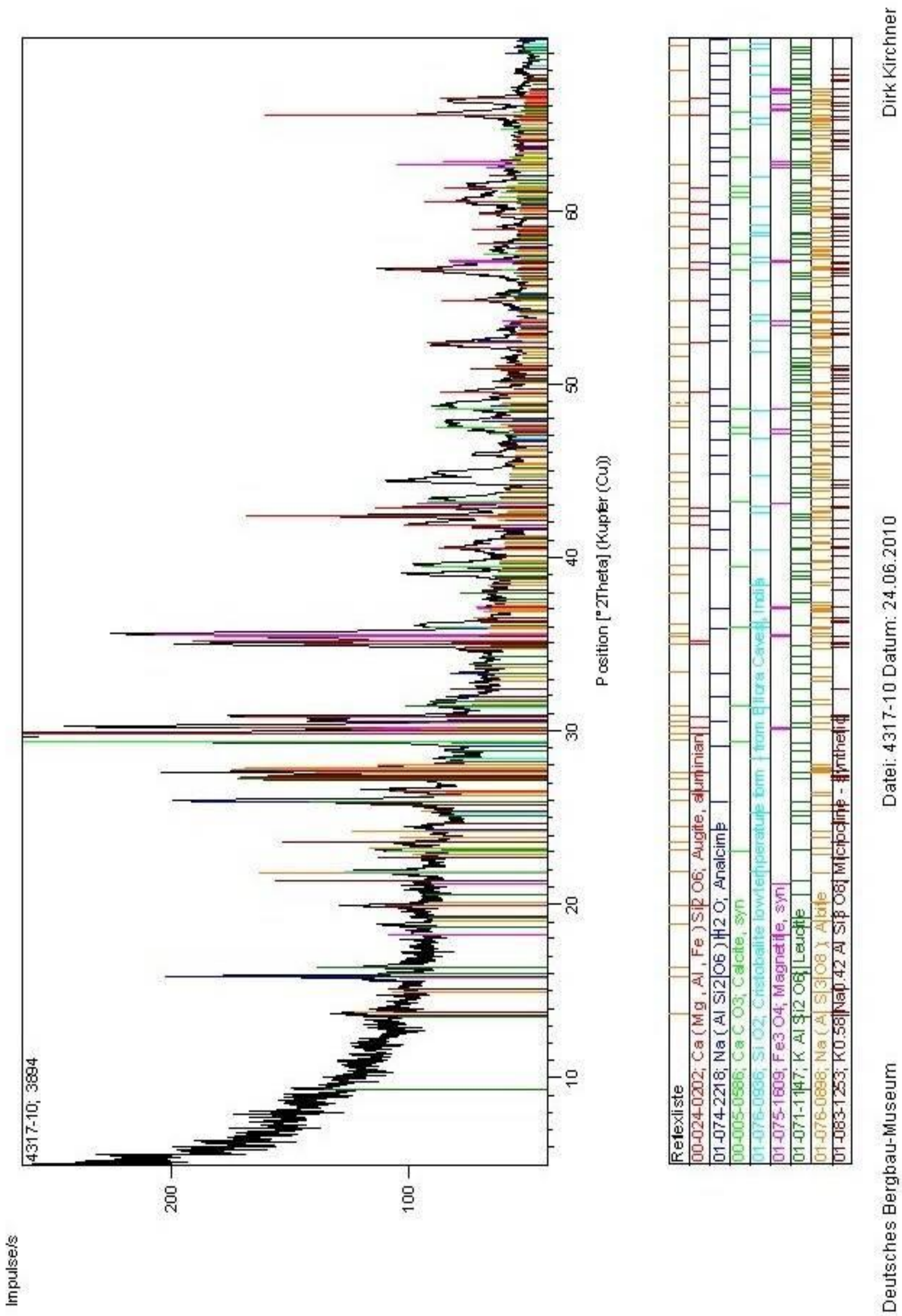


Figure 4. 60: XRD diagram of AT 3894.

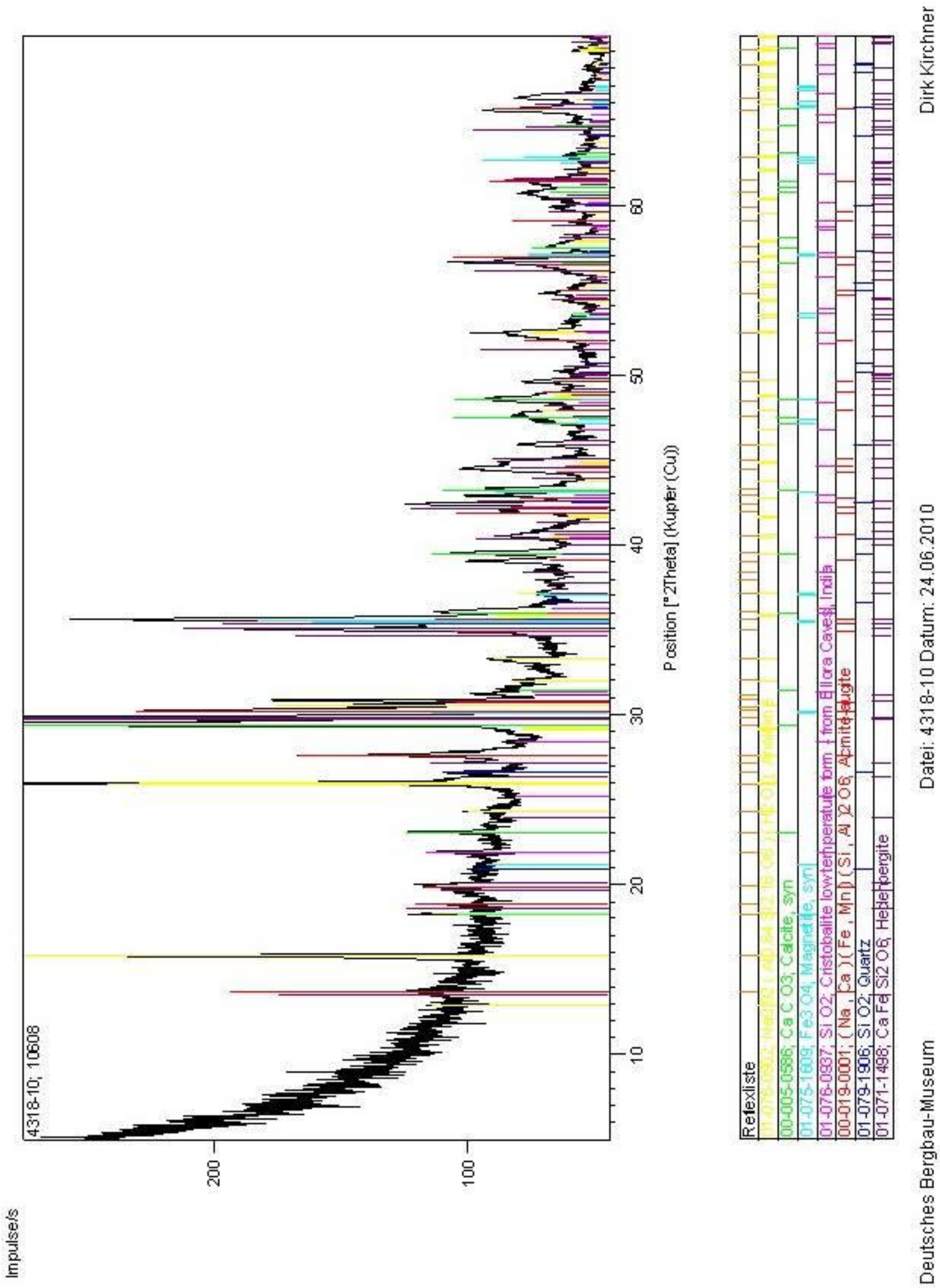


Figure 4. 61: XRD diagram of AT 10608.

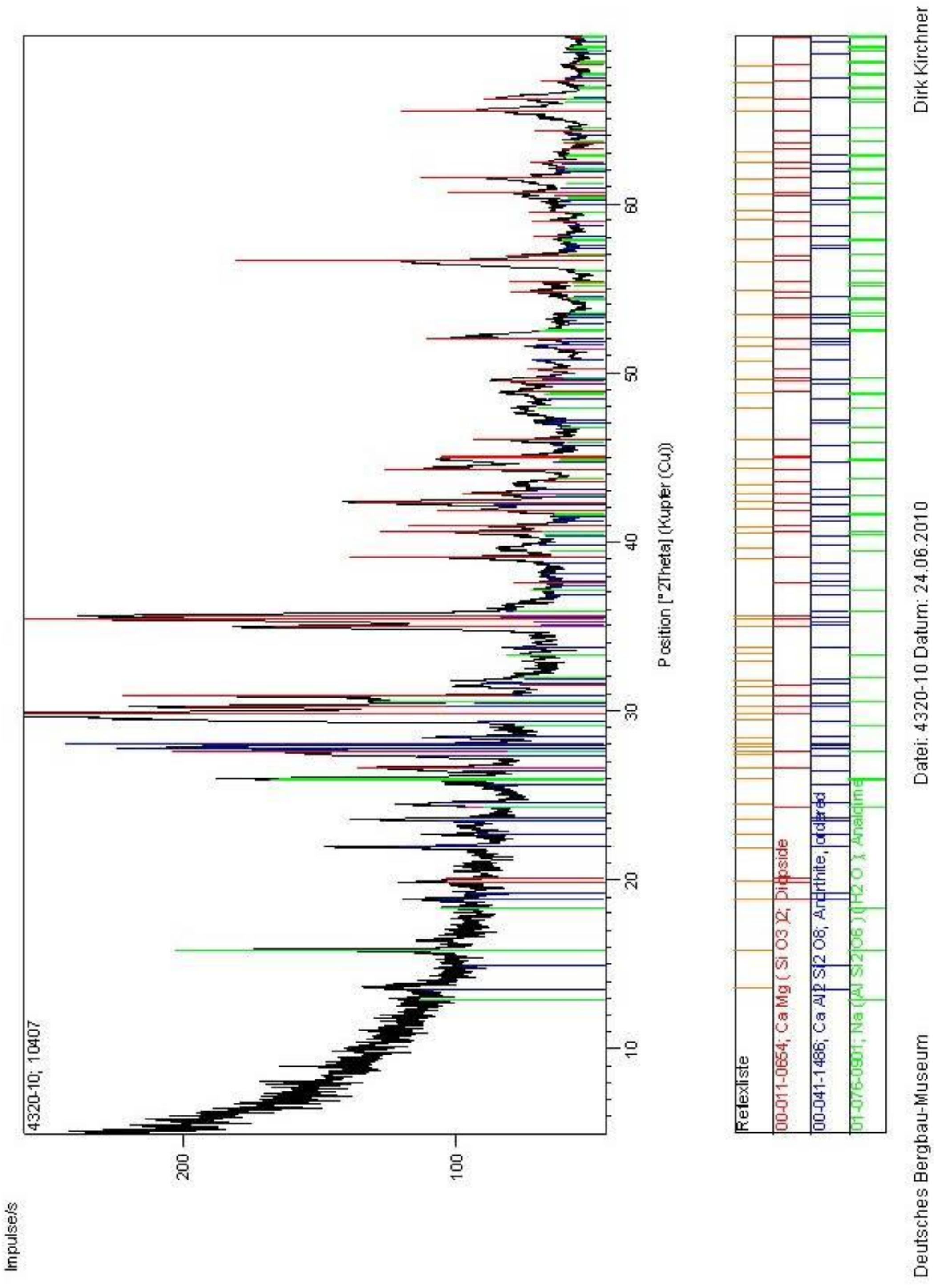


Figure 4. 62: XRD diagram of AT 10407.

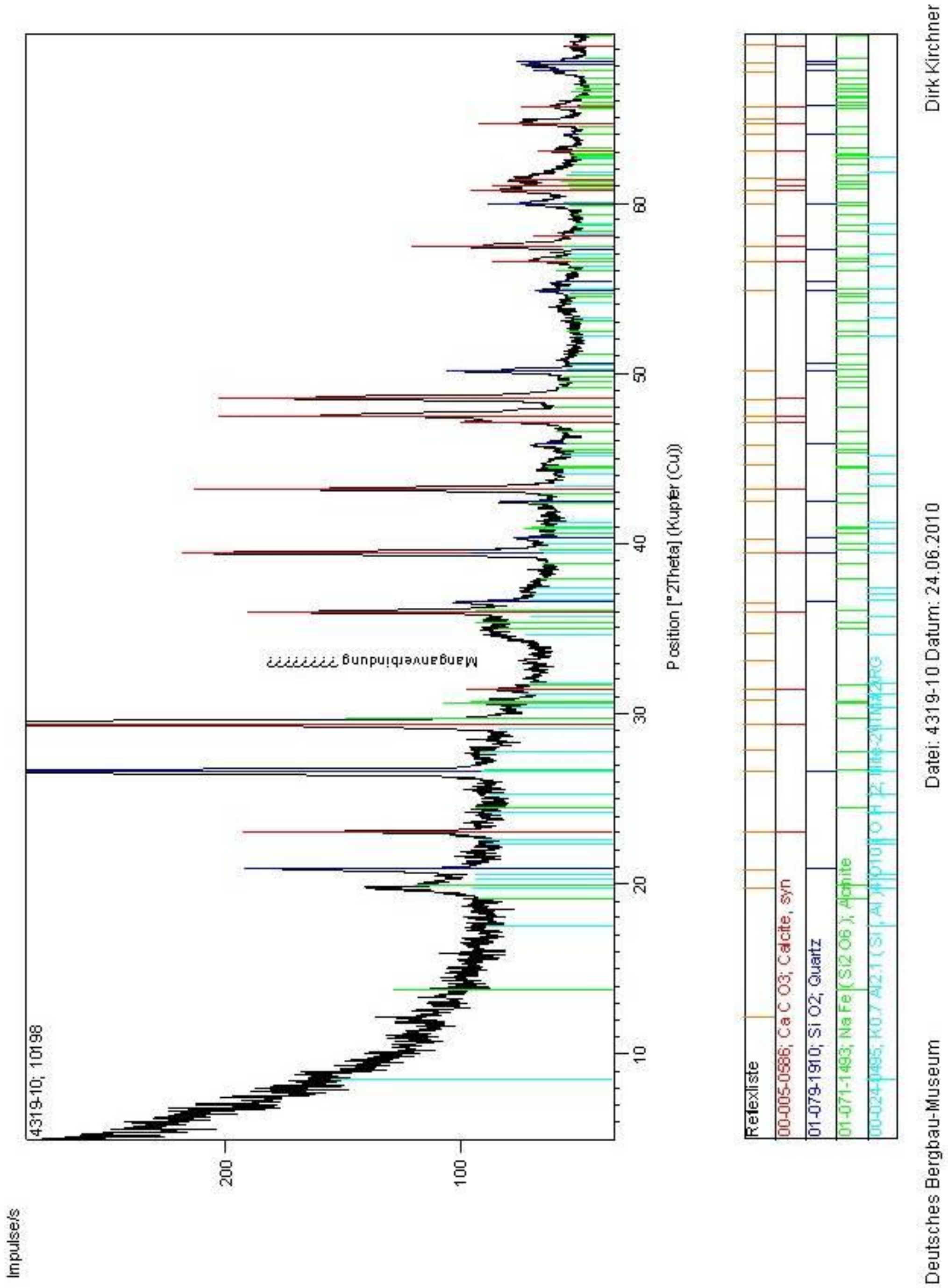


Figure 4. 63: XRD diagram of AT 10198.

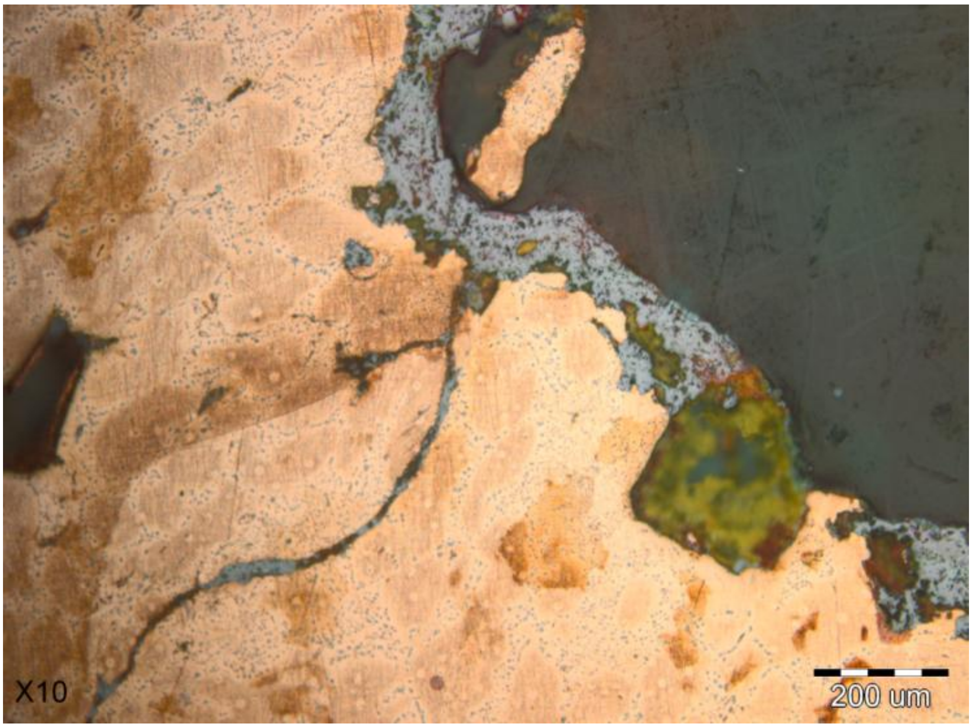


Figure 4. 64: Microscopic scene of etched metal surface x10 of sample A03-R1366. Tin as well as sulphur is clear in the cross-section image.

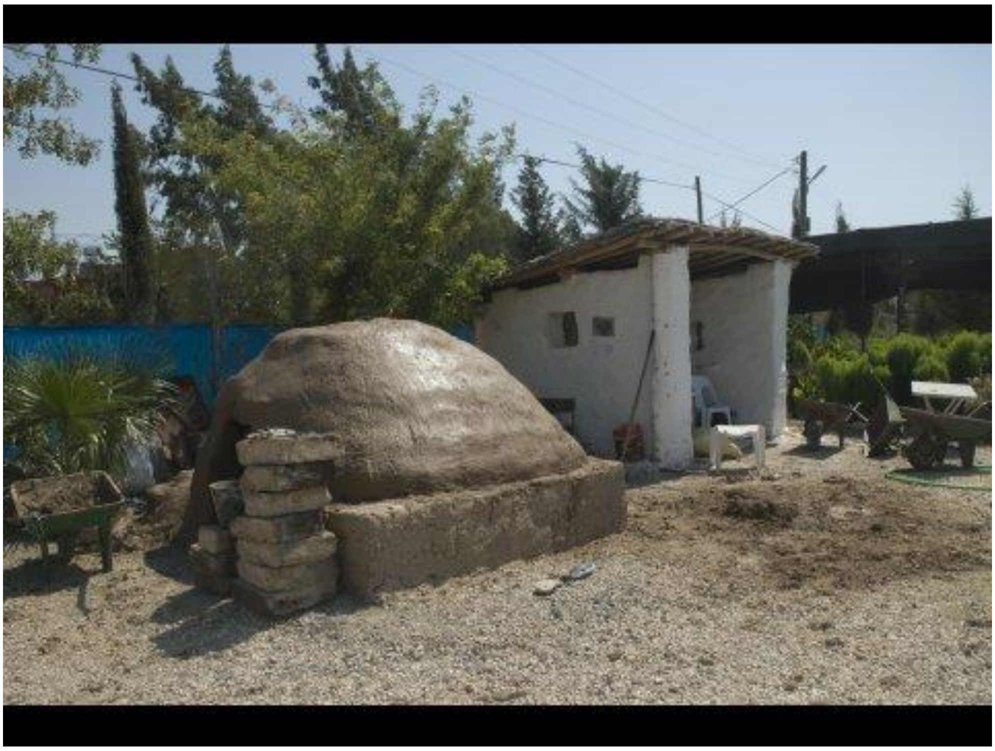


Figure 4. 65: Experimental Archaeology Project of 2010: Reconstruction of the Installation 2.

Figure 4. 66:Lower deck of the Reconstructed Kiln.

Figure 4. 67:Upper deck of the Reconstructed Kiln.

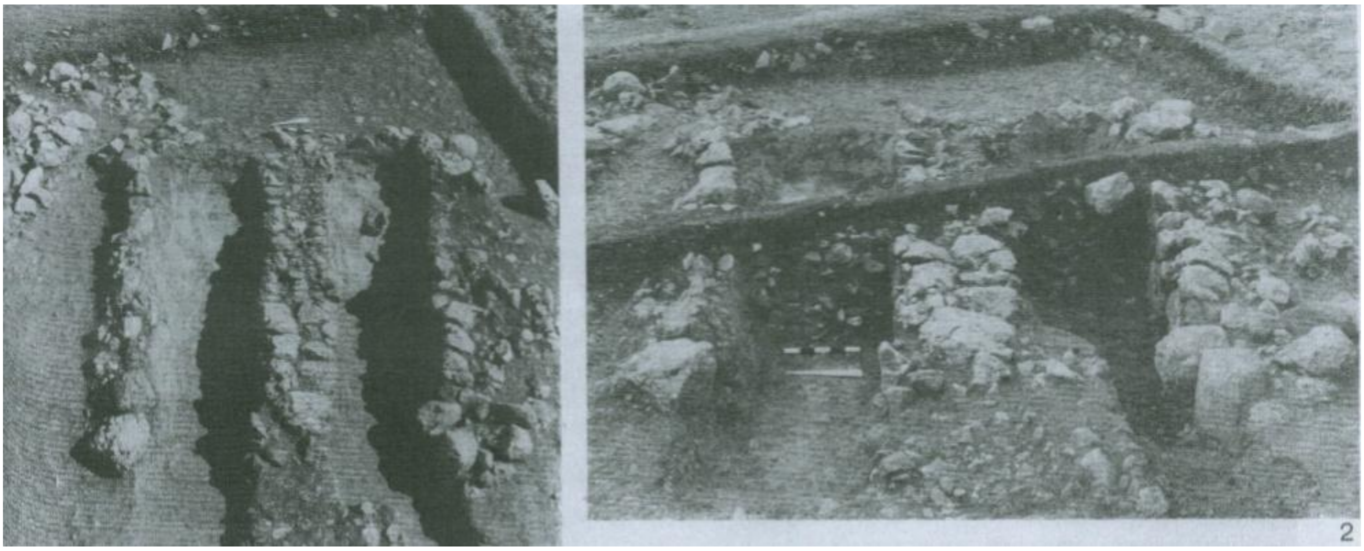


Figure 5. 1:Hattusa-Boğazköy Ofen 1 (Müller-Karpe 1988:taf.63, 1-5).

Figure 5. 2:The Late Minoan pottery kiln from Kommos Crete (Shaw 2001).

Figure 5. 3:Büyükkaya Pottery Kiln (Seeher 1996: 335–36, Abb. 3).

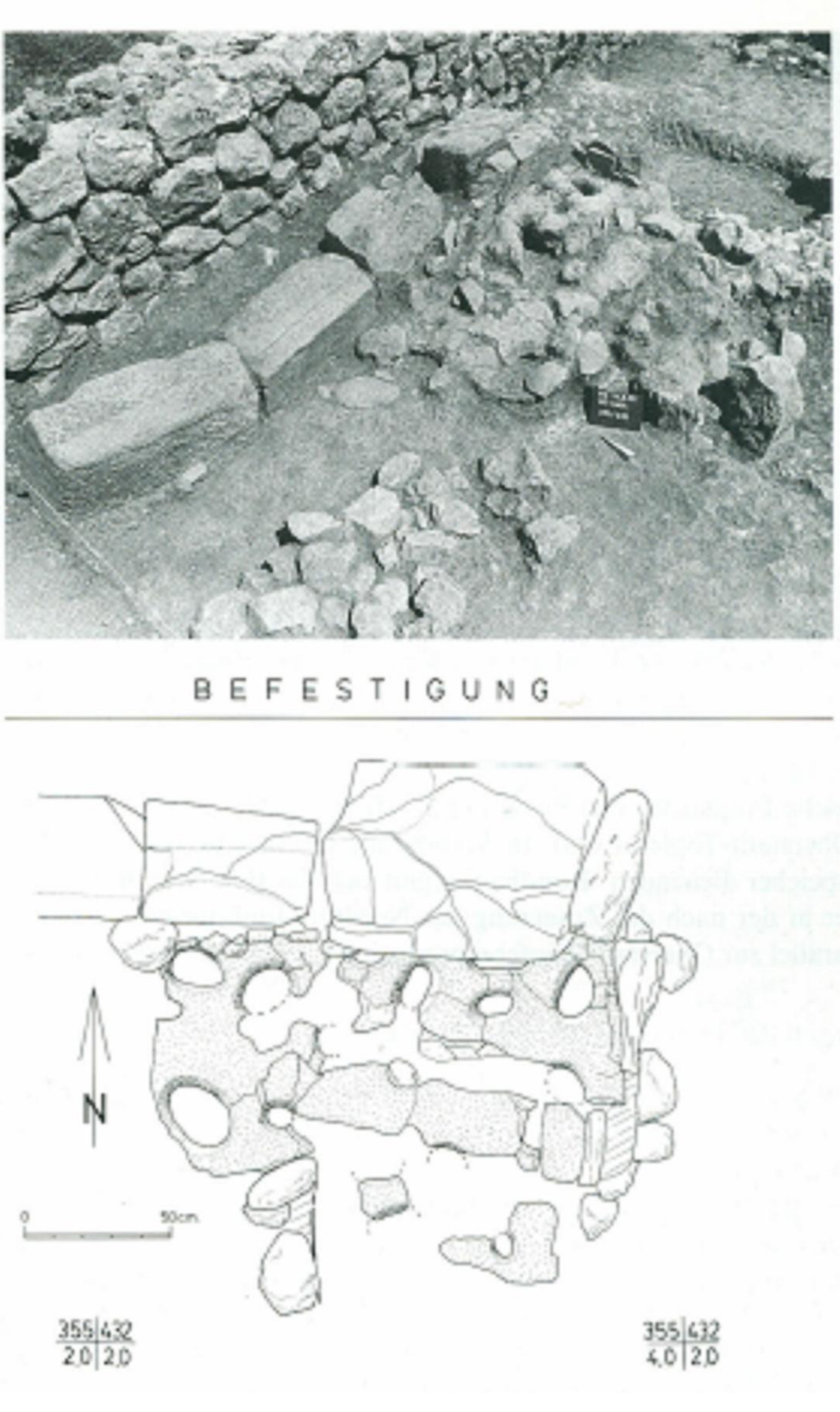


Figure 5. 4:Büyükkaya Pottery Kiln (Seeher 1996: 337, Abb. 4–5).

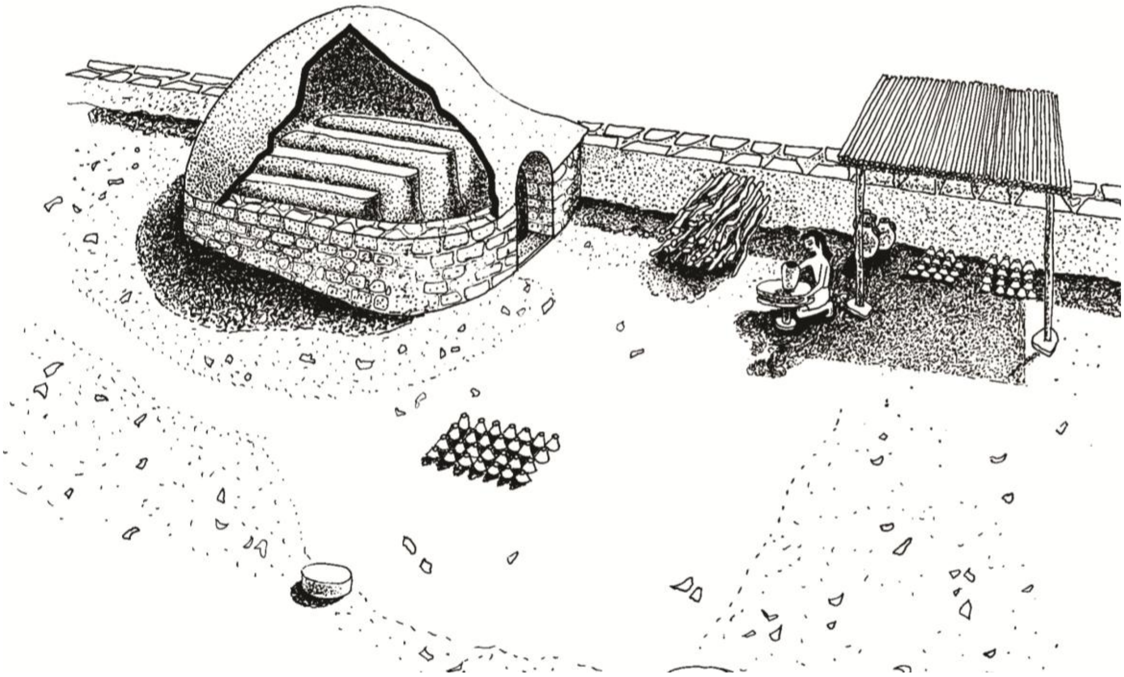


Figure 5. 5:Reconstruction of Kommos-Crete pottery kiln by G. Bianco (in Shaw 2001:23).

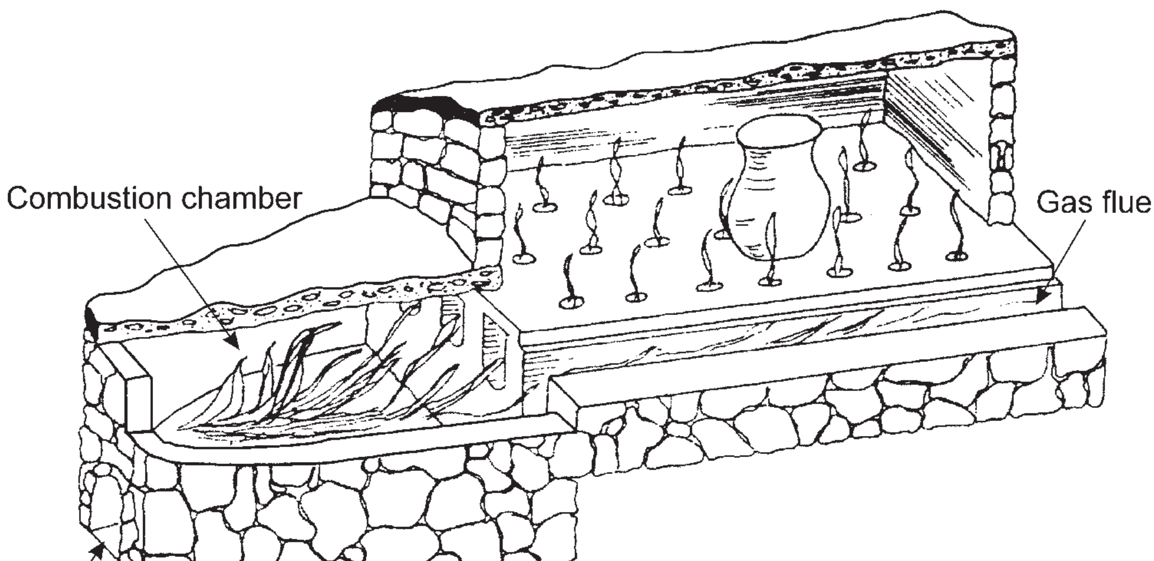


Figure 5. 6:Hagia Triada kiln (Di Vita et al. 1984, fig. 277).

Figure 5. 7: Hattusa-Boğazköy Ofen 1 (Müller-Karpe 1988:taf.63, 6).

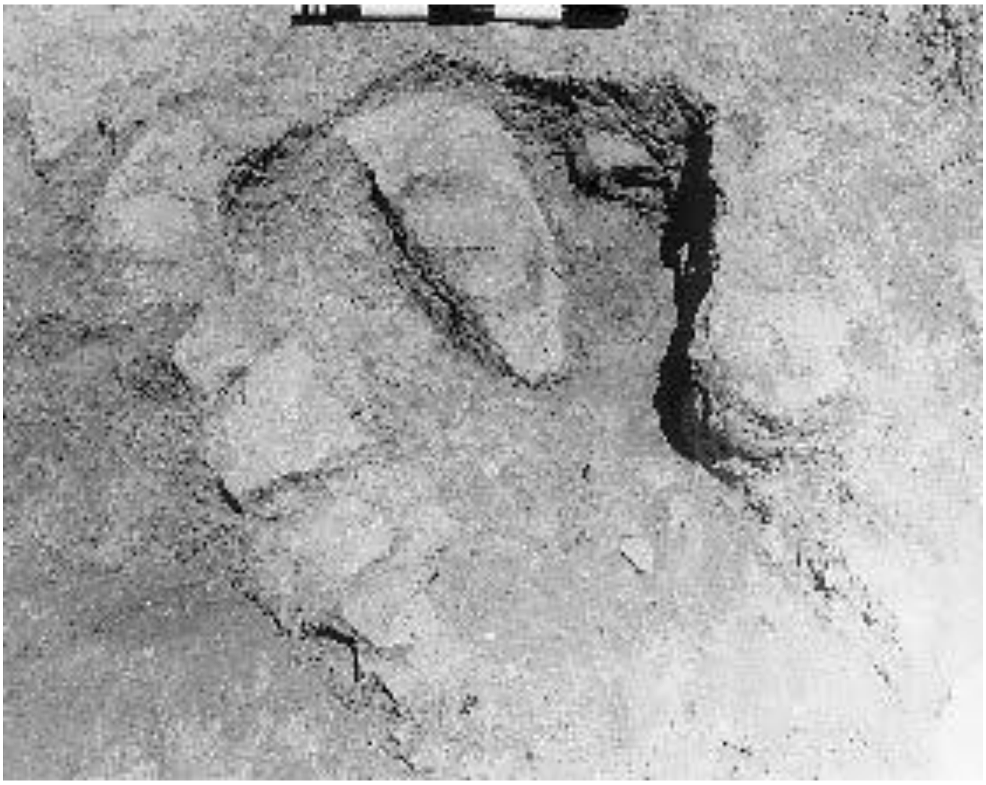


Figure 5. 8:Late Minoan III Oven from Kommos (Shaw 2001:fig.5).

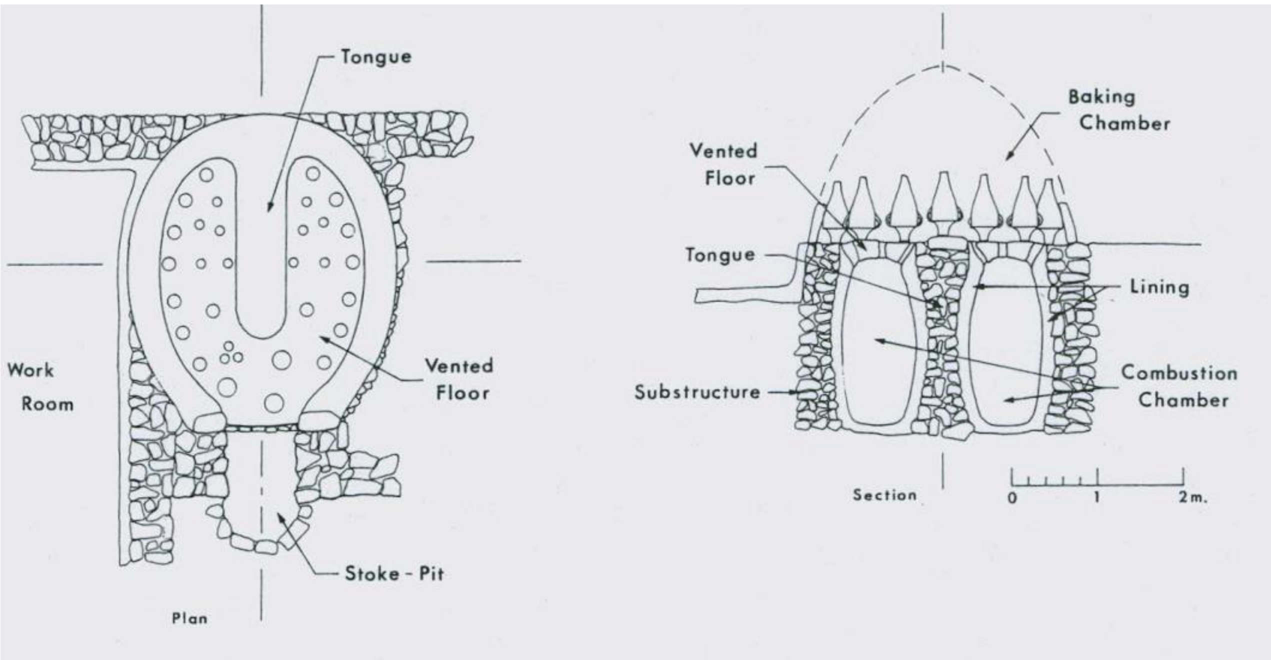
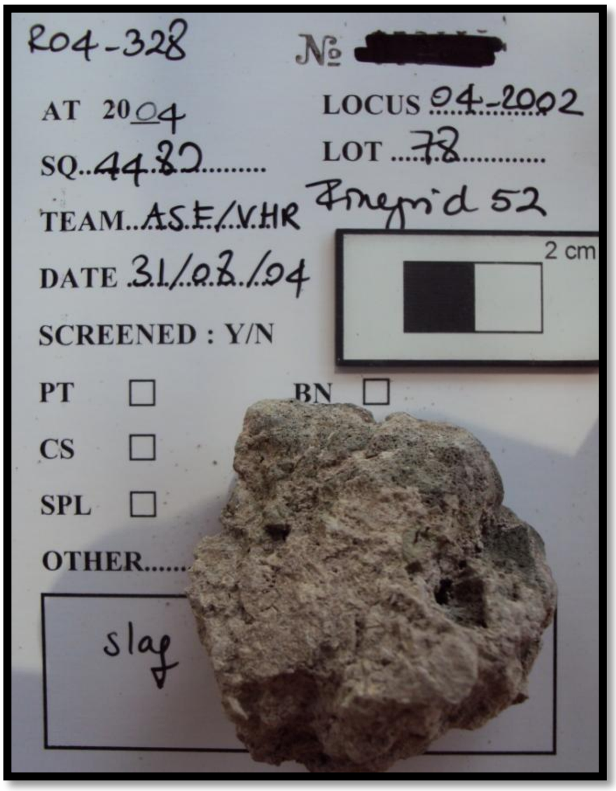


Figure 5. 9: Bilobate kiln typology of Sarepta (Anderson 1989:fig.5).

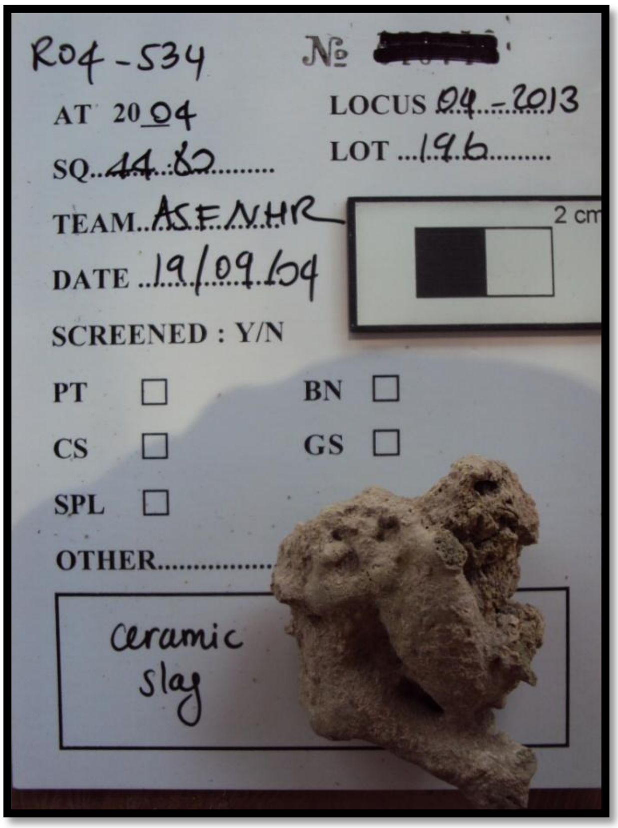
Figure 5. 10: Kiln C-D from Sarepta demostrating bilobate typology of pottery kilns (Anderson 1989:fig.8).

APPENDIX C

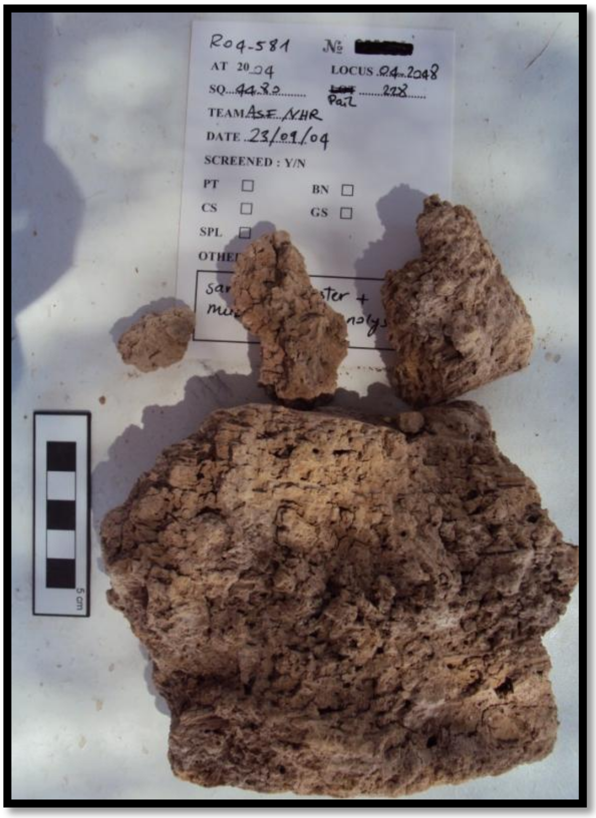
CATALOGUE



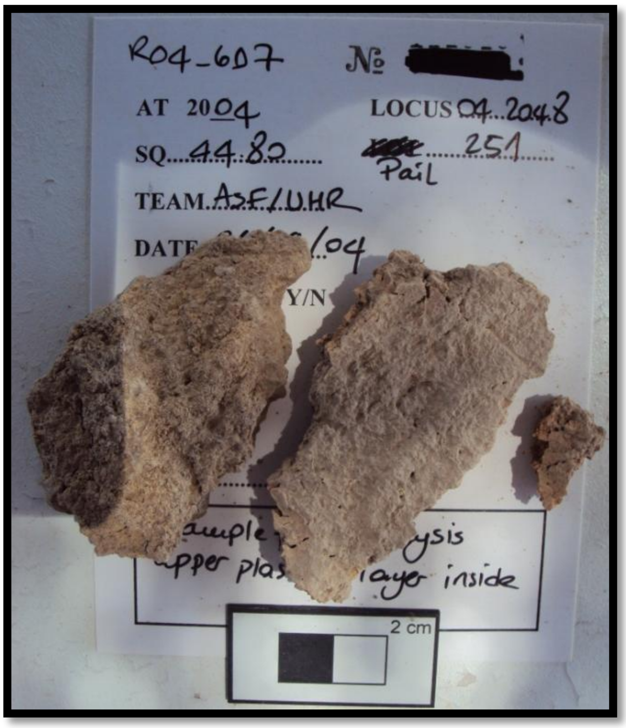
Catalogue 1: Sample R04-328



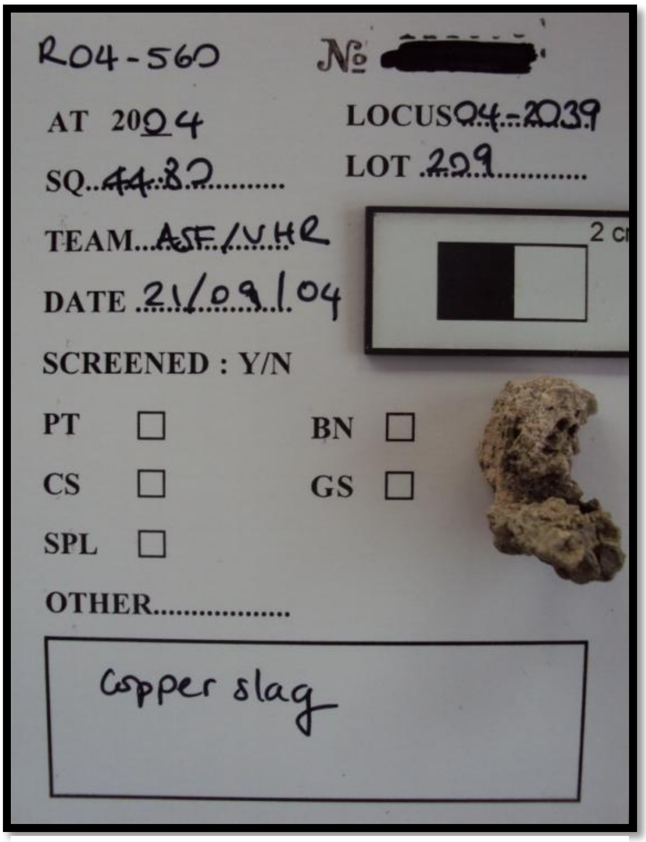
Catalogue 2: Sample R04-534



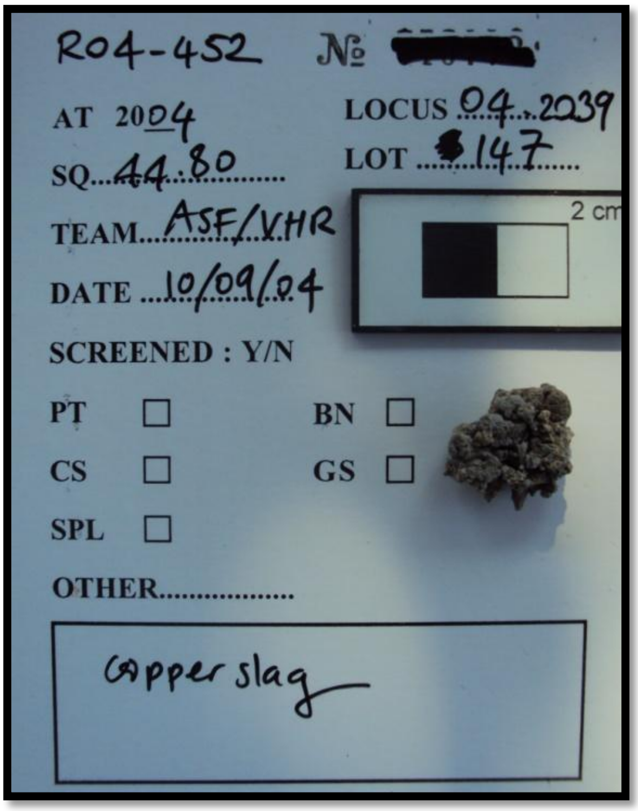
Catalogue 3: Sample R04-581



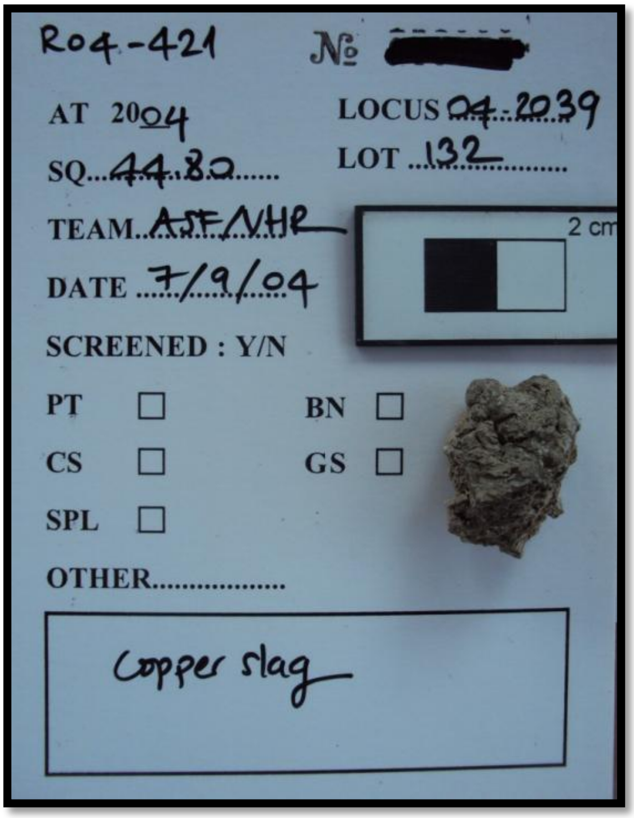
Catalogue 4: Sample R04-607



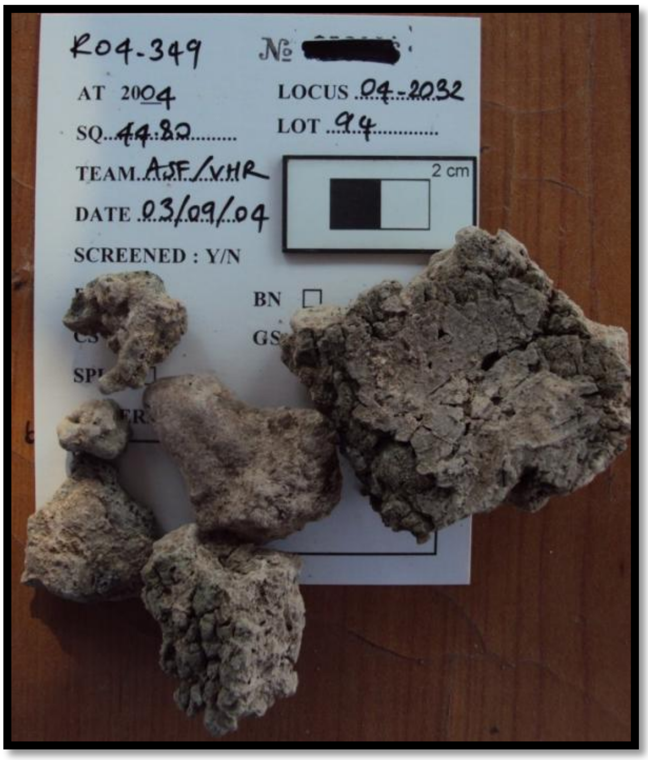
Catalogue 5: Sample R04-560



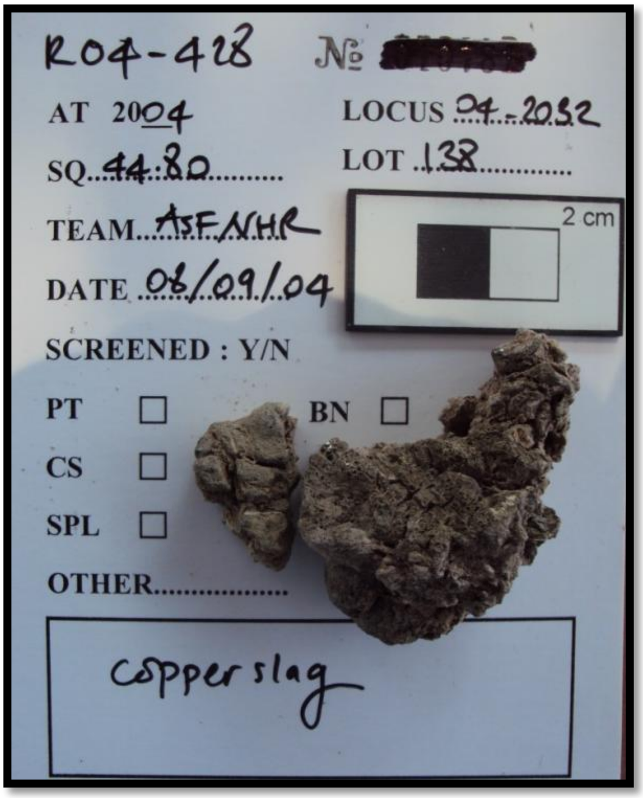
Catalogue 6: Sample R04-452



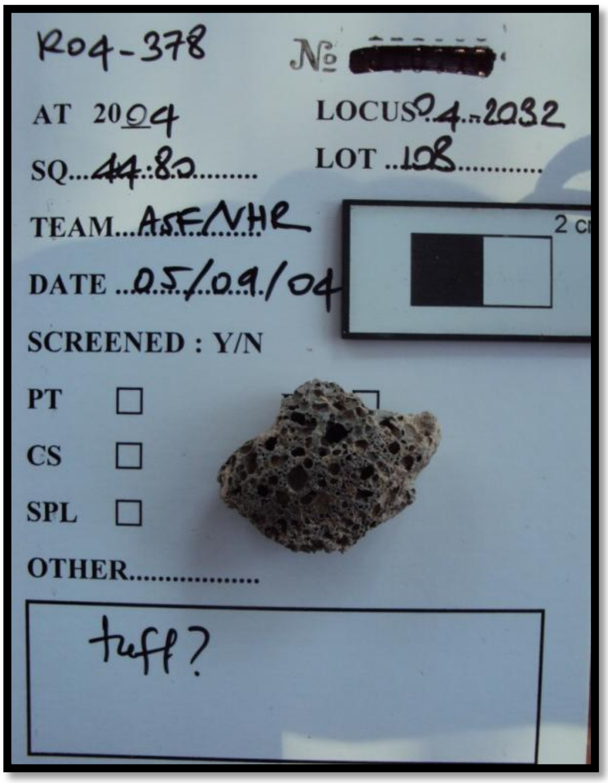
Catalogue 7: Sample R04-421



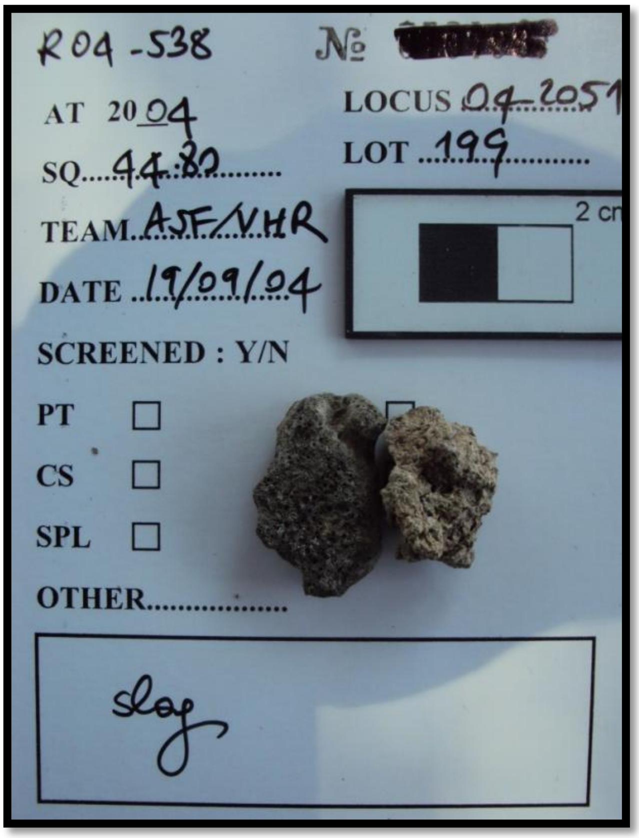
Catalogue 8: Sample R04-349



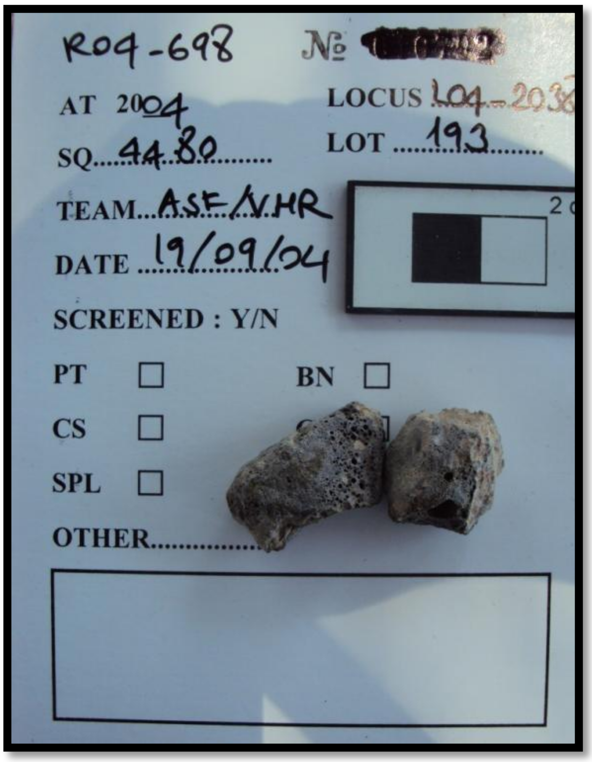
Catalogue 9: Sample R04-428



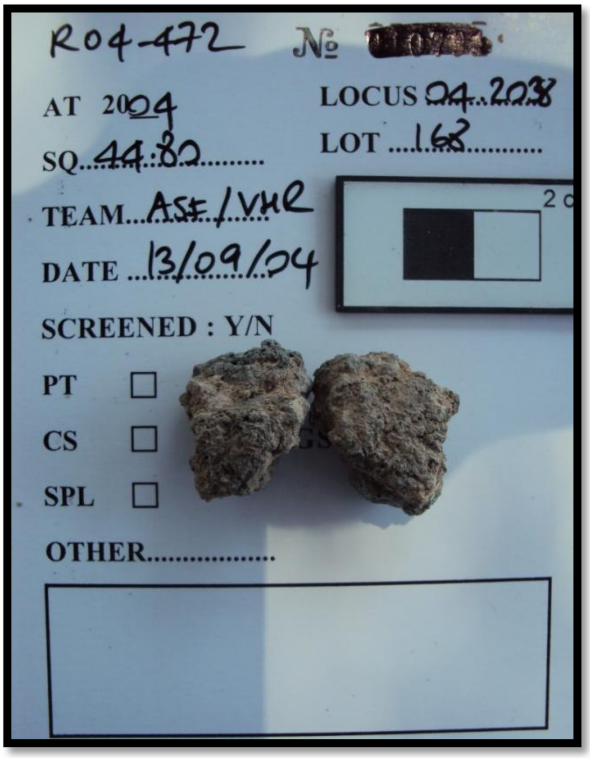
Catalogue 10: Sample R04-378



Catalogue 11: Sample R04-538



Catalogue 12: Sample R04-698



Catalogue 13: Sample R04-472

Catalogue 14: AT 11474 Sample Group

Catalogue 15: Detail from AT 11474 Sample Group

Catalogue 16: AT 11475 Sample Group

Catalogue 17: Detail from AT11475 Sample Group

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