Pottery and communal identity

Archaeometrical Study of Islamic Ceramic Assemblages in Northern Jordan

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"To my beloved wife"

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Abstract

The study of Northern Jordan Islamic pottery provided complete visualize regarding the pottery production and technology. Archaeometry close look allowed identifying the most frequently utilized raw materials that were mostly used to produce the different Islamic pottery wares.

The analysis of the pottery assemblages that were collected from the hinterlands of Abila, Gadara, and Umm el-Jimal, allowed comparison of the raw materials. Grouping of the samples was based on the raw materials that figured out the most popular source of the clayey materials. The study estimated technical aspects that revealed disparity in the durability of the Early Islamic pottery and the Middle, Late Islamic periods. The study confirmed that the Early Islamic pottery was fired frequently at higher temperatures than the Middle and Late Islamic periods. The constituents of the studied samples reflected the local geology of the studied area, except very few sherds that were brought from somewhere else. The petrography, XRD, and SEM enriched our knowledge about Northern Jordan Islamic pottery, which is not well documented. Pottery as a culture choice has been the key that this study used to discuss the communal identity. Although archaeometry is a trend usually used to gain scientific information, the information can always interpret and coupled with ethnographic and archaeological studies. Therefore; the archaeometry results showed similarities in the consumed clayey materials and tempering materials, which reflects culture choice. The study suggested that the communal identity has changed when comparing the Early Islamic period with the Middle and Late periods. Early Islamic assemblage, in general, is durable, wheel-thrown, and plain, this is their cultural choice if it was not imposed on them. While the Middle and the Late Islamic period's pottery was a cottage industry less durable, and frequently hand-made, although decorated, which reflects their culture choice and the structure of production in this period. The interpretation of the archaeometry results required comparison with the local geology of the region, which indicated a correlation between the results and the geology of the region.

The results of quantitative and qualitative scientific techniques contributed to the division of samples into groups, which facilitated their comparison with the local geology of the region. The study proved that the majority of the studied samples raw materials are a reflection of the local geology, which indicates conservative potters. Scientific analysis detected a change in the manufacturing techniques from the early Islamic period when compared with subsequent

periods, suggesting a change in pottery culture that can reflect a change in community identity. The study combined both the traditional archaeological pottery study techniques and the archaeometric, the combination opened new horizons for understanding Northern Jordan Islamic pottery tradition. The results of this study showed the importance of the pottery sherds to understand the Islamic culture, regardless of its source, whether from an archaeological survey or archeological excavations. Understanding the pottery tradition was the major factor that favored reconstructing the communal identity besides the administrative and the road networks in the area and the surrounding.

Kurzfassung

Das Studium der islamischen Keramik in Nordjordanien ermöglichte eine vollständige Visualisierung der Töpferproduktion und -technologie. Dank derArchäometriekonnten die am häufigsten verwendeten Rohstoffe identifizieret werden, die bei der Herstellung der verschiedenen islamischen Töpferwaren verwendet wurden.

Die Analyse der Keramik-Assemblagen, die aus dem Hinterland von Abila, Gadara und Umlel-Jimal gesammelt wurden, ermöglichte einen Vergleich der Ursprungsmaterialien. Die Gruppierung der Proben basierte auf den Rohmaterialien, deren übliche Herkunft aus tonigen Materialien stammt.

Die Studie ermittelte technische Aspekte, welche die Unterschiede in der Haltbarkeit der frühislamischen Töpferwaren und der mittleren, spätislamischen Perioden aufzeigten. Daraus resultierte, dass in der frühislamische Töpferei häufig mit höheren Temperaturen gebrannt wurde, als in der mittleren und späten islamischen Periode. Die Bestandteile der untersuchten Proben spiegelten die lokale Geologie des untersuchten Gebiets wider, mit Ausnahme von sehr wenigen Scherben, die aus anderen Gebieten stammten. Die Petrographie, das XRD und das SEM bereicherten unser Wissen über die islamische Keramik in Nordjordanien; zu der wir kaum Dokumentationen hatten.

Die Keramik fungierte in dieser Studie als Schlüssel bei der Erörterung der kommunalen Identität.Auch wenn dieArchäometrie einen gewissen Trend hat, bevorzugtwissenschaftliche Informationenzu gewinnen, können die durch sie gewonnenen Information immer mit ethnographischen und archäologischen Studien interpretiert und gekoppelt werden.

Die Ergebnisse der Archäometriezeigen, dass es Ähnlichkeiten gibt zwischen den verbrauchten tonigen Materialien und den Temperiermaterialien, welche wiederum die Kulturwahl widerspiegelt. Die Studie legt nahe, dass sich die kommunale Identität im Vergleich der frühen islamischen Periode mit der mittleren und späten Periode verändert hat. Frühe islamische Assemblage ist in der Regel eine langlebige und schlichteDrehscheibenware; gemäß der getroffenen Kulturwahl. Die Keramik der mittleren und späten islamischen Periode spiegelte

eine andere Kulturwahl wider, sie war weniger haltbar, hauptsächlich handgemacht und dekoriert.

Die Interpretation der archäometrischen Ergebnisse stellt die vorhandenen geologischen Informationen für das betrachtete Gebiet dar, um die Kompatibilität mit den vorhandenen Rohstoffen zu klären.

Die qualitative und quantitative Interpretation der Ergebnisse der Archäometrie erleichterte die Gruppierung der Assemblagen, was den Vergleich verschiedener Gruppen mit der lokalen Geologie ermöglichte. Die Studie belegte, dass die Mehrzahl der untersuchten Probenrohstoffe ein Spiegelbild der lokalen Geologie sind, dies deutet auf konservative Töpfer hin. Unterdessensind die Qualität und die Techniken während der islamischen Periode in Nordjordanien unterschiedlich, was wiederum auf konservative Neuankömmlinge hindeutet.

Die Studie kombinierte die archäologisch, traditionelle Töpferwerkstechniken mit der Archäometrie; diese Kombination eröffnete neue Horizonte für das Verständnis der nordjordanischen islamischen Töpfertradition. Das Verständnis der Töpfertradition war der Hauptfaktor, der die Rekonstruktion der kommunalen Identität neben den administrativen und den Straßennetzen im Bezirk begünstigte.

1. Chapter one: Background.

1.1 Introduction:

Ceramics (Pottery) is the most dominant artifacts in the hinterlands of archaeological sites, due to the frequent usage and durability. They are considered as one of the most important indicators for past economy, settlements, relative dating, production, technology, trade, art, and most importantly communal identity. Pottery importance relies on the information that can be obtained by running scientific techniques and includes information regarding their raw materials, which characterize pottery for specific technology and usage. In the past decades, archaeologists focused on pottery from a typological point of view for their identification, classification, and dating. Even until today, this type of studies is still in use and considered important. However, the amount of information that can be gained is relatively limited, therefore, there is a need to extract the locked data inside the pottery by using various scientific methods and techniques. The utilization of these techniques from different scientific disciplines has their potential to determine the type of clay and temper materials (non-plastic materials), the source of clay, technical capability, firing conditions, and firing temperature once produced. Thus, the scientific approach opens the door for maximizing the quality and quantity of information extracted from ancient pottery. Overall, combining scientific approaches with traditional archaeological approaches is convenient to maximize the quality of the information that can be extracted from pottery.

To understand the potter's technical skills in ancient societies, the technology of pottery production needs to be studied spatially and temporally. Consequently, interactions among ancient civilizations, among archaeological sites, and nature can be understood. The research pictures the ceramic producers and their ways of life Such a research brings up many questions concerning the selection and inspiration behind the gaining and use of pioneering types of ceramic and the related technologies. All of this information is connected to the issues of identity, and to the role of adopting or rejecting a change in the production (Gascoigne 2013, p. 1). Therefore; this study attempts to focus on assemblages of Islamic pottery collected by survey from the vicinity of three sites in Northern Jordan, Abila (Qweilibeh), Gadara (Umm Qais), and Um El-jimal. The surveyed pottery is usually used as an indicator of occupation or usage only, but this study goes further. It studies the pottery sherds by mean of scientific techniques to shed more light on their importance, and to prove that surveyed pottery sherds are valuable to understand and answer questions concerning a specific period and/or a specific site. Communal identity or ethnic groups could be traced. Assuming that communal identity means a group of people or population that have the same biologically self- preservation, share similar set of cultural values, language, and comprise a partially self-governing community (Dever 1995, p. 201). Islamic society of a certain area, such an area of study, may meet the elements in this definition; the only difficulty would be whether these elements could be reflected by pottery analysis or not. Identifying ethnicity depending on the archaeological remains relies on the examination of the insight of peoplehood, insight of folks or community that might have pointed to the manufacture and use of the material culture in the past. It seems a very difficult task as ethnic boundaries might be inaccessible, elastic, and always shifting. On the other hand; tying material culture to behavior or using artifact as a text remains hard but it is still one of the goals that the archaeologists look forward to disbanding. To be able to achieve advancement in reconstructing the communal identity, questions such as what and how culture materials inform us are always needed (Dever 1995, p. 201). Using pottery as markers of culture change may clarify many ambiguities regarding settlement patterns and distribution, cultural permanence local culture change, the degree of segregation or contact with other cultures, the level of technology, the social adaptation to the environment, trade, and common aesthetic traditions and religious beliefs. Accordingly, this allows archaeologist to shed more light on the development of lifestyle for past populations, where tangible dimensions of ethnicity are recognized (Dever 1995, p. 204). The concentration of scattered sherds indicates intensity and distribution of settlement and land use, therefore; site scatters survey was conducted, characterized by collecting both onsite and offsite artifacts choosing a representative sample, these pottery sherds are considered as an evidence of the past behavior including the shift from urban to rural settlement patterns. It is well known that the concentration of artifacts decreases with respect to distance from the site, forming a different density of artifacts in different zones (Wilkinson 2003, p. 5). The sturdy permanence of a ware or a form of certain type through different Islamic periods may have a socio-economical suggestion and thus may comprise ethnic markers and culture continuity (Dever 1995, p. 204). The development, decline, change in pottery production throughout the Islamic period from the 7th century AD. until the beginning of the 20th century AD. could suggest local production with the exception of some imports and imitations, which could reflect communal identity in the three sites. Communal identity or tribal group does not only mean conversion but also many procedures en route for orthodoxy (Levtzion 1979, p. 21). Orthodoxy could be traceably relying on the assumption that architecture and objects are secret codes and eventually signs of the new identity. The spatial and temporal variations may form a pattern not necessarily mentioned in textual resources, but also could be drawn by archaeological analysis (Whitcomb 2004, p. 3). Whether pottery is onsite or offsite, the homogeneous characters of pottery may reveal the unstratified socio-economic structure of the community. Similar practical nature of local pottery during the Islamic period reflects a similarly practical society (Dever 1995, p. 205). The degree of uniformity in the raw materials selection and the techniques of production throughout the Islamic period in Northern Jordan suggests the initiative of a single body, which may be sponsored by one or more ethnic groups (Avner and Magness 1998, p. 40). However, Islamic pottery was mainly produced in different styles and manners, compared to the pottery of the classical period, and thus, propose a change in the organization and family unit, which means different inhabitants. This is clear by the newly introduced pottery corpus and the disappearance of old styles (Amorai-Stark and Hirschfeld 1995, p. 21; Hoffman and Whitcomb 2004, p. 43).

Pottery sherds were collected for the purpose of this study from the previously mentioned sites, during three consecutive survey seasons in (Abila July 2014, Umm el-Jimal February 2015, and Gadara September 2015). The surveys covered almost the whole accessible fields of the vicinity of those sites. From each direction south-west (SW), south-east (SE), northwest (NW), and northeast (NE), as well as some special areas, which were traced by aerial photos, and called areas of special interest (AOSI).

This study is a part of a bigger funded project by DFG called ‘Historical land-use and landscape reconstruction in the Dekapolis region'. The main purpose of the project is to understand the previous land use to fill a gap in our knowledge concerning the intensity of land use during different time periods. However, the purpose of this study is to determine the technology of pottery production from Northern Jordan during the Islamic period, which has not been fully studied, except for few studies that concentrated on specific Islamic sub-periods but not the whole Islamic one. The importance of this study comes from the fact that it tries to know whether the technology of production had continued all over the Islamic period, or interrupted at certain periods by following new technology in production. Understanding the technology indicates the interaction between the pottery makers and the surrounding environment. Therefore; the contribution of this study to the project will be useful since pottery is an important element in understanding the previous land use.

For the purpose of this study, samples were selected according to their ware and time period. Scholars divided the Islamic period into three main periods as follow: the early Islamic (600-1000) AD.), which correspond approximately to the Umayyad period, and the Abbasid period. The middle Islamic period I, II; the middle Islamic I (1000-1200 AD.), covers the Fatimid, part of the Crusader, and the Ayyubid periods, while the middle Islamic II (1200-1400 AD.) covers the early Mamluk period. Finally the late Islamic periods I, II; the Late Islamic period I (1400-1600 AD.) that covers the late Mamluk-Early Ottoman periods, and Late Islamic period II (1600-1900 AD.), covers the Ottoman period in all sites (Walker 1999, p. 207; Whitcomb 1992 b, p. 386, 1997, p. 106). The selected samples were analyzed by different techniques to maximize the amount of information gained, and at the same time to eliminate any error that may have occurred, these techniques include petrography analysis and X-Ray Diffraction (XRD) to identify the mineralogical composition of the pottery samples. These techniques will help in identifying the tempering materials (non-plastic materials), the manufacturing technology, and the firing condition and temperature. It is known that samples contain a fingerprint that correlates to a certain manufacturing process upon production, and also capable of illustrating the level of technology achieved by the potters. The study investigates the absence or presence of different types of Islamic wares in the study area. The samples were selected systematically according to the availability of ware, the size of sherd and chronology.

1.2 Aim and justification of the study:

The main aim of this study is to use Islamic pottery as an indicator for reconstructing the relationships among the three sites during the entire Islamic period (Abila, Gadara, and Umm el-jimal). Abila and Gadara have similar environments, both are eastern of the Galilee Sea and the Jordan River, they are exactly in the Transjordan Plateau, while Umm eljieml is located farther more to the east in the Hauran region, it's a rocky, basaltic plateau that stretches across much of southern Syria.

The manipulation of raw materials and techniques of production could provide answers related to communal identity or transfer of knowledge from one communal to another. The adapted technical procedures could be traced by scientific techniques, therefore, it is vital to use them as a tool to uncover the enigmatic of pottery, and thus opens the door for a comparison among sites spatially and temporally. Unfortunately, these sites have remained to be understood both as individual settlements or as a potentially larger network connected by architectural and cultural traditions, as well as by political ties, or production and exchange.

There has been a lack of studies concerning the Islamic period ceramics except for as the study by Walmsley (Ghrandal, Pella, and Jarash), Donald Whitcomb excavation publications in southern Jordan (Aqaba). The Madaba plain project publications represented by the excavations of Tell Hisban, Tell Umayri and Tell Jalul. Bisheh study of the Umayyad (qusur), the Umayyad desert palaces, and recently, Tarboush Ph.D. thesis entitled Provenance and Technology of Early Islamic Pottery from North Jordan. These studies focused on architecture and art and almost ignored pottery, except for Tarboush how concentrated on the early Islamic pottery technology and provenance from the early Islamic period in Northern Jordan. Unfortunately, pottery was not appreciated right in documentary sources: how it was produced, what were the main ingredients and which production center was producing such and such; therefore, the necessity of archaeometry became more noteworthy to scholars involved in studying pottery production and provenance.

To fulfill the aims of this study, the following sequence was followed: first a description of the pottery fabric after defining the main ingredients, to allow comparing the fabric types. Fabric classifications are necessary to figure the sequence connection of the local ware types in any district. The understanding of the geological sources of pottery is essential to study the trade and exchange. Second provenance study; identifying the elemental bulk of the clay matrices allows the attribution of the matrices to the source of the clay materials by comparing them to the local geology. The inclusions and tempering materials, such as sand, chaff, shell, bone, grog, fossils, etc. provide clues concerning the provenance, but most interestingly, provide information regarding the skills of the potters. The advantages of the intentionally added materials have been experienced by potters, which reflect the skills of the potters and the source of these additives. Therefore; it is very important to identify whether the non-plastic materials were deliberately added or not. Despite that, the same source may have produced different fabrics, or even different workshops may have used the same source of raw materials but produced unexpectedly alike fabrics. Third manufacturing techniques entail the technology used to produce Islamic pottery from the selection of clay source until using the object, which passed through preparing of raw materials by the refining process, mixing process, shaping process, drying and finally firing (firing atmosphere and firing temperature).

In general, all the gathered information might help in reconstructing pottery development during the Islamic period, when creating a master sequence of pottery analysis in Northern Jordan. The reason behind choosing this area of study is based on the higher frequency of pottery sherds that are dated to this period.

1.3 Previous studies of scientific pottery analysis in Jordan:

Jordan was the home to several ancient civilizations that were established in the region due to its strategic geographical location that offered the country a role to play as a medium for trade and communication. Although there are a substantial number of archaeological sites in Jordan, a database for pottery has remained to be constructed. Pottery is the most abundant material culture that constitutes a major part of archaeological records (Matson 1982, p. 20). Edwards and Segent (1984) studied the pottery from the Chalcolithic site of Teleilat Ghassul and found that all of the pottery was hand-made. According to him, the potters were highly skilled since they fired the pottery at a temperature relatively less than $1000C^o$ under reducing conditions. This study was one of the first studies that dealt with the scientific analysis of pottery. A few years later, other studies were accomplished by other scholars studying pottery from different sites of Jordan. ‘Amr (1987) examined the diversity of the Nabatean pottery from Petra in search of the locality of fabrication. In his study, pottery and clay samples from Petra and nearby depositions of clay were examined using Neutron Activation Analysis. The results confirmed Petra as the locality production of pottery. London (1987) in her study (1987) preliminary petrographic analysis of pottery from Tell el-Umeiri and hinterland sites, concluded that pottery was locally made. Bataina (1996) studied the provenance and technology of the Neolithic pottery from Wadi Shueib area, which revealed that the pottery was locally hand-made and fired at a relatively low temperature, between $600C^o$-$700C^o$ in an open pit under oxidizing conditions. In the same year, Quran (1996) studied the Early Bronze Age I pottery of Jebel-Abu Thawwab reached similar results; pottery was locally made in an open pit in an oxidizing atmosphere. Tawalbeh (1996) studied the painted and glazed ware from the Ayyubid –Mamluk period from the site of Dohaleh in Northern Jordan; he concluded that the painted pottery was fired at a partially low temperature between 600C^{o}-700C^{o} in an open pit, while glazed pottery was fired at a higher temperature around 900C^{o} in an updraft kiln. Al-Saa'd and Roussan (1998) analyzed a collection of Islamic painted pottery to determine the firing temperature and firing atmosphere, they found that pottery was fired in an updraft kiln under oxidizing conditions at a temperature below 750C^{o}. Alawneh (2006) studied the provenance and technology of pottery samples from different sites of Jordan, all of the samples were dated to the transition period of late Roman /early Islamic, the study concentrated on the permanence, alteration and of pottery sherds from the sites of Amman, Aqaba, Beit Ras, Khirbet Al-Nawafleh, Jarash, Pella, Madaba, Gharandal, Humaimah, Umm al-Rasas, Umm al-Walid, and Jericho. Tarboush (2015) studied the provenance and technology of early Islamic pottery from Northern Jordan, samples were selected from four sites in Northern Jordan Jarash (Gerasa), Umm Qais (Gadara), and Tabaqat Fahl (Pella), and Tal al-Husn. He concluded that tempering materials and inclusions match the geology of the area, which means that pottery was locally produced; the pottery was fired between 700C^{o}-900C^{o} in different firing conditions.

2. Chapter two: The Northern Jordan Geography, Geology, and Archaeology:

2.1 Introduction:

To fulfill the objective of this study, the geography and the geology of the studied area are addressed in this chapter. The contribution of such factors probably led to the rise of civilizations throughout different archaeological periods. The attractive natural Landscape, the environmental factors, and the strategic location along Northern Jordan led to a major shift in the nature of the landscape. Gadara (Umm Qais) and Abila (Qwelbih) present the northern highlands landscape of the Transjordan, while Umm el-Jimal is located in the Northern Jordanian Badia. Therefore, studying the geography, geology, and archaeology of the sites is essential to understand the variation in pottery assemblages; it is well known that man always adapted techniques that comply with the surrounding environment and his needs

2.2 Geography:

Jordan is located east to the Mediterranean, which is considered as the heart of the region were many ancient civilizations flourished. The area has a plethora of cultural resources. Jordan is distinctive as being considered as one of the countries that have plenty of archaeological structures and remains. The geography is diverse, from the lowest point on earth the Dead Sea to mountains, highlands, and deserts. This variation has created different ecosystems that contributed to the flourish and survival of ancient civilizations. Throughout the various archaeological periods (Paleolithic, Neolithic, Chalcolithic, Bronze ages, Iron Age, Classical periods, and Islamic periods), Jordan was continuously the cradle of civilizations. The archaeological remains of Jordan constitute multi-diverse sites, from the religious to the residential and public buildings. Jordan has also diversified cultural materials. Moreover, Jordan hosts four World Heritage Sites presented by Petra in 1985, Quseir Amra in1985, Um er-Rasas in 2004, and Al-Maghtas (the Baptism site in 2015.

The strategic location, geography, and environment were the main reasons for the settlement forms and the economic systems of Jordan throughout history. The location within the eastern coast of the Mediterranean played an important role in settlement patterns and economic systems as a station of trade and communications between the west and the east (Kennedy 2007, p. 74). Jordan being placed in a junction connecting Asia, Africa, and Europe, is the main reason behind the flourishing settlements overages. Besides, Jordan has moderate temperatures and land fertility. Jordan today is located on the East Bank of the Jordan River, where Jesus was baptized. The north of Jordan is bordered by Syria; the east is border by Iraq and Saudi Arabian and the south by Saudi Arabia and the Gulf of Aqaba.

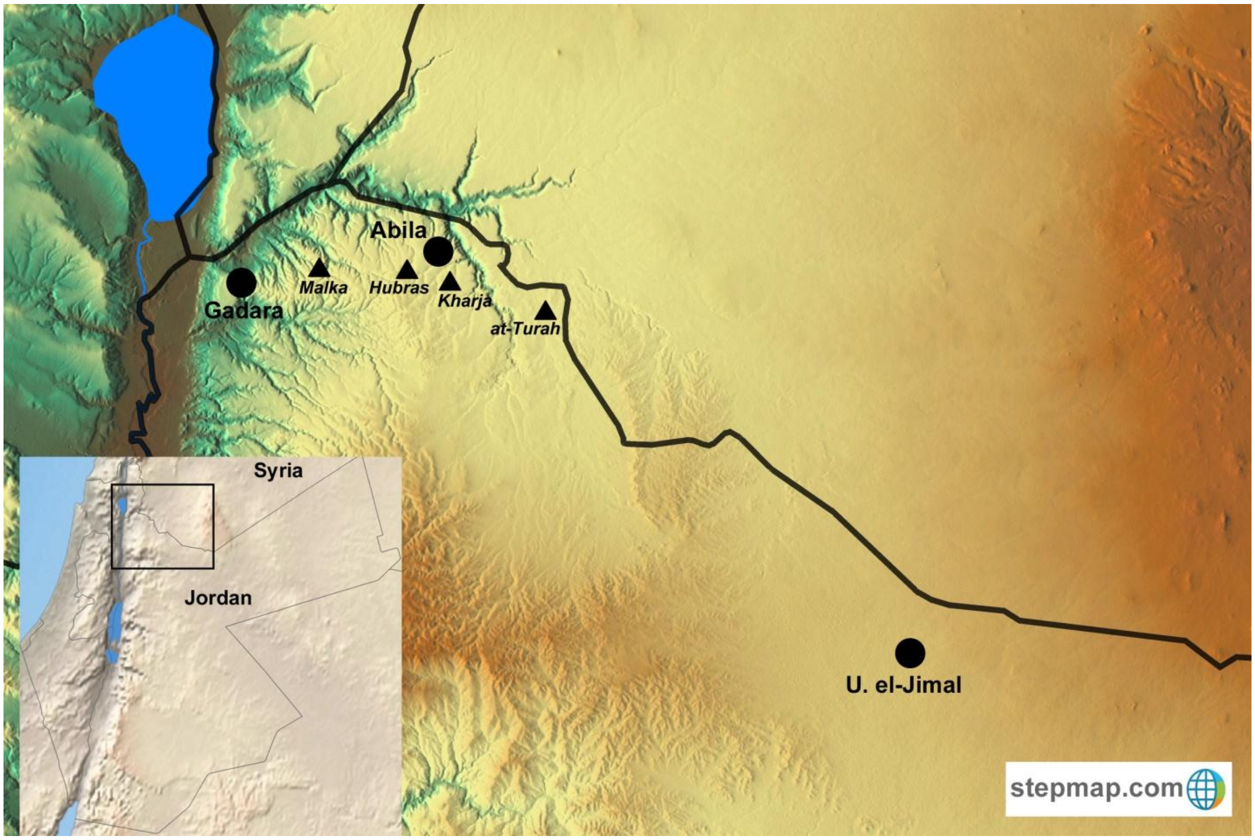

Fig. 2.1: Location map of Northern Jordan Project (NJP), the study area. Modified by Z. N. Ben Badhann.

In general, Jordan is divided into three geographical zones: the Jordan Rift Valley, the highlands of the Jordanian Plateau, and the desert steppe. The Jordan Rift Valley runs along the western border, the Rift Valley starts from Aqaba in the south to the northern borders. To the north of the Dead Sea, the Jordan River Valley, which ultimately runs further than Jordan's northern border passing through the Sea of Galilee (Lake Tiberias), (South 1997, p. 7; Metz 1989, pp. 67–69; Salameh and Haddadin 2006, p. 8). The slender band of highlands, which is known as the Jordanian Plateau lies between the Jordan Rift Valley from the west and the desert steppe from the east. This plateau was extensively occupied by the ancient civilizations. The mountain series or the Highlands run from north to south close to the western border with a varied topography The elevation varies from approximately 600m in the north to 1700 m in the south (South 1997, p. 10; Metz 1989, p. 67). The largest geographic zone of Jordan, which covers around 80% of the country, is the desert steppe. The district is basically an expansion of the Syrian Desert. In the north, volcanic rocks are predominant; while in the south granite and sandstone are the major rock types. The southeast desert, is predominated by sand dunes (South 1997, p. 8; Metz 1989, p. 67).

Jordan is considered to have an arid warm climate. The west part of the country is well-known for its Mediterranean climate, nevertheless, the east is more continental (Metz 1989, p. 71). The highest rainfall of the country is in the northern highlands, which reaches more than 300mm annually; enough to grow rain-fed wheat, which was the reason leading to the high concentration of occupation and population throughout history (Shoup 2007, pp. 2–3). On the contrary desert, steppe receives less than 150 mm rainfall annually.

2.2.1 Abila (Qweilibeh):

The location of Abila played an important role as being a desirable place to settle. It is located in a region known as the Syrian-Palestine Levant. It is located to the east of the Galilee Sea and the Jordan River. It's in the Transjordan Plateau, in an area known today as Beni Kenana or al-Kefarat region. It is, bordered from the east by the desert, the west the Jordan rift valley, and from the north by Yarmouk River (Reuben 1970). Abila is about 13km northeast of the modern city of Irbid, and around 5 km south of Yarmouk River, east of the southern end of the Galilee sea (Tiberias Lake). In the Eastern side of the site, Wadi Qweilibeh extends till it pours in Yarmouk River valley. The Wadi used to drain water from Ain Qweilibeh to the Yarmouk river valley and reaches in length about 12 km, While the width changes roughly as we progress every 1 km towards the Yarmouk river valley (Menninga 2004, p. 42).

2.2.2 Gadara (Umm Qais):

The Umm-Qais plateau is located in North Jordan; it is about 30 km northwest of Irbid and approximately 3 km south of Yarmouk River. The archaeological ruins of Umm Qais are situated on a terrace edge of mounts overlooking Tiberias Lake and Golan Heights. Gadara is situated in the far north-west on the highest peaks of the Jordanian highlands overlooking the valley of the Yarmouk river to the north and the Wadi Al Arab from the south (Ababneh 2016, p. 52; Maxwell 1990, p. 4). The elevation of Umm Qais ranges between 400m to 800m above sea level. The archaeological site of Umm Qais is placed close to the end of what is called Gadarene Plateau (Baly 1974, p. 213; Maxwell 1990, p. 5), the plateau is delimited from the north with Wadi Al-Yarmouk, and from the south Wadi Al-Arab, moving to the west along the Gadarene plateau, noticeably the plateau becomes slender with smaller interrupted wadis heading northwest towards Yarmouk River either southwest towards Wadi Al-Arab (Maxwell 1990, p. 7). Gadara is located on top of a slender mount bonds Gadarene plateau with Ard al-Ala plateau (Maxwell 1990, p. 127).

2.2.3 Umm el-Jimal:

Umm el-Jimal site is located 15 km east of the city of Mafraq. The site was completely built of basalt stones. Umm el-Jimal is situated in the partially dry region of northeast Jordan, on the border of the basalt plain shaped by prehistoric volcanic epidemics, starting from the slopes of the Jebel Druze, the plain is known as Southern Hauran. The southern Hauran plain consists of a thick layer of basalt bedrock with a reddish volcanic fertile soil on top. The annual amount of rainfall is about 100mm, which is barely enough to grow rain-fed wheat (DeVries 1990, p. 7), the Via Nova Traiana is about 6 km west of Umm el-Jimal, the site perhaps was constructed half a century prior to the roadway, which dates to 111-14 A.D. (DeVries 1998, p. 38), Umm el·Jimal lies in a junction-shaped by the amalgamation of two wadis, that transport the runoff waters from the lower inclines of the Jebel Druze. The old town was situated on the west bank of the eastern wadi branch, while the standing town lay on the east bank of the wadi west branch. Umm el-Jimal is located in a desert district, therefore it suffers water shortage, the inhabitants of the site adapted to the water shortages through constructing complicated water channels that pass the harvested rainwater to large wells and ponds (DeVries 1981, p. 57).

2.3 The Geology of Northern Jordan:

2.3.1 Introduction:

Jordan is a part of the Arabian plate, located in the northwest; the area geologically is complex to be depicted as a single unit. East of the Mediterranean Sea the region is divided according to the tectonic activates to a number of zones (Bender 1975, p. 13). This section concentrates on the northwest high plateau and the northeast basalt plain, Abila, and Umm Qais are both located within the northwest high plateau, while the third site Umm el-Jimal is located in the basalt plain in northeast Jordan. Identifying the source of raw materials in nature by studying the geology of the area is essential, in order to compare the scientific analysis results of the studied samples with the geology of the area, pottery main ingredients are clay together with some inclusions and

tempering materials (none plastic), all those ingredients are naturally occurring, depending on the geology of the area. Studying pottery by mean of scientific techniques characterizes pottery types and manufacturing techniques, therefore; the study of raw materials distribution in nature is vital because it provides information concerning regional trade routes. Clay is considered the most important constituent of pottery, it is produced by a natural weathering of some rock types, and hence it is important to know the particular rock type and the geology of the district.
Understanding the connection between the geology of the district and the mineralogical composition of the samples, allows us to draw an abundant amount of information regarding the origin of the raw materials used to produce the studied samples, it also helps in characterizing a specific clay of a precise area, this is usually done by comparing the local geology with the mineral composition of the samples (Renfrew, C. and Bahn, P., p. 314).

An extensive literature concerning the geology of Jordan is available. Therefore; the following sections will introduce a brief summary of the geological setting of the studied areas, by recognizing the geological groups, units, eras, and formations of the region of the sites. Northern Jordan geological formations are compiled mostly of late Jurassic and Cretaceous precipitation. Kurnub sandstone is the earliest, which was formed between the drawback of seas water in the Jurassic period and move forward during the Cenomanian era of the next Cretaceous period (Burdon, Quennell 1959, p. 35). Sea levels moved forward during the Cretaceous period towards the west and southeast until they increasingly enclosed the whole Jordan up to Ma'an before water started to retreat. During those periods a huge quantity of marine deposition occurred, due to this fact this period was divided into two series the first (earlier) is Ajlun group and the second (later) Belqa group. Ajlun group is divided into two subgroups the Cenomanian and the Turonian deposits, both subgroups consist of hard limestone beds alienated by marl or clay layers of diverse thicknesses (Burdon, Quennell 1959, p. 37). In Northern Jordan the thickness of this series varies between 500m to 600m, while moving to the south the series tends to disappear, Ajlun Dome is considered the highest level of this series. Belqa series is signified in the northwest of Jordan mainly by the Senonian deposits. Rock types of this series do not differ a lot from Ajlun series, except of that, the limestone of this series is softer, the color ranges from whitish to grayish, and in some places like Irbid it can be pinkish, due to softness of this limestone, it was not favorable for building, nor it was fertile, comparing with the Basalt plain north of the Yarmouk river Wadi, the only advantage is cultivation was much easier (Burdon, Quennell 1959, p. 42). Seas made their final retreat in the Eocene and Oligocene epochs, which facilitated in speeding up faulting and folding in Jordan and Palestine, at the beginning an Island appeared expanding from the Judaean to Ajlun highlands, but finally at the end of the Eocene the nearby area became drier (Baly 1974a, p. 37). There is no evidence of further depositions in Transjordan by the end of Eocene, even if there were, it is no longer there, it has been vanished by alteration. Neocene epoch occurred after the Miocene and before the Pliocene, in this epoch the processes of mountain building started, while the vast faulting incidents produced the Rift Valley (Burdon, Quennell 1959, pp. 57–65). Even during the Quaternary the process carried on, added in the late Neocene to the early epidemics of the volcanic motion.

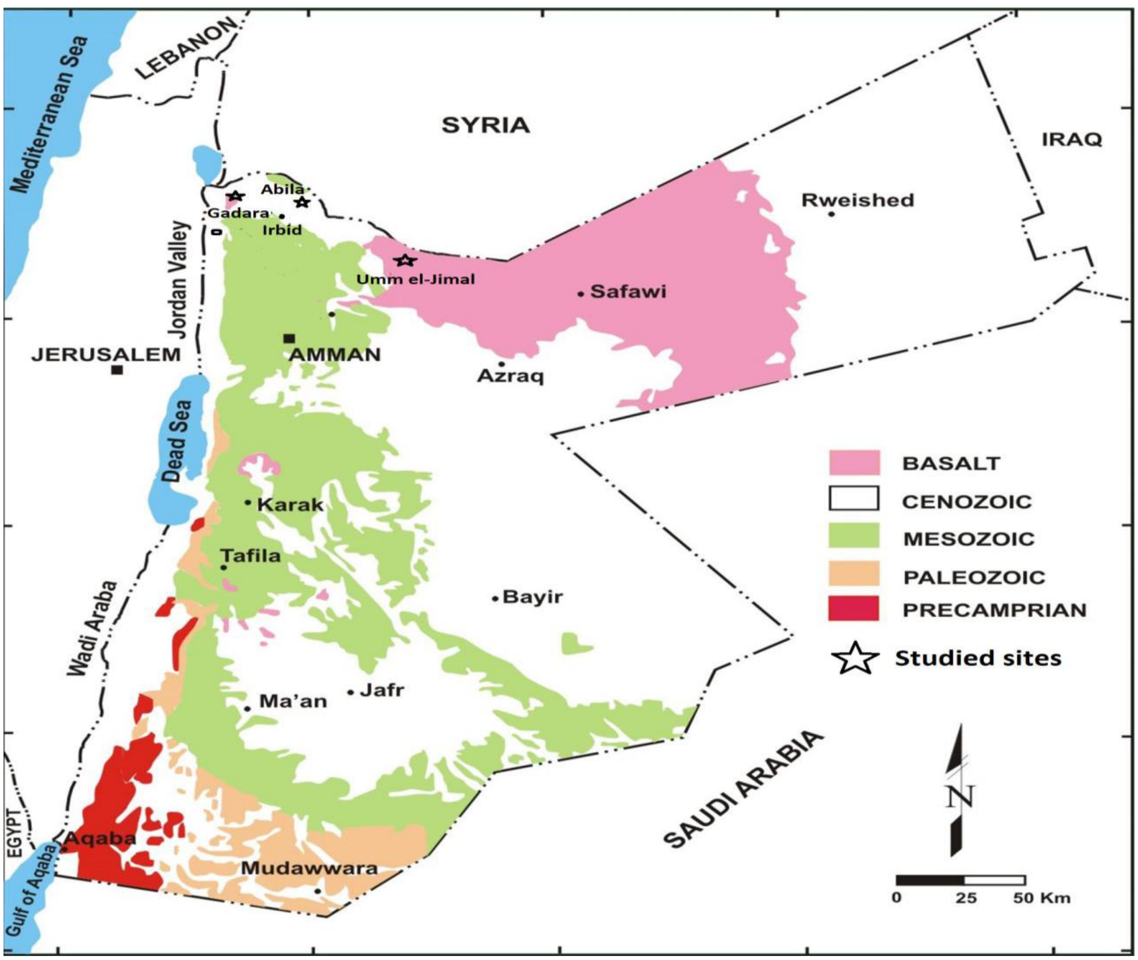

Fig. 2.2: General geological map of Jordan, showing the distribution of the main rocks. (Modified after Abed 2000).

The whole northern part of Jordan and even south and north of the Tiberias Lake were covered by the eruptions, again when the Pliocene was close to ending, faulting occurred in the Rift

Valley leading to extra lowering, forcing tributaries lowering foot altitudes (Baly 1974a, p. 24). Volcanic activity became more aggressive in the Pleistocene epoch, which resulted in producing a wall, due to lava flow between Al-Hula Lake and the Tiberias Lake, Lisan Lake was formed south of the wall as well as the Dead Sea basin, resulted in lifting up levels of the tributaries of Jordan, and the deposition of a large quantity of gravel all over the lake coasts, just before the start of the Neolithic period, Lisan Lake pulled away leaving what we have at present days the Tiberias Lake and the Dead Sea (Baly 1974a, p. 24). Oligocene and Neocene mountain forming processes are mainly responsible for the current day formation, formation lines in the Levant directed north-northeast to south-southwest, the most important fold in Northern Jordan is Ajlun dome, similar to the anticline Judaean hills, north-east-south-west drift are enforced by the north to south faults, Northern Jordan main fault starts east of Tiberias lake along the Jordan Valley, about 5Km west of Umm Qais until the western side of the Dead Sea. The EastWest trend and the northwest-southeast trend models are depressions (graben), due to anxiety faults. The east-west depressions start from Haifa crosses the Tiberias Lake until Saweida (Baly 1974a, p. 8). Yarmouk River goes along with east-west graben line, and the north-west-south-east graben appears starting from Sidon transversely in upper Jordan Valley, through Dera'a and Azraq, the Eastern part of Yarmouk River passes through this graben (Burdon, Quennell 1959, p. 53). The Jordan Rift Valley formation processes is not well-known, but there are three theories of how it was formed, the first is what is called Rift: this theory supports the idea of that, the Jordanian and Palestinian plates moved apart, which caused a fell down of the Valley, while the second theory, which is called ramp: suggest that the valley was forced down, due to the push of the Jordanian side and the Palestinian side together (Baly 1974a, p. 23), and finally the third, which is called shear: suggests that the gap between Jordan and Palestine was wider but filled in by erosion (Burdon, Quennell 1959, pp. 57–58).

2.3.2 Abila and Gadara geology:

Gadara and Abila are located in The Umm Rijam chert limestone formation. The southern side of the formation is bounded to the Muwaqqar chalk marl formation, and it contains eleven thick basalt layers about 190 m. belong to Arabian Harrat volcanism (El Akhal 2004, p. 1).

2.3.2.1 Belqa group:

Quennell (1951) and Burdon (1959) both were the first to launch this name for the group, this Group dates from the late Coniacian to the Late Eocene and reaches the Cretaceous/Tertiary boundary, the Late Cretaceous – Eocene Belqa Group mainly contains chalk, chert and phosphorite placed in a marine or semi-marine steep setting, exactly over the Ajlun group (Bender 1974, p. 73). The formation at the bottom of the group shows the depositional environment change. Sediment deposition occurred during pulsing phases of a marine on lap towards the south and the east crosswise the Arabian Cretaceous (Powell, Moh‘d 2011, p. 39). This Group is divided into five subgroups according to formations in chronological order: Wadi Umm Ghudran, Amman, Muwaqqar, Umm Rijam and Wadi Shallala formations. Crops of this group are visible at the most lower level beside Yarmouk River in North Jordan, and next to the eastern boundaries of the Dead Sea clef. Apart from where it is covered by Neogene/Quaternary sediments and volcanic rocks, this group is considered the larger part of the Jordan plateau from the Yarmouk River, in the north, until the Ras En Naqb–Batn El Ghul cliff, in the south (Powell, Moh'd 2011, p. 41). The thickness of the succession increases east of Jordan, where it reaches about 550-600m in the Jafr area and from 600-800m in the Azraq-Wadi Sirhan area, while in the Azraq-Hamza basin rapid thickening to 2.400-3000m, due to synsedimentary extensional rifting at some stage in the Coniacian to Maastrichtian time (Bender 1974b, p. 40; Powell, Moh‘d 2011, p. 39).

2.3.2.2 Wadi Umm Ghudran:

The thickness of this formation varies from 30-35m approximately, the basal Coniacian Mujib Chalk Member surmount Belqa Group, which remnants uncomfortable over the Wadi As-Sir limestone formation. The formation can be distinguished by looking at The boundaries, they are usually buff to dirty white chalk with broken wrinkle fragments remnant on top of the badly weathered uneven surface of the underneath formation. Wadi Umm Ghudran Formation contains two individual parts the lower is enormous yellow to white-gray chalk, while the upper is a medium-size to thin embedded fossiliferous to coquinal yellow-gray limestone irregular with marls and soft marly limestone. The domination of sea fossils such as fish fragments, shark teeth, pelecypods, ammonites and planktonic, benthonic foraminifera, suggests that deposition occurred in a shallow or moderate deep pelagic environment (Bender 1974, p. 78). Lime production started during the Coniacian on the Jordanian shelf when the Tethys Ocean toggle from mainly benthic organisms as originators to the skeletal parts of large pelagic organisms. Coccolith and foraminifera are Plankton with the miniature shell. They are also a big part of the carbonate making the limestones of Cenomanian to Turonian age; most probably they were distributed predominantly by calcareous skeletons of invertebrates and benthic algae. The Coccolithophorida skeleton made of calcitic elements which are quite anti to diagenetic modification. It is yellow-green algae with tiny calcite plates about 0.1 mm in diameter, each about 0.008 mm wide is concealed and are set to form a hollow sphere. Among the diverse species of these algae, the skeletal elements vary in form and the morphology is frequently characteristic of the species. The planktonic algae cell at the last stage of their life cycle starts to show calcitic elements. While during cell growth around the middle of its lifecycle the algae may make a replica and multiply without the calcareous skeleton, calcareous particles at the final stage of the algae life are concealed in the cell and then it sinks to the base of the sea and deposit there (Bandel, Salameh 2013, p. 171).

2.3.2.3 Amman Silicified limestone formation:

The unit was formed during the Coniancian- Santonian- Campanian. Lithology of this unit is characterized by large quantity of chert beds with silicified limestone, it is worth noting that, limestone, phosphatic chert, and some phosphatic beds are clear close to the top, the dark color tone of the formation and the well-stratified nature, makes it traceable by the aerial photography (Barjous 2003, p. 40), the surface of this formation is mainly covered with a thick red or red-brown color soil layer, while the lower part forms a sharp slopes, often with wavy striped hues, the unit contains Campanian fossils, while Oysters and gastropods considered the major benthic fauna in this formation, this type of macro- and microfossils indicate Santonian to Maastrichtian age, the thickness of this unit is approximately between 50-70m (Bender 1974b, pp. 78–79; Barjous 2003, p. 40). Chert beds of this sequence propose deposition of pelagic laminated siliceous oozes, which is probably resulting from a periodic dissimilarity of fairly carbonate-rich and carbonate-poor siliceous oozes, resolving out from the water column, the sediment type shows that it was controlled by the depth of the water, which indicates a mid-shelf environment. The concentration of Oysters and Gastropods propose shallow oxidized water, shell beds interbedded with Chert are splintered and wedge-out towards the west, which indicate that Shelly materials were transported into the area from superficial water by muscular storm-generated westerly-directed currents (Barjous 2003, p. 40).

2.3.2.4 Muwaqqar chalk marl formation:

This unit forms the new rocks of the Mesozoic in the area. Muwaqqar is a region situated south-east of Amman that is infinitely enclosed by chalk marl rocks dating back to the Maestrichtian-Paleocene age (Powell, Moh'd 2011, p. 74).

The domination of planktonic, foraminifera, calcareous nannoplankton and uniform chalk/marl advanced all over the area, means a deep-water, marine environment. The lack of Bituminous horizons, represents local steadiness, therefore; Muwaqqar Chalk-Marl basin suffers anoxic, which is clear from infilled and suggests a consistent sea base. On the contrary; fish fragments point out a flourishing nektonic fauna, which is not the case since macro-fossils absence suggests harsh conditions either very high or very low salinity. The compact sequence at the summit of the series and the depositional gap, are again indicated by glauconitic, phosphatic marls and chalks (Powell, Moh'd 2011, p. 72). The dominant rocks in this formation are the yellowish, grey-green and pale rose-colored chalk-marl, this formation contains some thin layers of flint or gypsum with huge lime concretions, the diameter may reach up to few meters, this type of concretions do exist also in Phosphorite unit, and the Silicified limestone unit. The thickness of this unit differs towards the north, in the southeast it is about 10m, while in areas close to Wadi Arabah and the Jordan valley it reaches 90m, and it exceeds 250m in the Yarmouk Valley region and Wadi Ash Shallaleh, in the Azraq Basin and Jafer Basin, the dominant color of this formation in Jordan is usually dark black, what is called Oil shale, which a Bituminous limestone, in the Yarmouk and Ash Shallaleh valleys the thickness of this rock is more than 200m, while in Al Lajon east of Karak it is only 30m (Abed 1982, p. 94).

2.3.2.5 Umm Rijam chert limestone formation:

The high stand parasequence set of this formation is referred to the Eocene age. The thickness of this formation is about 220m; the lower 5-20m of this formation consists of chalky or marly limestone, which is easily discriminated from the Muwaqqar and Amman formations beneath (Am Abed 2000, p. 216). It is a monotonous succession of chalky limestone, chalk, chert, porcellanite and grey microcrystalline limestone. The formation contains various calcareous nannofossils, planktonic foraminifera, and deep-water benthic foraminifera. Due to the harsh environment, Macrofauna noticeably missing, apart from sparse phosphatic, skeletal fish fragments, gastropods and large nummulitids. The constituent of this formation corresponds to a high sea-level, which is clear by the uniform pelagic sedimentation (Powell, Moh'd 2011, p. 72).

The formation is subdivided into three units, the lower marly chalk, the bedded chalky limestone, and the upper Chert:

1. The lower marly chalk: it is approximately 60m thick, having a white creamy color lighter than the Muwaqqar Chalk Marl Formation. Bedding differs from enormous to thin towards the top. Almost 20m over the base of this unit some fossils and trace fossils are found. Bituminization is behind the brown-black color, while the blue color may be due to silicification. Limestone is uncommon; it only appears as thin pink bands.

2. The bedded chalky limestone: marl and bitumen are uncommon in this unit, while limestone and chert appear in larger quantity, and chalk fluctuate from enormous amount at the bottom of the unit to a thin layer near the top, the thickness of this unit may reach up to 120m.

3. The upper Chert: the rock type minerals of this unit does not differ much from the bedded chalky limestone, except of frequent thin marly-chalky limestone and chert, this unit is considered of a minor occurrence, it is easily differentiated by is black-brown color, the thickness of this unit is about 30-40m (Moh'd 2000, pp. 15–16).

2.3.2.6 The Basalt:

Basalt covers approximately around 11,000Km2, of the Northern Plateau, the plateau is located east of the northern part of Al-Azraq, known as Wadi As-Sirhan Basin, the flow of lava in that area made the landscape almost inaccessible. The series of lava flows maintained the type of the resulted basalt outcome, which is characterized by multi-cracks, due to isolation and broken blocks. The elevation of basalt varies from 1100m above sea level at the Syria-Jordanian border in the north to around 550m in the south close to Wadi As-Sirhan Basin (Bender 1975, p. 17). Basalt has Six dissimilar phases of main emissions can be imminent, the lower three phases are only known from the groundwater wells drilling in Wadi Zulayl located northeast of Amman, the thickness of the three phases altogether is about 150m, they have 5m fossil soil, red clays, and weathered basalt surface in between separating them from each other. The third phase or the uppermost of the first three phases covered by soil ranges in thickness from 6 to 20m, then the fourth flow covering the soil layer of 6o m thick in the same Wadi. The fourth flow covers an older flow or middle and upper Eocene limestone, which is covered locally by calcareous sandstone, and sandy marl of Miocene age, therefore; the first four eruptions may be dated at the earliest in the late Eocene and the latest end of Miocene. The later flow (fifth) is about 25m thick, it is considered the most widespread of the northeast basalt plateau, it covers earlier flow and Paleogene and Miocene sediments, correlates with Yarmouk River area, but it was exposed to Pleistocene erosion. It is clear that the first Tuff eruptions began after extrusion of the fifth lava flow. The sixth phase shows north-trending flow many Kilometers long, 30m thick, without any weathering traces on the surface, almost certainly associate to the basalt flow down Yarmouk River valley to the west, overlie Pleistocene fluviatile gravels and fossil landslides (Bender 1975, p. 123). Burdon 1959 pointed that the latest eruptions could have sustained into historical times, similar in some places in the Jebel ed-Drouz area in Syria. The basalt of Gadara and Abila is characterized by fine to microvesicular grains; they have a porphyritic appearance, dark to medium gray color. The texture appears under the microscope vesicular, amygdaloidal, almost doleritic, coarse, subordinately medium, and rarely fine-grained, in some cases variable glass amount in the groundmass are present, in general, they are holocrystalline (means mineral grains can be distinguished by the naked eye), having intergranular (means the wedge-shaped spaces between a meshwork of lath-shaped crystals, such as plagioclase, are filled with granules of other minerals) to intersertal textures (means having a small proportion of glass or cryptocrystalline material) (El Akhal 2004, p. 4). The phenocrysts consist essentially of olivine and a minor amount of plagioclase. The dominant shape of olivine phenocrysts is subhedral to euhedral lacking zoning; it forms about 10-15% of the rock volume, hence; indicating adequate time to balance with the melt at mantle depth. Plagioclase phenocrysts regularly present as elongated crystals forming about 2-5% of the rock volume. The main constituents of the matrix are nearly coarse-to Medium size grains of plagioclase, olivine, augite, tiny amount of apatite and opaques. Plagioclase is considered the major mineral representing 45-50% of the Matrix volume. The basalt of the Gadara and Abila plateau fall within a trend of the alkali olivine basalt, Nepheline and forsteritic olivine are present with the standard minerals signifying silica-under saturated rocks (El Akhal 2004, pp. 5–9).

2.3.2.7 Soil:

Terra Rossa is the dominant soil of the area; it is distinguished all over Mediterranean Palestine since it is the natural weathering product of limestone. It has a very good water storage capacity, even though it has a high clay content, which is reflected in very small pores, affecting the quantity of water offered for plants, due to the high adhesion coefficient in the fine pores. The weathering of calcium usually present in soil affects the pH-value in the most upper layers, therefore; it is mainly neutral to slightly acidic. In general, it is quite fertile soil but easily eroded

(Lucke 2002, p. 121). The Bashan Plateau soil south of the Yarmouk River developed mostly from the soft limestone of the Senonian-Eocene type, less fertile than the basalt plain soils to the north of the Yarmouk but more easily cultivated. Around Gadara and Abila (and predominant in northwest Jordan), this soil is classified as a Red Mediterranean type, one of the most valuable kinds of agriculture. As one moves west on the extension, of the Gadarene Plateau toward Gadara, the soil covering this ridge becomes shallower, and in many places, bare rock is exposed. On the Ard al-'Ala plateau, however, this soil is abundant once again, occasionally reaching a depth of about 2 m (Burdon, Quennell 1959, p. 55).

Abila is located on the Transjordan plateau, right at the edge of the still moving Arabian plate. The plate activity was the main factor, which led to many earthquakes in the region producing the Jordan Valley. Minimum 8 heavy earthquakes took place in the region in the past 1300 years (Fuller 1987, p. 53). The movement of the Arabian plate away from the African plate formed the deep graben, which is known now by the Jordan Valley, having the lowest point on earth below sea level.

There are many subdivisions reveal regional crustal distortion and drainage systems in the Transjordan dating to the Eocene period uplifting of the Arabian shield (Schulman 1978, p. 59; Fuller 1987, p. 42). Abila is located in a subdivision called Irbid plateau. The elevation of this plateau ranges between 400 to 550 m above sea level, where Abila lies around 450 m above sea level. There are many Wadies incise draining N towards the Yarmouk River and W towards the Jordan Valley. The site Abila is located at the junction point of two northward Wadis, the main Wadi is called Wadi Quailbeh has a perennial brook, and the second is small Wadi called Wadi Abila usually water runs in it only in winter. The portion of the stream valleys are of the Yarmouk drainage have stretched out watersheds with relatively incomplete dendritic drainage models, simulations of the hydrological systems, point out that this kind of drainage model causes rapid erosion on a natural slope of land surface (Schumm 1977, pp. 63–69; Fuller 1987, p. 44). Abila wadies are steep slopes northwards, but to the south, they are pretty gentle.

Wadi Quailbeh is incised between 50 – 100 m into the soft chalky source rock which are driven from marine sediments deposit, in shallow water conditions and uplifted during the Middle Eocene period (Schulman 1978, p. 59; Fuller 1987, p. 45). Usually, marine sediments are divided into two groups thin and thick; at Quailbeh only thick sediments appear. They are mainly constituted of chalk, limestone, phosphate beds, and flint nodules (Fuller 1987, p. 45). According to the geological photo maps, Abila bedrock is defined as chalk, limestone and chert beds, dating from the Eocene period. The region is known by the domination of chalky bedrock, except to the north of Wadi Al-Yarmouk, basalt flows of the series Pleistocene are capping the limestone and marl formations (Fuller 1987, p. 43). Immediately under the basalt flows spread outcrops of Oligocene and Miocene formations are present, vary in consistency from conglomerate to clay, sandstone and limestone (Fuller 1987, p. 46).

Abila upper stratigraphic section contains a calcareous conglomerate with very well-cemented clasts of chert and limestone. The majority of the clastic material in the calcareous conglomerate uncovered at Abila consists of pebble-size inclusions, the size ranges between 5 – 14 mm, while some siliceous pebbles get to 60 mm in diameter. The conglomerate is a very well cemented and utilized as building stone (Fuller 1987, pp. 46–47). Light color calcareous sediments are located beneath the conglomerate, made of fine biochemically derived calcite (CaCO) particles, varying from clay to silt size. The spotlight of the Yarmouk Valley points out that calcareous sediments strata are of numerous hundred meters thick, this type of calcareous sediments when uncovered it weathers producing soft stone known as Caliche, which is usually used in constructing buildings as in the case of Abila (Fuller 1987, p. 47). Caliche stone is soft enclose a lot of natural caves, besides it is easy assembly into tombs and aqueducts, in between the calcareous conglomerate and the chalky limestone flint beds are present and all of the excellent quality for tool manufacturing (Fuller 1987, p. 48).

Rainwater easily erodes calcareous rocks, due to the high consumption of water by this type of rock; it looks like the area around Abila is still in a youth stage of Karst cycle, characterized by many scallop shaped pockmarks on the surface of the bedrock (Fuller 1987, p. 49). The only perennial spring in the area is Ain Qweilibeh, it is located 600 m south of the site, in the past water was channeled by two aqueducts to the site, Wadi Qweilibeh passes through the site, therefore; to connect both sides of the wadi at the center of the site Roman built up a bridge of basalt, it is still functioning until today, due to the massive size of the bridge, the Fuller believes that the flow of Brook during the Roman period probably was double or even triple of today (Fuller 1987, p. 50), and the aqueducts were transporting around 10 times of what it does today (Fuller 1987, p. 251).

2.3.3 The Geology Umm el-Jimal:

The Jordan Badia district covers a broad and major part of the Hashemite Kingdom of Jordan. It covers around 72,600 km2 of East Jordan, expanding from north to south, which comprises 81.3% of the whole area 89,400 km2 of Jordan (Al-Homoud et al. 1995, p. 51). Almost the whole of Jordan is covered by sedimentary rocks. In the south, various Precambrian plutonic and metamorphic rocks are showing in the south-west of Jordan. When moving towards NE direction thickness of the sediments increases, were increasingly younger sediments are uncovered (Bender 1974b, p. 40). The Precambrian rocks are covered by unconformably Unmetamorphosed Cambrian to Silurian sedimentary rocks. These rocks consist mostly of clastics, and a number of thin carbonates incline lightly north and north-east under the Cenozoic sequences (Al-Homoud et al. 1995, p. 54). The upper Cretaceous is characterized by the occurrence of higher carbonates depositions, containing a diversity of marls, limestones, and dolomitic limestones. While during the Tertiary, carbonate deposition sustained and the progression formed a major upper aquifer complex. In the NE of Jordan Quaternary basaltic rocks are found, they wrap around 1/7 of Jordan. Slight basaltic interruptions are also originated beside the east cliff of the Jordan Rift Valley, typically connected with faults. Around 11,000 Km2 of Jordan is covered by basalt flows from the Tertiary-Quaternary continental. The basalt plateau ranges in width between 50 km and 170 km from E to W and expands 180 km starting the Syrian border, E and S of the Azraq basin, into Saudi Arabia. Jordan basalt is a part of the North Arabian Volcanic Province, starting from the S margins of the Damascus Basin in Syria, through Jordan into Saudi Arabia, to the E border of the Azraq and Sirhan basins. Recent detailed studies proved that the basalt projections are alkali-olivine in nature. Several numbers of different basalt lava flows were distinguished and dated using K-Ar techniques, the dates are varying from 13.7 Ma to less than 0.5 Ma for the surface rocks. While the sub-surface flow date at 23 Ma. The younger flows are centered on Jabal al Arab.

The Jordan Natural Resources Authority called the exposed basalts by the name Harrat Ash Shaam basaltic super-group; the farther subdivided Harrat Ash Shaam into five major groups known as the Bishriyya, Rimah, Asfar, Safawi, and Wisad. The basalts consist of lava flows formed a enclose systems which are inclined from north-west to south-east, beside pyroclastic sediments and volcanic centers of dissimilar types, as well as shield volcanoes and strato-volcanoes. A substantial quantity of material has been blown up from many fissures, with basalt and some tuff being ejected from clusters of inaccessible cones. The Eastern Badia shows the most important faulting systems, broad swells, and basins in the central and NE of Jordan, such as Al-Azraq-Wadi Sirhan Basin formation were due to Block. A plentiful ground surface features and the basalt enclose systems all stretch out along different linear zones. The recognized dominant fault trends are three that is E to W, NW to SE and ENE to WSW. Deep tensional forces caused the NW fault systems. Perpendicular dislocations are regularly small. Ar-Ramtha-Wadi Sirhan graben is the most important system, passing through the Azraq area and into Saudi Arabia. The amplify thickness of Mesozoic and Tertiary deposits of the Azraq basin occurs due to the Fuluq fault system (Al-Homoud et al. 1995, p. 55).

It is noticeable that fine grains occur in most of the Badia. They differ in dimensions and quality. There are four morphological types can be recognized, depending on their size, form and drainage distinctiveness. The first deposits are fed by wadis, without having any external drainage. This type is usually saline and shows a lot of the characteristics of playa deposits. The second deposits are fed and drained by wadis. This type is rarely saline or of low salinity. The third is minute linear features a line the wadis. Usually, they take place in areas where the ground surface enclosed at some point in Wadi flow permits the precipitation of slack-water deposits. The fourth is small features developed depressions. Where some receive and deliver water and others take action as sediment traps because of the absence of drainage (Al-Homoud et al. 1995, pp. 56–57).

Sirhan sub-basin is located in the central of Jordan to the NW-SE, the site Umm el Jimal is situated in within this area, the Sirhan sub-basin developed at some stage in the Cretaceous period. Decrease started in the Cenomanian and nonstop during the Senonian in the north part of the basin, which is clear as seen by looking at the thickness and sediment facies, besides the major decrease, which took place during the late Cretaceous transgression. The beginning of rifting in the basin corresponds with doming, during the late Jurassic to early Cretaceous regression. Sandstone appears to be dominant in the NW part of the sub-basin from the early Cretaceous sediments, with thickness reaches 400m, with secondary limestone and shale deposit in an open marine environment, the strata is followed by approximately 900 m limestone dolostone and marl from the Cenomanian-Turonian age. Compression started to dominate the tectonic setting along the Mediterranean margins during the Senonian age. The major part of the Levant due to the compression was composed of chert, bituminous, limestone, and some phosphorite. In the SE part sedimentation during the early Cretaceous were slow, about 700 m sandstone, dolostone, and evaporites were deposited during the Cenomanian-Turonian, while during the Senonian around 950m of sandstone, dolostone, and coarse clastic sediments accumulated during the Paleocene-middle Eocene, about 700m of sediments were deposited (Nairn, Alsharhan 1997, p. 47).

2.4 Archaeology of Abila (Qweilibeh):

The location of Abila played an important role as being a desirable place to settle and live. It is located in a region known as the Levant in the Syrian-Palestine, eastern of the Galilee sea and the Jordan River, it is located in the Transjordan Plateau, in an area known today as (Beni Kenana or alKefarat region), the site is bordered from the east with desert, and from the west with Jordan rift valley, and from the north Yarmouk (Wineland 2001, p. 3). Abila is about 13km northeast of the modern city of Irbid, and 5 km south of Yarmouk River and east of the southern end of Galilee Sea (Tiberias Lake). Wadi Qweilibeh runs through the sites and extends until Yarmouk River valley, the Wadi used to drain water from Ain Qweilibeh to Yarmouk River valley. The length of the valley is 12 km where water used to flow until recently. When the farmers started to use modern pumping, they built up a cistern over the spring to collect enough water for pumping. Therefore; the eco-system of the Wadi and the area changed forever. The width of the valley gradually decreases from 3 km in its beginning to 2 km at its end (Menninga 2004, p. 41). Abila is located on a limestone plateau in a Mediterranean climate zone with an annual amount of rainfall of approximately 400mm. The plateau is covered by a red fertile Mediterranean soil. The site built on a hill called (Tell Abil) at a cross junction of two wadis and another small Wadi separates them from the plateau, which gives it a good defensive position. The archaeological remains which were uncovered at the hill were the earliest, later the site expanded to the valleys and the adjacent plateau (Lucke et al. 2012, p. 101). Archaeological records point out that the site was occupied from the early Bronze Age to the Ottoman period (Mare et al. 1982, p. 47), during the Roman-Byzantine period the settlement reached its peak, the population peaked at about12000 people (Fuller 1987, p. 246). The economy of Abila was mainly depending on agriculture, which is shown by the number of agricultural fields in the vicinity of the settlement (Fuller 1987, pp. 247–278). The soil in the region is rich in lime coming from the limestone bedrock, which makes it very fertile, and easily cultivated, therefore it was and still utilized to grow different types of crops such as olives, grapes. Archaeological remains indicate the fertility of the region by grave painting and coins, where different crops and species are being painted. Thus, the fertility of the region together with the climate encouraged cultivation (Menninga 2004, p. 41). Climate is considered as one of the main factors of prosperity in Abila, therefore Abila and the other Decapolis cities suffered the climate deterioration during the late Byzantine period, which caused aridity and change in the socio-economic strategies from agriculture to nomadism (Lucke et al. 2012, p. 104).

Figure 1Fig. 2.3: Aerial view of the north area of Tell Abil, showing the remains of the Umayyad Palace and the Byzantine church (modified after Kennedy D.L. 1980).

The density of settlement again increased until the other the decline that was started in the late Ottoman period, never the less the event did not negate continuous occupation. At the beginning of the 20th century, favorable climatic conditions encouraged many tribes to settle again (Lucke et al. 2012, p. 124). Jordan climate, in general, is affected by western current wind comes from the Mediterranean, which usually carries moist and eastern arid wind, which usually carries sand, that is why there is a huge fluctuation in temperature between different seasons, which may vary between 0^{o}C and 46^{o}C, relative humidity varies also between 50 - 70 percent(Maxwell 1990, p. 16).

Abila Archaeological site extends on an area of about 5,403 Km^2, (Lucke et al. 2005, p. 66). Ain Qweilibeh, a spring stems from a hillside about 1.5 km south of the site flows to the north into Wadi Qweilibeh, then to Abila until it reaches Wadi Al-Yarmouk (Lucke et al. 2012, p. 105).
The archaeological site Abila is located within the Yarmouk Drainage in the Transjordan Plateau. It is composed of two Tells; Tell Abila in the north is considered the main Tell, delimited from the north by Wadi Abila and the other Tell in the south is called Khirbit Umm el-Amad. The two hills (Tell) are separated by a lower saddle area and both are bordered from the east by Wadi Qweilibeh (Lucke et al. 2012, p. 105). Abila has many other ruins in addition to the Tells such as several Churches, Byzantine shrines, a Roman Bridge, an extensive underground aqueduct system, an olive press, a Roman villa, an Islamic fortress and residence and many frescoed tombs (Mare 1996, p. 262). Archaeological evidence proved that Abila has been occupied from the Bronze Age until the beginning of the Ottoman period, which spans about 5500 years, Abila was heavily occupied during the middle Bronze age and during the Hellenistic period (331-63 BC) (Menninga 2004, p. 48).
During the Hellenistic period, Abila was very prosperous as indicated by pottery and the two tombs at the site. Mare (1992) pointed out that the site was an important city among the prosperous Greco-Roman cities of Decapolis. Abila became one of the Decapolis cities sometime between Alexander's conquest and the summit of the Seleucid period (198 BC). Roman period started in63 BC when Pompey the Roman leader arrived at the area and introduced new political and administrative changes, which led to stabilization and growth to the site Abila and other Decapolis cities. Pompey was the leader who freed Abila from the Hasmonean Kingdome (Wineland 2001, p. 72). Many buildings still stand as a witness of growth at Abila during the Roman period such as the public buildings, the temples, the theater, and streets. Culture materials like pottery and coins, which were found at Abila present the importance of the site even during the late Roman period, and the garnished fresco tombs too (Wineland 2001, p. 74).
In the Early Byzantine Period (324-491 AD) while Abila has been mentioned by only two sources, occupation in the city was represented by ceramic, coins and tombs. With the beginning of this Period (AD 324), Abila and the rest of Decapolis converted to Christianity. This was, of course, evidenced by the emergence of new constructions of early churches. The late Byzantine Period (c. 491- 661 AD) is well represented at Abila, through ceramic, coins and tombs that have

been discovered in different areas. Four churches were excavated at Abila, which suggest the divided Christian population at Abila by sectarian opinion, and the multiple churches were needed to meet their needs (Wineland 2001, p. 111).

Abila during the second quarter of the seventh century AD was ruled by the Umayyads after they defeated the Byzantine army at the Battle of Yarmouk in 637. The Umayyad occupation of Abila is obvious, a lot of Umayyad pottery sherds collected from different areas, adding up the Umayyad public building located on the top of Tell Abil, even though not many coins dated to this period. It is obvious that during the Umayyad period several Byzantine basilicas were approved out within this Period and then used again as domestic installations, the only lacking evidence is the Umayyad tombs (cemetery), which is until today not located at Abila. The area was flourishing until the middle of the seventh century (747- 748 AD), when the whole area was destroyed by a shocking earthquake (Wineland 2001, p. 113).

Ibn Khurdadhbih a geographer from the ninth century AD was the only one to list Abila as one of the regional sites during the Abbasid period (A.D.750-969) together with Pella, Jerash, and others. During the Abbasid period, it seems that occupation of the site was minimal, which is clear by the disappearance of any traces from this period. This could be attributed to the (747-748 AD) earthquake, where All the population been forced to abandon the site. The site remained unoccupied until the Fatimid period (969-1171) AD. Regrettably, the site did not recover its rank as one of the important urban centers in the area. The site was reoccupied during the Fatimid period; evidence of occupation is slightly few. During the Ayyubid and Mamluk Periods (c1174-1456 AD), there is some slight evidence of occupation but totally abandoned during the Ottoman Period (1516-1916 AD). Because, in February 1806, Seetzen visited the site and mentioned that total abandonment (Wineland 2001, p. 115). The site attracted the attention of many scholars and archaeologists, such as Bourguignon d'Anville 1732 when he illustrated Abila on maps, later in 1784 he added Abila to his ‟Atlas Antiques‟. Many of Abila's ancient architectural remains are excavated such as canals, tombs, gates and public buildings, but there is still many to be uncovered. The site has been extensively occupied from the early Roman until the Umayyad periods (63 BC-AD 750). Abandonment occurred after AD 969 (Lucke et al. 2005, p. 65). Eventually, it appears that environmental, political and climate factors were for the culprits behind the abandonment of Abila (Lucke et al. 2005, p. 79).

Ulrich Seetzen1806 was the first to examine the archaeological remains of Abila (Wineland 2001, p. 4). Later the German architect-explorer G. Schumacher 1889 significantly describes Abila in his writing after his visit to the site 1888 under the title " Abila of the Decapolis" his work was funded by the Palestine Exploration Fund. In 1933 Nelson Glueck visited the site during his survey of the district Transjordan, then an excavation team from American worked at the site for seven seasons. The first intensive survey of Abila was conducted by Harold Mare in the summer of 1980, Mare was a Professor at Covenant Theological Seminary in St.Louis, Missouri and Director of the Abila Archaeological Project until his death in 2004 (Wineland 2001, p. 20). The main results of the work at Abila are presented in two important works, which are the Michael Fuller unpublished Ph.D. dissertation in 1987 and John D. Wineland in 2001, the Fuller focused on survey materials and water system of the site, and Wineland Focused on the political and social history of the site offering mixture of the first excavation season.

The Fuller's provided and important information regarding the intensity of settlement history and dates, where he pointed out that the site has been occupied at least from the late Paleolithic until the middle Bronze Age when the city was first established and from then until the end of the Abbasid period.

As a dating material, pottery was used to study the different phases present in the stratigraphy of the excavated areas of the site, pottery evidence revealed Chalcolithic phase (4250-3300 BC), Early Bronze Age (3300-1950 BC) and Middle Bronze Age (1950-1550 BC). The most presented phase of the previously mentioned phases was the Late Bronze Age by pottery as well as a tomb from this period, Iron Age (1200-918 BC) was present too (Wineland 2001, p. 98).

A diversity of archaeological remains are present at Abila, showing the importance and richness of the site during the different archaeological periods, such as villas, basilicas, theatres, Odeons, baths, and tombs. Depending on the excavation work at the site, Abila was divided into many areas, such as, Tell Abil or area A, where it is believed to be Abila of the Decapolis during the early Roman period. Numerous archaeological remains were excavated at the site, the most important is the Basilican Churches, although Basilicas were known earlier among the Greek and the Romans, where it was a place of meeting of the people to discuss business (Mare et al. 1992, p. 61). The adaptation of Basilicas by Christians guided them to develop basilicas according to their own needs; therefore, Christian's basilicas are easily differentiated by their architectural elements. Umm el Amad basilica is the most important at the site, it dates to the seventh century

AD, it looks like it was built over an earlier structure, which could be a Greek or Roman temple (Schumacher 1889, p. 23). Standing on Tell Umm el Amad the highest elevation at the site, suggests that the city Acropolis would be situated there, where Umm el Amad church is situated nowadays, it is an exceptional church that has five aisles, very much similar in architectural plan to the Nativity Basilica at Bethlehem (Menninga 2004, p. 43). These types of churches were not common during the early Christian Byzantine period in the Middle East (Mare et al. 1992, p. 62). A Umayyad feature was exposed at the site, it is a structural part of it was built above the apses of the basilica, and extends to the east, outside of the basilica. It is most likely a mosque built within the walls of the basilica, relying upon its architectural elements.

Hellenistic and Roman temples were also uncovered, as well as a Umayyad palace and a bath with Nymphaeum connected to water channels. The Cardo Maximus and the Decumanus are still visible until today, both are paved with basalt. A lot of structures are still covered, the most important among them is the theater, but unfortunately, no elements of the theater structure are visible today except, from the back cut of the hillside, where it seems the theater was located, but due to masonry debris nothing is seen. Outside of the city walls, Abila cemetery extends alongside Wadi Qweilibeh to the east of Umm el Amad church, and to the northeast of Ein Qweilibeh (Mare et al. 1992, p. 65). Many of the tombs have fresco decorations, inspired by the Roman daily life of Abila.

2.5 Archaeology of Gadara (Umm Qais):

The archaeological remains of Gadara are on the eastern elevation of the plateau, which is enclosed from the north to the Yarmouk River and from the south Wadi Al-Arab. The site spreads out across the whole plateau, to the west; the settlement extended about 1.5 Km, but due to the sloping topography of the region, settlements towards the north and south were limited, only less than 0.5 Km. The site has the maximum width of 450 m, in its eastern end, gradually narrowing while heading to the west, until it reaches about 200-300 m, in the middle, again it expands when heading towards the western plateau, where it reaches about 300-500 m (Maxwell 1990, p. 127). Most of the archaeological remains of Gadara are dated to the Roman, Byzantine periods, and the different Islamic period. According to previous excavations, two-thirds of the ruins belong to from the Roman period. The most likely settlement started first in the upper city, which stands for the further eastern side of the site, and extended westward comprise the middle city and western city during the late Roman and Byzantine periods. During the nineteenth century, when the explorers visited Gadara, they described the city walls, which seems that the walls were still visible, but it seems that they were indicating only the upper city walls (Schumacher 1890, p. 53).

Fig. 2.4: General view of the Ottoman village of Gadara (The Image courtesy of www.HolyLandPhotos.org).

Unfortunately, very little parts of these walls still stand today. However, it is not clear if the upper city had been surrounded by a defense wall, as the greater city walls are concerned, the topography may propose a row where these walls could be traced (Wagner-Lux and Vriezen 1980, p. 157). In some places where the landscape relatively helps, some wall remains possibly appear to be part of the city wall. In general the Hellenistic and early Roman cities were regularly surrounded by fortifications, while in the Late Roman and Byzantine periods, it looks like the growth of urban areas was not only within the fortifications of the cities (Maxwell 1990, p. 130). As Gadara is concerned, probably the middle city growth was incorporated with the upper city within the same fortification wall.

Gadara has an east-west Roman road, which was documented by the scholars who visited the site, the road is colonnades, and it is about 1 km in length that stretches from the eastern gate of the city to the present west gate. The decumanus maximus is another paved Roman road, which is called the north-south street west of the Basilica terrace.

During the summer of 1980, a German mission started to excavate in two different areas of the Roman road, the first was a side street paved by basalt adjoining the arched rooms beneath the terrace, most probably ongoing farther than the western theater. A canal system was uncovered that contained the remains of ceramic pipes, which initially were placed under the street pavement in the northern half of this area. There is no proof that the aqueduct which reaches Gadara from the east go through the city. Most probably the construction of this system could assist in supplying water to the canals system as well as the baths and nymphaeum.

The second excavation in 1980 was conducted to the west edge of the middle city was revealed a section of the decumanus maximus. Another example of the water system was uncovered with some ceramic water pipes and cistern, which is certainly was used for water collection (Wagner-Lux and Vriezen 1982, pp. 154–157). The second trench revealed that the road was constructed over an earlier structure could be a building, in general, the total excavated area of the decumanus maximus was about 34 m with columns in situ (Wagner-Lux and Vriezen 1982, p. 160).

A big part of the upper city on the eastern plateau vanished, due to modern occupation, comparing to what Schumacher showed, it is absolutely true in the case of the summit of the upper city, where is nothing preserved of the ruins, except for some structures a big part of them were robbed, can be seen on the slopes around the top. A large terrace extends about 90 m from north to south and 30 m east to west, located in the northwest corner of the upper. Earliest travelers point out that the terrace could be a temple or a church (Buckingham 2011, p. 429). The German excavation mission determined that the basalt wall, which is 1.7 m wide, was constructed to support the terrace on the slope of the hill (Buckingham 2011, p. 160). To the eastern side of the wall, the terrace consists of two floors, the upper floor made of reused basalt and limestone, which were used to be a part of an architectural structure related to the stylobate of the colonnade structure over the supporting wall (Wagner-Lux and Vriezen 1980, p. 51). The second-floor layer lies about 0.5 m beneath the first layer and consists of large limestone slabs, the dimensions are about 80 by 30 cm (Wagner-Lux and Vriezen 1980, p. 160) as stated by the excavators the lower floor is of a Roman origin. The basilica located in the center of the terrace, it is a square building measure about 23 m in length from each side, with a central octagon about 10 m in width (Wagner-Lux and Vriezen 1980, p. 53). The basilica has two entrances, the main door is located in the middle of the west wall, and the other is smaller in size located in the center of the east wall (Wagner-Lux and Vriezen 1980, pp. 52–54). The church has four apses in each corner of the structure there is one, two are in a good state of preservation the once located on the eastern side. The apses seem to be set off from the building, which is indicated by placing traces of the chancel posts and screens (Wagner-Lux and Vriezen 1980, p. 54).

Southeast of the apse, close to the wall block, there are two grooves; most likely they were used to hang a shelf. The grooves may stand for cultic function (Wagner-Lux and Vriezen 1980, pp. 54–55). A sarcophagus in the northeast apse was uncovered, and two shaft graves in front of the sarcophagus (Wagner-Lux and Vriezen 1980, p. 57).

A walking area around 5.5 m in width is located when arriving at the center octagon. The floor pavement does not differ from the apses, it is paved with stone tiles in geometric patterns using different colors (Wagner-Lux and Vriezen 1980, pp. 54–56). The ambulatory guides to the central octagon, where there are six column bases still in situ out of eight on the north side, while the western part of the octagon is detached by chancel screens from the ambulatory, and the eastern part of the wall have a small apse in the center (Wagner-Lux and Vriezen 1980, p. 56). To the eastern side of the apse, a limestone drum of a column contains an engraved cross on its east side. The date of the construction of the basilica is about the first half of the sixth century AD. (Wagner-Lux and Vriezen 1980, p. 57). The arrangement of the fallen architectural elements suggests, that the destruction occurred, due to the earthquake with no doubt. Below some architectural elements some Umayyad materials were uncovered, proposing that the church was unused before the distraction of the earthquake in the middle of the eighth century (Wagner-Lux and Vriezen 1980, p. 58).

The colonnaded 30 m by 30 m court to the north of the basilica, have fifteen columns still standing, connected with a corridor 28m by4 m by the west wall of the basilica, while on the eastern side of the corridor a row of basalt columns to its west. According to the excavators, the colonnaded court and the corridor were constructed probably during the same time as the basilica(Wagner-Lux and Vriezen 1980, p. 162).

The west theater is located at the south end of the basilica terrace, it used to have a scena, which does not exist anymore measured approximately 53 m wide, and the diameter of the orchestra is 20.5 m.   The theater have fifteen rows of seats facing west, the first row had a headless Tyche sitting in the center (Schumacher 1890, pp. 65–67). To the southwest of the theater about 30m a mausoleum (now gone) was documented by Schumacher, the mausoleum is facing east-west, it is semi-subterranean structure, the back section is incised into the limestone rocks of the hillside and front was built of basalt blocks. The dimensions of it are 15 m in length (east west) and the width is 6.4 m (north-south), according to Schumacher speculation, depending on the basis of its construction technique, the mausoleum probably looks like the oldest remaining monument of Gadara(Schumacher 1890, p. 67). The north theater is located at the northeast corner of the upper city, it is not preserved as the west theater (Schumacher 1890, p. 50). Comparing to the western theater the north theater is larger in size, the scena is 77.5 m wide and the orchestra diameter is 23.5 m, unfortunately, the number of seat rows is not known (Buckingham 2011, p. 259). North of the eastern edge of the northern theater the east gate is located, few traces of this gate is still present in situ (Schumacher 1890, p. 54). Adding to the upper city, three underground vaulted rooms in the north were documented, all of them have the same size 7 m long by 2.6 m wide (Wagner-Lux and Vriezen 1980, p. 141). The last structure of the upper city is the west gate, as described by Schumacher 1886; it is bordered by basalt pillars.

The Middle City west of the basilica terrace, where the paved street crosses the decumanus maximus, the middle city persist westward for approximately 450 m along the colonnaded road. Because of the topography of the site, the eastern part of the middle city of Gadara was slenderer than the western part from north to south, due to this fact most of the ruins are within 100 m of the decumanus maximus, except for some structures in a very sleazy state. The shops or the storerooms are located to the south of the crossing of the two roads, there are fifteen visible vaulted rooms, all of them measured about 4.9 m in length, while the width varies between 3.30 m to 3.90 m, and the height varies between 3.15 m to 3.30 m. The rooms are constructed using two types of stones, the lower courses and the door frames are made of basalt, but the rest of the rooms are made of limestone (Wagner-Lux and Vriezen 1980, p. 138; Schumacher 1890, pp. 62–63). By crossing the road towards the west from the vaulted rooms, about 30 m west and about 50 m south of the decumanus maximus, a wall with unidentified function is stretching from north to south, built by basalt using (head-and-stretcher technique), the height of it is around 1.2 m, only the upper course is constructed of limestone (Wagner-Lux and Vriezen 1980, p. 138). Farther north of this wall a vaulted limestone ceiling room with an eastern access, measuring 10.7 by 3 m., due to the orientation and construction techniques, it may belong to the business quarter as the vaulted shops to the east. The bath complex is located about 100 m west of the side street, the complex structure is built on a sharp slope, heading down from the decumanus maximus, the complex measures around 42 m north to south and 18 m east to west (Wagner-Lux and Vriezen 1980, p. 139). The bath complex consists of several chambers, the first is room VI located on the north end of the building measures 33.25 m by 7.5 m, most probably the function of this room was an apodyterium and frigidarium (Holm-Nielsen et al. 1986, p. 225). South of room VI is room IV it measures 19 m by 10.5 m, which is the main tepidarium (Holm-Nielsen et al. 1986, pp. 224–225), room III measures 19 m by 9 m which were the main caldarium (Holm-Nielsen et al. 1986, p. 220), and room I south of room III, measures 9.5 m by 10.4 m, had a hot tub for room III, anyway it seems like after reconstructing a new phase, the room was closed by the construction of an apse for other purposes (Holm-Nielsen et al. 1986, p. 224). A series of four rooms located next to the west side of the bath building, room X measures 5.8 m by 6 m functioned as a tepidarium, room VII measures 5.8 by 5.8 and room IX measures the same, both functioned as auditorium and laconicum (hot dry bath) correspondingly, and the last room is room V, measures 6.8 m by 4.7 m served as another caldarium(Holm-Nielsen et al. 1986, pp. 224–226). Excavation at the southeast corner uncovered room VIII, measures 6.75 m by 8.5 m, which functioned as furnace and other purposes (Holm-Nielsen et al. 1986, p. 226), further to the north side of the bath complex lies room XI, measures (3m by 2.75 m, in fact, this room is located under the decumanus maximus pavement and, served as a storage room reachable directly from room VI (Holm-Nielsen et al. 1986, p. 226). Excavation results revealed the time periods of utilization of this complex, it was utilized during three different time periods, the first is the early Byzantine period, when the bath was mostly used at its greatest capacity (Holm-Nielsen et al. 1986, p. 220), the second is the late Byzantine period, this time period was slightly inferior, because of some rooms were reduced in size, and the building materials were reused to reconstruct the bath after the 365 or 447 A.D. earthquake (Holm-Nielsen et al. 1986, p. 220). The third occupation phase is the Umayyad period, it is clear that the structure was not used anymore as a bath, nevertheless as dwelling area, and some rooms only, those are located on the western side. Fatal damage occurred after the 746/7 A.D. earthquake, and since then the bath complex was never used again (Holm-Nielsen et al. 1986, pp. 228–229). It seems like that the bath complex was fed with water from different types of installations when the decumanus maximus was excavated in two areas both ceramic conduits and cisterns for water collection was uncovered. Only a 100 m away from the bath complex, just at the junction of the decumanus maximus and the paved street one of these installations was located, in general, Gadara citizens were aware of creating a water collection system, especially there is no sign of a nearby spring. Around 100 m west of the conjunction of the decumanus maximus and the side street, a remaining of the nymphaeum is there. The nymphaeum remaining measures about 17 m east to west by 12m north to south. Actually, the nymphaeum was constructed facing the road south, as well as the east and west, on each side, there is a central apse in the back wall surrounded by wings expands outward at about 45^{o} angle (Maxwell 1990, p. 151). A series of niches were located in each wing, where statues initially placed, some figurine fragments were found on the eastern side of the building (Weber 1988, p. 1). Weber 1988 concluded that the northern section of the nymphaeum functioned as a storage area of the water used in the nymphaeum. The nymphaeum regarding its architectural style dates to the second to third centuries A.D. (Weber 1988, p. 1). It is most likely that the nymphaeum destruction took place during the late Byzantine period, due to the deposits covering most of the remains, which mainly date to the sixth and seventh centuries (Weber 1988, pp. 11–12). Herakleides baths are located in the northwest corner of the middle city, around 80 m off the decumanus maximus, the building dimensions are 30.7 m north to south by 19 m east to west, the name of the building comes from its builder, Herakleides, confirmed to whom mosaics dating to the fifth or sixth century (Wagner-Lux and Vriezen 1980, p. 142).

A vaulted ceiling limestone building ruins located south of the decumanus maximus in approximately around 110 m, and west of the West theater in approximately 340 m, the building size is 21 m northeast to southwest by 6 m northwest to southeast, unfortunately the function of this building is not known (Wagner-Lux and Vriezen 1980, p. 139). West of the previously mentioned building in about 120 m south of the decumanus maximus, stretches out the remains of al-Qasr (Schumacher 1890, p. 74). It is a rectangular structure, 20 m * 20 m, includes a central octagon. The Qasr is constructed of enormous limestone blocks, except the door pillars, the stones of the wedge-shape arch doorway built of and some parts of the interior (Wagner-Lux and Vriezen 1980, p. 140).

The interior south-west corner has an apse, its diameter is 5 m, and the depth is 2.8 m (Wagner-Lux and Vriezen 1980, p. 140). Just about 10m south of Al- Qasr, a limestone terrace has three courses is still visible, the dimensions are 48.5 m from east to west by 20.6 m from north to south, probably this terrace belongs to al-Qasr complex, because of the parallel orientation between the complex east-west walls and the terrace, perhaps the date of the structures, relying upon the building styles belongs to the middle Byzantine period, sometimes in the middle of the sixth century A.D. (Maxwell 1990, p. 158).

The Western City extends onto Ard al-‘Ala plateau, it is not easy to describe this area, comparing to the Middle city and Upper City, first because it is hard to find the city wall, which surrounds this area, Second the main architectural ruins west of the middle city such as (circular structure, west mausoleum. hippodrome, and monumental gate) would have normally found their places exterior of an enclosed city area in the time when they were built. Therefore; it seems that the western city was a natural expansion of a later settlement period, probably during the late Roman-early Byzantine, due to architectural remains, it would be safe to assume that it was a residential area (Maxwell 1990, p. 160-161). It is really hard to distinguish what type of compounds are located in the Western City, because of the fact that the majority of the area is covered by cultivated fields, olive groves, and a military camp. In general, it seems that the Byzantine settlement was mainly concentrated on the eastern side of this area, while the Islamic period occupation tended to be more on the western side (Andersen and Strange 1987, p. 90). Occupation of the western city seems to be discontinued, as two periods could be definitely recognized(Maxwell 1990, p. 164). Directly south of the decumanus maximus around 600 m west of the basilica terrace, a rounded structure about 11 m in diameter, referring to the structure style it dates to the Roman period, unfortunately, the original function of this structure is not established, some proposed that it is a monumental tomb, but excavation could not prove that, The other option is that the ruins are those of the south half of a freestanding gate. It is clear that the structure was used during the Byzantine and Islamic as a water reservoir, which perhaps has added confusion in determining the original plan and use of the building(Weber 1988, pp. 18–19). A subterranean staircase leads down to the mausoleum; the stairs are just 4 m south of the circular structure. Entering the mausoleum requires descent of seventeen stairs, where they are connected to a vestibule, measuring 12.5 m north-south by 9.2 m east-west. Four pillars support the roof of the vestibule are still in situ (Wagner-Lux and Vriezen 1980, p. 140). The vestibule has an apse of approximately 5.3 m in diameter right in the center of it; the apse is facing the main door of the burial chamber. When arriving at the end of the apse, a narrow hall of 1.6 m wide, covered by three arches, spans the burial chamber width. The vestibule most probably has been constructed during the early Byzantine period, as an addition to the Roman subterranean mausoleum. It seems that the vestibule is connected to the church above, which suggests that the church has served as a worship place for the Christian community burials below (Davies 1953, p. 51; Weber 1988, p. 25). The remaining structure of the west city is the monumental gate, The central feature of this structure was a triple-vaulted gateway, probably flanked on the north and south ends by semicircular towers, which makes the entire structure about 44 m north-south by 14 m east-west. The gateway contains a central passage 6.3 m wide and two side passages each of them is about 2.2 m wide. The adjoining towers, each about 11m wide, includes large rooms reachable on the ground level (Maxwell 1990, p. 173). The gate was built of limestone and basalt; the lower courses are mainly out of basalt. Depending on the architectural model, the massive gate was probably constructed close to the end of the second century A.D. (Maxwell 1990, p. 174).

The Necropoleis is located to the north of the middle city, it includes a large number of tombs, and one mausoleum built of limestone and basalt, the mausoleum is located on the southern slope of the wadi, it appears that the structure has two phases, the first phase had a platform supports a crypt for single burial, measures about 6.38 m by 6.25 m, while in the second phase the platform was extended for about 2.7 m towards the east and 5 m in width, and staircase of four stairs were added in this phase, unfortunately, both phases were not dated precisely, but some evidence propose that they might be either late Roman or early Byzantine (Maxwell 1990, p. 175).

The aqueduct is approaching the site of Gadara from the east, it is one of the ways that supply the city with water, even thou the source of the water can't be verified, but it may have been carried on from Ain at-Turab, which is about 12.5 Km east of the city (Schumacher 1890, p. 78).

2.6 The Archaeology of Umm el-Jimal:

The site of Umm el-Jimal was occupied for about700 years, the occupation of the site started from the 1st Century AD. until the 8th Century, once more occupation took place at the site in the early 20th Century. The site was first established as a rural Nabataean village about the second half of the first century AD., the site had its momentum from the late Nabataean settlement, and continued to be under the rule of the Nabataean during the 2nd and 3rd century AD., until the Roman controlled the Nabataean kingdom, and transformed the name of it to Provincia Arabia(DeVries 1990, p. 8). Excavations proved that the village did not have any disturbance, on the contrary, had prosperous rural life starting from Trajan 106 AD., until the end of the Severan Dynasty (235 A.D.) with a high population number around 2,000-3,000 people. Prosperity during the middle of the 3rd century AD became declined due to the waves of disorder that damaged the Roman Mediterranean. For example, De Vries Hypothesis blamed the civil war that was triggered by Queen Zenobia of Palmyra's rebellion against Rome(DeVries 1990, p. 8). Reuse of the village masonry violated the entire village, to provide building materials for the fortification of the town. Until today remains of the village are still visible, around three to four hundred meters diameter of debris located on a moderate slope in about two hundred meters east of the southeast corner of the still standing architectural remains (DeVries 1990, p. 9). Umm el-Jimal, the military station, during the 4th and the 5th centuries AD., a defensive system was constructed during the rule of the emperors Diocletian and Constantine. While the construction of the gate and the wall next to the village had started already in the 2ndCentury, Butler had recorded a dedicatory inscription from the remains of the Commodus Gate, which was inscribed as a recall for the construction of the defensive wall during the co-principality of Marcus Aurelius and his son Commodus (DeVries 1990, p. 9). It is obvious that the Tetrarchic castellum of Umm el-Jimal has lost its military function starting from the early 5th AD. A century and converted to a marketplace, this conclusion was drawn depending on the artifact types, uncovered from the streets between its barracks. A small Roman temple was recorded by Butler, he suggests that the temple dates to the early Nabataean period (DeVries 1990, p. 11). The small Roman temple, by the sixth century, already became surrounded by a domestic complex built by Christians. When the majority of the population midst the Byzantine era converted to Christianity, more churches were constructed at the site of Umm el-Jimal; fifteen churches just during the late 5th and 6th centuries AD. Even the Barracks building underwent a foremost adjustment, which integrated the construction of the southeast corner tower. The function of such common towers during Ghassanid phylarchy is local defense. Butler's estimate of 10,000 residents may be more, while DeVries discounting the number to 6000-8000 may be safer, due to the ignorance of Butler to the use of the bottom floors as stables

(DeVries 1990, p. 11). During the second half of the 7th century, and the first half of the 8th century AD., Umm el-Jimal became one of the Muslim areas, under the control of the Umayyad caliphs ruling Damascus from 661 AD., until 750 AD. Livelihood at Umm el-Jimal did not disrupt until the end of the Umayyad period. Evidence of occupation is the central structures presented by the Praetorium and House XVIII and church 22, which was modified during this time period (DeVries 1990, pp. 11–12).

Fig. 2.5: Part of Umm el-Jimal ruins totally built of basalt as the entire site.

The Praetorium was widely repaved and ornamented with frescoed plaster during the Umayyad period. Umayyad could not stop the depopulation of Umm el-Jimal after the earthquake in 747 AD. (DeVries 1990, p. 12). The particularity of the site of Umm el-Jimal comparing with the previously mentioned sites Abila and Gadara are that Umm el-Jimal mainly has a common house indicates the behaviors of the residents. It is clear just by looking at the architecture of their houses to distinguish that they were mainly farmers, most of the ground floor stories were barns and stables, and together with this, courtyards as living rooms for individuals and pens for animals. The hydrology systems outside and the terraces fields point also extensive agriculture (DeVries 1990, pp. 13–14).

The site of Umm el-Jimal is about 800m long and 500m wide. Most of the visible architectural remains belong basically to the late antique, almost 150 structures still standing, and big parts of the perimeter wall, which is suitable for keeping in domestic. Within the perimeter wall, there are three groups of buildings alienated by large open spaces, where the Barracks and the Cathedral are located. The site has no plan like Decapolis cities; there are also no streets, except for the alleys between houses. Umm el·Jimal represents the simple way of life, where arrangement plans are not desirable. Umm el·Jimal departed from the Hippodamic plan could only mean going back to normality (DeVries 1990, p. 20).

The town can be approached today from the southern wall, entering from the stone door of the Barracks through the doorway, which is clear that it had been constructed in a later phase, over the door a parapet is found, the door functions on its joint hinges. The doorway leads to a courtyard; where there is a Series of rooms, DeVries based on a lost inscription, suggests that the building was a Castelum, constructed by order from Duke Pelagius in 412 A.D. Analysis of the two towers proves that they were added in a second phase during the Late Byzantine period around the 5th and 6th century AD. (DeVries 1990, p. 22).The corner Late Byzantine tower has some Greek inscriptions and four parapets over the upper window. The inscriptions combine Christian signs, allusions to the psalms and a martial spirit. A small Chapel connected to the Barracks from the exterior on the right side; probably it is a later addition during the Late Byzantine period. Unfortunately, the function of this small chapel is not defined. Heading north following the path towards House 102, one passes by the Numerianos Church, it is located on the left, while walking through the path, it is badly decayed, it used to have a mosaic floor, but later reuse of the Church, replaced the mosaic floor by normal plaster, and it has balcony on the upper level above the side aisles. A cloister with cistern located on the north side and further following the path between Houses 102 and 116 one notices two clusters of houses. These houses present the domestic areas of the site (DeVries 1990, pp. 22–23). The double Church is accessible by turning left around 104. The Basilica or the northern Church, it is built rather in a different way, where the vaults of the partition among the side aisles and the nave rested on columns, not as usual on piers. This church was paved with a sequence of fine plaster from the late 5thto the 7thCenturies. The second Church is called the southern hall-type church, it is coarsely built. It has an abnormally big apse and doorway. An ablution basin emerges from the wall, exists to the right of the door. It is a single hall Church, which had a flat corbelled roof held up on transverse arches(DeVries 1990, p. 24). Houses 99-105 toward the entrance of House XVI have a highly structured gate, the external doorway was planned for a lockable double door, but the internal is simply elegant arched opening. The best examples of roofing presented by the use of cantilevered ceiling and the roof are planned to support stone beams. Using basalt as building materials allows corbels to carry larger loads, due to the durability of basalt comparing with limestone, beside it is an easier method of roofing than the widespread use of columns. However, all rooms are slender, because of the limited length of the ceiling beams (DeVries 1990, p. 25). In-house XVIII, the entrance is a breach in the walls of the western rooms. Excavation revealed that the house was utilized in the Late Byzantine period, modified and used again during the Umayyad period. The"Sheikh's House" as the villagers call it, it has a large courtyard, to the left a cantilevered stairway of finely cut tramples, across there is a high wall with twin stairways creating V shape. On the opposite wall, there are two lintels relieving. Over the door there is a little square window, the window position has been put in, to avoid any weight to rests on the lintel except where it is straight carried by the door· posts. Moving to the right one more door has a bright low sprung little arch over its lintel to attain the same purpose. In the south side of the court, an arch of the single gateway allowing entrance into the courtyard. This house presents a classical late antique Hauran house. The house was built in a way to improve privacy and security. From the exterior, it looks rigorous, but once you enter, you are in the courtyard in the center of the private domestic activity.

The eastern exterior facade consists of three stories, with an arched double window, it is considered the symbol of Umm el·Jimal today. Underneath the double arched window, there is a gate, almost half of the double stone door still in situ, the gate allows access to the reservoir, which has arches to support the slab roof to avoid evaporation and soiling of the water supply (DeVries 1990, pp. 26–27). House XVII, in its north façade, has a doorway, it has relieving arch slot covered with a little balcony roof. The house corner towers are partially standing, just to the right of the door. The tower lower courses were interlocked to add strength to the masonry and allow the northwest corner to bear the remarkable mass of the tower masonry. The oval reservoir probably was formed by extracting the basalt bedrock for masonry use. It is quite clear that this reservoir received the overflow from the main reservoir and from one of the two main aqueducts that carry the runoff water. Survival of Umm el-Jimal needed regular awareness to water collection and storage, the hydrology system was simple but well engineered, successful in this relatively dry environment (Vries 1990, p. 28). The tetrarchic castellum is located to the northeast of Reservoir 9. The castellum was built around 300 A.D. when the 6th-century town was flourishing; the castellum had already been deteriorated. It has a 100m square defense wall with a visible gateway, and small square outset corner towers and rectangular towers nearby. All corners towers are square, except the southwest corner tower appears squeezed, because of the edge of Reservoir 9. Excavation detected a good chronology in this area, the reservoir 9 was constructed prior to the fort, dates to the early 4th Century; the fort, during the 5th century, was used as a marketplace, and during the 6th most of the building materials were reused in the construction of the East Church and nearby House 79.

The West Church 18, it is not well built, but the southern partition linking the nave and the side aisle is still intact, the Church has four large arches, crosses signs are visible on arches and doorway next to the apse. When the Church was not anymore in use, the apse was separated creating a single room. According to De Vries, this Church was a funerary church, because of the tomb and the sarcophagus outside the new entry narthex. The Church is located outside of the town wall, suggests a late building date (DeVries 1990, p. 31). The Cathedral (14), has an inscription stating Valens, Valentinian and Gratian, both were co-emperors in 371AD. the inscription is on a stone was reused as a beam in the right doorway. The inscription dates the construction of the church to 556AD. if the date is correct, the churches of Umm el-Jimal could be dated to the Heraclian late 6th to the early 7th Century or Umayyad period 7th Century.

The Praetorium 2, it is the most excellent built structure on the site, initially, it is an official public building present the Roman imperial presence in the 2nd-3rd Centuries, while later it became part of a domestic complex, it is quite clear from the addition of the rooms on the west side of the large courtyard. The southern façade of the building contains a triple set of doors. The middle door opens at the atrium, which has four Corinthian columns supporting a partial roof, dispatching the center open to the air. One of the rooms was plaster repaved in the Umayyad period. In the west wall of the atrium, a triple doorway leads to a large pre-Christian basilica, had two stories high pitched ceiling. The opposite door directs to a cross-shaped room, where the arms of the cross are roofed with barrel vaults. The Druze added to the central corbelled ceiling, which had straight flat beams covering the opening, clearly visible nowadays, some remnants of cruder beams. The room was paved again using mosaic and re-plastered with frescoed plaster during the Umayyad period (DeVries 1990, pp. 31–32).

The southwest quarter of the town, by entering the gate opposite House 54, heading through House VI courtyard, a large inscribed stone lies; Butler suggested that it is a Nabataean altar with a Greek-Nabataean polyglot dedication. Finally, the Nabataean temple 8 is situated in the courtyard of House 49. It was named by Butler. Yet, stratigraphy analysis discovered that the building was established in the 4th century AD., which does not confirm Butler conclusion, most likely it is a late Roman temple.

2.7 The Previous Archaeological surveys of Northern Jordan:

The main objective of archaeological surveys is providing an overview of the landscape of the study area that can provide the base for other studies. To understand the economy of a large region, the cultural landscape and the within the context of a dynamic environment should be understood. Therefore; comprehension of the principles that cause the preservation and revival of landscape features are important to be studied. Besides, how the cultural landscape was managed throughout different time periods important as well (Wilkinson 2003, p. 3). The prime aim of the archaeological survey is to describe and analyze the archaeological landscapes of Northern Jordan to reveal the social, the economic, and the physical environments. These landscapes can be documented relying on their characteristics that include field boundaries, artifact scatters, archaeological settlement sites, roads. canals, temples, and inscriptions(Wilkinson 2003, p. 3).

The first systematic survey that took place in Northern Jordan was conducted by Prof. Bethany Walker in 2003. The project was initiated to examine possible variations of the settlement, during the late Islamic periods, within the district between Irbid and the Yarmouk River, and to evaluate these prototypes with the central and southern Jordan. The main objectives of Walker's survey of Northern Jordan were to discover patterns of the growth and the decrease in village life all through the Mamluk and Ottoman periods. Walker counted on her previous archaeological surveys in Jordan, the archival records, and the archaeological finds, to explore the constant effects on land management policies and local planting practices on settlements, markets, political structures, and the environment(Walker 2005, p. 67). The second important purpose of the survey was to look at the human factors that contributed to the environmental deterioration and the impact of land use strategies from the 13th century AD. until today (Walker 2005, p. 68). The survey was focused on Malka Village, which is a part of the hinterlands of Umm Qais. As well as two mosques located in Hubras village, which is part of the Abila hinterland? Both Malka and Hubras are located in the Umm Qais and Samar administrative region. Malka is about 7 Km northeast of Umm Qais, while Hubras is about 15 Km also northeast of Umm Qais (Walker 2005, p. 70). The Malka and Hubras survey team have documented 17 archaeological features, that include rock-cut installations in bedrock used for water transformation and storage, wine presses, three tombs in natural caves, a single-chamber tomb, a badly deteriorated Greek inscription, a large industrial complex, a Byzantine dromos tomb, and a farmhouse (Walker

2005, pp. 74–75). Pottery sherds collected from the agriculture field's zone was dated to the Iron Age throughout the Ottoman periods, but the majorities were Roman, Byzantine, and Late Mamluk. The most widespread forms were jars and bowls, around 25% of the glazed wares collected belong to the 15th century A.D. and later. The most interesting outcome of Malka and Hubras survey was: the quantity of the transitional period (Mamluk to Ottoman) pottery in Jordan, which is superficially studied, therefore; the survey open the door for archaeological research on the Late Islamic period (Walker 2005, p. 75).

The village of Hubras is located 16 km north of Irbid, and about 6 km south of Sahm. The cultural heritage village of Hubras is mentioned in the historical sources of the 14th century AD., it seems that the village had a market during the Mamluk Period and a had famous intellectual elite of Damascus (Walker 2004, p. 130, 2007, p. 477). By the end of the Mamluk era, Hubras the hinterland of Abila suffered from the lack of population, like most of the villages of Transjordan, while during the Ottoman period around the mid-sixteenth century AD., life slowly started getting back to the village, which is clear by the number of the mosques and shrines. Once more before the end of the 19th century AD, Hubras appeared again in the written sources when some families started to register their land for tax purposes with Ottoman government (Walker 2007, p. 478). During the excavation at Hubras mosque, it appeared that Hubras mosque is one of the oldest mosques in Jordan. The mosque passed through several modification phases, from rebuilding to expansion. The Early Islamic mosque is small; it contains a single Mihrab and a black and white mosaic pavement. During the 13thcenturyAD.,-as stated by an inscription, which was once on the mosque minaret- the mosque was exposed to an enlargement to receive a higher number of prayers as the village became bigger. Therefore, a second Mihrab was added, a flagstone pavement replaced the mosaic pavement, and pillars to support a series of vaults and flat roof were added. It is believed that the mosque was in use until the mandate period (Walker 2007, p. 478).

In 2006 Prof. Walker conducted a survey in the village Sahm, which is located in the same vicinity as Malka, it is about 22 km northwest of Irbid, and the village is located above Wadi Sahm, very close to the Syrian border. A steep wadi splits the village into two parts known by the local inhabitants as Husn and Masarra (Walker 2007, p. 476). Unfortunately, the village was not attested in the medieval sources, it only became visible in the 16th century and one more time in the Tanzimat-period (tax registers) during the 19th century. The cultural architectural remains of Sahm are located on top of the upper slopes of Wadi Sahm hills, in the center of the cultural heritage village there is a mosque, it is a single vaulted stone room, attached to another room, which was used to be the villager's school. The second standing masonry is the springhouse, while the rest of the village houses were incorporative with caves, mostly used for habitation, storage of spare grains, animal pens, and food processing (Walker 2007, p. 477).

To have a better view of the southern Hauran optimal agricultural land, Prof. Walker started the 2010 Al-Turra survey, it is a collaborative joint American-Jordanian project between Missouri State University and Yarmouk University. The village is part of the southern Hauran plateau, located around eight Km north of ar-Ramtha, and to the east of ash-Shajarah and wadi ash-Shumar, and north-west of Wadi ash-Shallala. To the northern and northeastern fields of the village is the Syrian border. The village is positioned within the optimal agriculture land, right on the west margin of the steppe (Walker et al. 2011, p. 510). The village was chosen due to its historical importance during the Mamluk and Ottoman eras. The village had gained its importance during the Mamluk era, because of the flourishing economy due to the high grain production, and the stability brought by military protection. When the ottoman took over the Mamluk, many of the southern Hauran villages were abandoned, which is not the case of at-Turra. During the Ottoman era, the village continued to produce grains, such as wheat and barley as well as animal husbandry and apiculture (Walker et al. 2011, p. 511). The location of the village within the Hajj route contributed to its success. The village was visited by many travelers, who described the village life during the 19th century AD., Burckhardt, Buckingham, Wetzstein, and Schumacher (Walker et al. 2011, p. 512). The main objectives of Al-Turra Survey were; a). traditional archaeological survey of the village’s farmland. b). an ethnographic survey in the village. c). an architectural survey in the village. d). Soil survey. The main results of the survey were the documentation of 114 features. The documented features were rock-cut features, architectural remains, caves, cisterns, environmental features and looter pits. Besides the previously mentioned features, both lithics and pottery sherds were collected, the actual number of lithic tools and fragments collected were 161, and the pottery sherds were 1423 sherds, the best-represented era from the pottery sherds corpus is the Early Islamic period, mainly Umayyad rather than Abbasid, while the Byzantine pottery appeared in the second place, followed by the middle Islamic period, and finally the Late Islamic period (Walker et al. 2011, pp. 518–521). The most distinctive sherds of the Byzantine period surveyed pottery sherds, were African red slip, painted wares, combed jars, and ridged amphorae. Among the Early Islamic era sherds were the Umayyad and Abbasid painted ware, Abbasid mold-impressed bowls, and some splashed glazed ware. The Middle Islamic period pottery looks like the Syrian Ayyubid and Mamluk assemblages, such as underglaze painted ware, sgraffito's, and the handmade geometric painted ware (HMGP). The minor representation of at-Turra assemblage was the Ottoman period pottery, but still, there were some common wares of the Ottoman period pottery such as monochrome glaze bowls, graffito, Kütahya ware, and gray Gaza ware (Walker et al. 2011, pp. 523–524). The whole pottery assemblage of at-Turra is quite different in the phrase of fabric and chronology from that of the central Jordan, while the assemblage provides an evidence for important regionalism in material culture, settlement and market networks (Walker et al. 2011, p. 524).

Ash-shajrah and Kharja villages survey, in 2012 a multidisciplinary survey was conducted as part of a study of the Upper Wadi Shellaleh and its drainage system. The initial objective was to understand the issues behind the settlement inconstancy of the Middle and the Late Islamic periods in the most fertile region between Irbid city and the Yarmouk River. The survey combined the archival, ethnographic, architectural, and environmental analysis, just to understand the fluctuation of settlement during the middle and late Islamic periods (Walker 2014, p. 640). Both ash-Shajrah and Kharja are located about 15 and 12 km to the north of Irbid, the villages confront each other on the summit of hills across Wadi Shellaleh, close to the Syrian border. In order to have a clear overview of the Northern Jordan geographic transect, both ash-Shajarh and Kharja fulfill the gap between Malka, Saham, Hubras, and at-Turra. The survey targeted all accessible lands, such as olive groves, fallow land, and rocky outcrops. The objectives of the survey were as the previous surveys, targeting each individual land-use, environmental, and topographical zone. The introductory results of the survey propose a convincing prototype of settlement and land-use during the Islamic period. But a part of the western upper Wadi Shellaleh appears to be abandoned during the Abbasid period for the opposite bank of the Wadi. The reason behind the shift may be, because of the differences in the outlet systems and soil individuality of the two divisions and alteration in land use. It is quite obvious that during the early and the middle Islamic periods, a group of settlement structures developed on the east bank of the Upper Wadi Shellaleh, differentiated by large rural villages, and their scattered settlement and land use after the 14th century AD. Islamic pottery sherds were scattered all over Khirbat Majid on the east bank, where the Byzantine necropolis is located, which suggested that the necropolis hosted settlement during the Umayyad and the Abbasid periods (Walker 2014, p. 640). The hinterland (agriculture Fields) related to the sites have a lot of natural terraces, were irrigated by a series of runoff systems, that made use of the springs in the area. The most interesting results of the survey were the discovery of undocumented site north of Kharja known locally as ‘Ayn Ghazal. The site comprises Roman tombs of columbaria form, and a huge water storage system. While a Byzantine period architecture was documented in the most portions northwest of Tall ‘Abduh, where a great variety of Islamic period wares were found, on the contrary of what was earlier known about the area (Walker 2014, p. 640).

Northern Jordan Project and the DFG funded project that fund this study complement each other. The NJP study areas from 2003-2012 are part of the hinterland of Abila and Gadara. The writer participated in the 2010 and 2012 survey seasons of NJP, and the three surveys of the DFG project Historical land-use and landscape reconstruction in the Dekapolis region, 2014-2017. Therefore; few samples of the NJP pottery sherds from different survey seasons were analyzed. The archaeometric results correspond to the study samples. The two projects Conjunct in many research areas, which make both of them a comprehensive study of the environmental history and the archaeological remains of Northern Jordan.

3. Chapter Three: Materials and Methods.

3.1 Introduction:

The study of pottery life cycle from the stage of the collection of raw materials to the fabrication stages, through distribution and utilization to finally dispose of, is a precious contribution to archaeological research. It is important to study the particular contribution of the physical sciences to the reconstruction and interpretation of pottery life cycle (Tite 1999, p. 181). The main idea of this thesis is reconstructing the technology of pottery production by combining several scientific techniques of analysis; these are microscopy, XRD, and chemical analysis. Pottery is considered the first human-made ceramic materials; in fact, it is a synthetic form of stone, prepared by bringing together the four basic elements documented by the ancient Greeks: earth, water, air, and fire. Actually, pottery is an intentionally prepared mixture of clay with other solid materials (fillers), and water. A wet mixture of clay and fillers can be formed into a preferred shape; the shape must be dried and finally fired to high temperature (over 600^{o}C), which transforms it to a fused pottery. In general fired pottery has a coarse hard surface, stable, and durable, and cracks easily if introduced to an external force. The term pottery is used as a common name for objects comprising of fired clay, to refer to the lower grades of ceramic materials such as Terracotta, and earthenware, different from stoneware and porcelain (Goffer 2007, pp. 237–238). Pottery exists roughly in all archaeological sites, starting from Neolithic Period 8300 BC (Rollefson 2008, p.71). Characterizing the archaeological records, mainly depends on pottery, because it was a widespread material during the previous archaeological periods, and the high survival rate, due to its high durability (Al-Saad 1999, p. 213; Matson 1982, p. 20; Rice 2015, p. 3). Archaeologists consider pottery one of the most valuable archaeological materials, usually, it is collected and studied to reform patterns of lifestyle, production methods, trade, and exchange. Not to forget that pottery is used as an indicator of the relative dating of the archaeological sites, and the related culture materials (Shepard 1985, pp. 1–5).

It is of importance for archaeologists undertaking archaeological fieldworks, to identify the function, form, and ingredients of the different pottery vessels. The Specifications of the vessel could reflect the social economic situations and cultural choices. Different scientific techniques provide wealthy information about how and where the vessel was produced (Zheng and Hsia 1992, p. 132). Chemical and physical or geological techniques grant data about the technology of production and the provenance of raw materials (Peacock 1970, p. 375; Al-Saad 1999, p. 213). Archaeologists are in need of such information regarding provenance and technology, therefore; scientific methods provide a full vision of a certain type of pottery(Rice 2015, p. 310). The study of provenance and technology can be accomplished by using mainly three approaches, these are mineralogical exploration, chemical analysis and physical examination (Rice 2015, p. 372). The qualitative and quantitative analysis allows recognizing many characteristics of the pottery samples such as hardness, porosity, density, microstructure, and chemical mineralogical composition (Rice 2015, p. 344).

Major and minor mineral constitutions of pottery samples can be determined by using the main method of identifying minerals in geology, which is petrography analysis (Rice 2015, pp. 375–377). Petrography can inform us about the burial conditions as well as the function and date of pottery objects (Maggetti 1982, p. 122; Matson 1982, p. 20). The use of petrography analysis or thin section has the potential of launching the exact geographical source of the raw materials by evaluating the results acquired from studying a thin section, in comparison with the local geology (Rice 2015, pp. 376–382; Tite 1972, p. 215). Furthermore, there is an extensive array of other techniques that can be used to determine the mineral types that make up a ceramic object such as a scanning electron microscope, thermal analysis, X-ray diffraction and X-ray fluorescence (Al-Saad, 1999: 213; Parkes, 1986: 181- 92).

Chemical analysis has the potential of revealing the provenance of pottery samples, by determining the major, minor and trace elements (Goffer 2007, p. 250; Rice 2015, p. 389; Mommsen 2001, p. 658). Investigating pottery by applying scientific methods, widen the objectives of the research for archaeologists. Several questions usually archaeologists ask can be answered, questions such as: Are it local pottery or imported? How was it made? How old is it? (Janssens and van Grieken 2004, p. 104; Leute 1987, pp. 1–2). The foremost target of this study is archaeometry, therefore; different types of analytical techniques were used to investigate the selected samples from the three study areas, some techniques for determining the manufacturing technology, the origin, and other for defining the potter's capability skills.

3.2 Survey Methodology:

The main objective of the survey is detecting remains of agricultural activity in the vicinity of the previously mentioned sites by looking at the distribution of different artifacts connected to agriculture practice. To answer the question concerning the density of land use, the interconnection of soil properties, field usage, and the distance of fields from the settlements, site scatters survey was conducted, which means artifacts (pottery sherds) not connected to the site (Wilkinson 2003, p. 4). To analyze the density and distribution of artifacts, the survey started from the suburban region of the archaeological sites towards the hinterland of the three ancient sites. The presence of artifacts carpet in the hinterland of an archaeological site indicates land use, but there are also other variables such as soil depth and soil erosion that may influence this phenomenon(Wilkinson 2003, p. 11). To examine if the survey method applies to the three sites, an intensive survey methodology was conducted, characterized by collecting both onsite and offsite artifacts.

Fig. 3.1: NJP team in Umm Qais 2015 surveying a plowed field.

Mainly pottery sherds were the most abundant, which can be used, as evidence for past behavior. In the case of Abila, the survey was conceptualized as a transect survey in terms of spatial coverage in four transects radiated out of the center of Abila. All transects were oriented by GPS running to the south-west, north-west, south-east, and northeast thus complementing the transects to the north, east, south and west searched by Dr. M. Fuller in the years 1982 till 1987.

The length of each transect differs according to the topography of the region in each direction, but it was meant to be 2.5 km long from the center of the site Tell Abila. After 2.5 km distance, the pottery sherds are almost nonexistent, which refers to the possibility of access to untapped fields in archaeological times. The souvlaki method' developed by the Sydney Cyprus Survey Project was applied in this survey(Given and Knapp 2003). For the sake of geomorphology olive groves, harvested wheat fields, harvested vegetable orchards, and fields in fallow, which are located on the plateaus where the fields of the survey, to ensure having stable surfaces without any major soil movements. Each field was measured by a handheld GPS –device, because fields were chosen according to land use and field size. All survey fields were subdivided according to their width in different lines drawn every 10m. Thus the field surveyors walked in a distance of ca. 10m from each other surveying a strip of land of 2m width. The length of each field was divided into plots of 50m. Because each person searched a single plot of 50 m length covering a corridor of 1m on each side every single plot represents a search area of 100 m² (Bintliff et al. 2007). Within these plots, all pottery sherds were collected, counted and bagged separately thus accounting for a very high precision and accuracy in analyzing the material culture of the off-site carpet.

To improve accuracy each plot was searched in a time span of 5min., also the visibility was rated due to coverage of ground by vegetation preventing clear visual detection of sherds in some cases for further analytical and statistical studies. Fields have been chosen depending on the geomorphology and vegetation cover, therefore in each transect, the size of the field may differ due to the previously mentioned reasons.

3.3 Petrography:

The microscopic investigation of the archaeological materials such as pottery in transmitted and reflected light remains indispensable, as a mineralogical method of analysis. Petrography has several advantages over the other mineralogical methods. Generally; it is cheap and reliable technique concerning the adequate information that obtains. Pottery analysis by petrography permits characterizing the type of raw materials, as well as, any specific individual fabrics, and it may suggest provenance. Petrography allows establishing precise technical aspects, which portray the ware and any diagnostics of particular fabric groups (Herz and Garrison 1997, p. 264).

Different characteristics of the mineralogical constituents may be obtained by petrographic analysis. Grain size whether fine or coarse, grain shape rounded or sub-rounded or angular or sub-angular. Additionally; allows estimating the firing conditions and temperatures, and determining the non-plastic impurities and tempering materials. The identification of the potter's technical skills is another advantage of petrography. More broadly; determining the provenance of an exploited clay deposit, during a certain time period, through pottery analysis, may point out the shift in population centers. While exploiting clay deposit in a specific area and time period, then shifting to new clay source, during the same time period, may give us a clue of shifting in population centers. (Herz and Garrison 1997, p. 266).

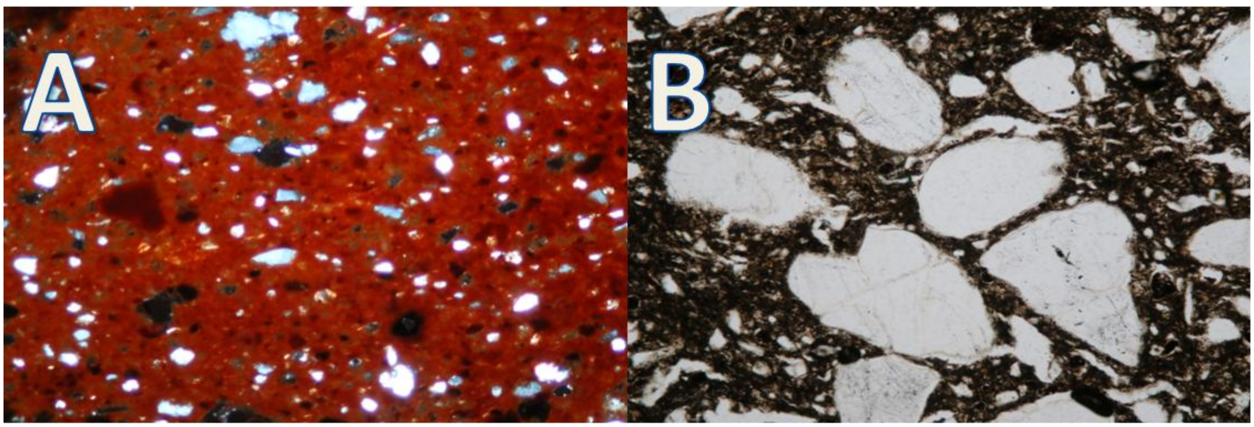

Fig. 3.2: A. Fine sub-rounded grains by CPL mode. B. Coarse sub-angular grains PPL, mode images width1mm.

Petrography analysis has the potential of identifying minerals by their optical properties under the polarized light microscope. A mineral is a naturally occurring chemical compound, it is homogeneous, inorganic solid with a specific chemical assembly and atomic ordering. The optical characterization of any mineral under the polarized light microscope reflects the crystal regularity, and many other physical properties, which rely on the chemical composition and the crystal structure (Rice 2015, p. 375; Shepard 1985, p. 139; Tite 1972, p. 215). The thin-section analysis permits the identification of different minerals that give information concerning the geographical source of the raw materials. Specifically; the tempering and the inclusion materials that were used to manipulate the clayey materials physical properties. The added non-plastic materials usually represent the local geology (Herz and Garrison 1997, p. 255). In addition, petrography analysis can yield helpful information, concerning the manufacturing technology of pottery (Rice 2015, pp. 375–377). The absence of the natural occurring inclusions is out of the question because they are essential components of most wet clay mixtures. A wide range of materials vary in their composition, their effect on plasticity, the drying and firing grade of the clay mixture, and the consistency and durability of finished objects were used as tempering materials. Materials were added as non-plastic materials vary, but the most common are sand, volcanic ash, crushed rocks, crushed pottery (grog) and seashells, twigs, straw, and dung (Goffer 2007, p. 240). Tempering materials, as well as natural inclusions, are adequately large enough to be identifiable in thin section. In principle, optical microscopy has the capability of determining with complete certainty if pottery production was made locally or imported. The potter's skills could be indicated as well, by determining a certain type of tempering materials, if it was deliberately added or naturally occurring (Peacock 1970, p. 381; Rye 1981, p. 13; Tite 1972, p. 206). If the tempering materials do not contest with the geology of the archaeological sites, most probably the pottery maybe imported (Reedy 1994, pp. 116–119; Maggetti 1982, p. 130; Rye 1981, p. 13).

3.3.1 Thin Section:

To do petrography analyses, thin sections of all the samples have to be prepared, in order to be able to study individual grains. Preparing a thin section needs a slice of the sample (pottery sherd), the slice has to be polished, using different types micromesh from one side, until it becomes very smooth. When it dries, because polishing needs a lubricant, which is usually water, the polished surface is adhered to a glass slide, using epoxy resin, the sample has to wait then until the epoxy resin harden, this is usually takes about 24 hours, when it hardens well, the other surface of the sample needs to be ground, until the thickness of the sample reaches to 30µm, because most of the minerals are translucent when they are in this thickness, which allows their identification under the polarized light microscope (Rice 2015, p. 379; Shepard 1985, p. 158; Tite 1972, p. 215; Peacock 1970, p. 379; Reedy 1994, p. 115).

The advantages of thin section analysis are: (a). identification of different kinds of minerals, (b). the shapes and location of minerals in the sample, (c). the orientation of the particles, (d). the porosity or the void size, (e). any surface treatments or modifications, due to firing or post-depositional factors (Rice 2015, p. 378; Leute 1987, p. 120). The main diagnostic features of the thin section are the optical properties, crystal shape, and cleavage. Several optical properties can be imposed by plane polarized light, such as color, cleavage, refractive index, and fracture, while twining and interference color can be distinguished by crossed polarized light (Shepard 1985, pp. 139–140; Rice 2015, p. 379). Since the identification of minerals depends mainly on the optical properties of each mineral, therefore; petrography reveals how a translucent substance influence the light passes through it (Shepard 1985, p. 139). The velocity of light passes through minerals will produce a range of colors, what is known as interference colors, by recognizing the color, categorization of isotropic (a substance in which light has the same velocity(refractive index) in all directions) (Patzelt 1974, p. 12). Anisotropic minerals are obvious because isotropic minerals emerge colored during using crossed-polarized light, on the contrary, anisotropic minerals appear Opaque, which means no change in light velocity. Analyzing the thin section under the plane polarized light; some anisotropic minerals can be distinguished, because of their characteristic pleochroism. The difference between the absorption degrees of light, when entering anisotropic mineral, and the dissolved light produces a color change of the mineral when the sample stage of the microscope is rotated, is called pleochroism. Isotropic minerals do not show pleochroism, because of their absorption is independent of the vibration direction of the polarized light (Rice 2015, p. 377; Leute 1987, p. 120; Kerr 1977, p. 152).

3.3.2 Polarized Light Microscope:

It is essential, when analyzing pottery to defined minerals, to have a concrete interpretation of the sample being study. Minerals identification by polarized light microscope depends on determining the optical properties of the minerals. Besides the magnification of the sample constituents, it does affect the light that passes through it (Rice 2015, p. 377; Shepard 1985, p. 139; Reedy 1994, p. 120). The basic principle of the polarized light microscope is that, light is released from a light source vibrating in all directions (natural light) towards a mirror, which reflects the light through a polarizer, where the polarizer transmits the light vibrations into one direction (vibration direction), "polarizer serves for the production of light waves of uniform vibration direction" (Patzelt 1974, p. 8), then the polarized light passes through a condenser lens onto the thin section, which is placed on the sample stage horizontally concerning the polarized light (Rice 2015, p. 377; Tite 1972, pp. 216–217).

The polarized light microscope magnification is usually ranging from 16X to 400X (Reedy 1994, p. 116). Magnification obtained, due to the objective lens system and the eyepiece, which produces a magnified image when light passes through. The other important part of this type of microscopes is the analyzer, it is located between the objective and eyepiece lenses, the main function of this part is to permit the passing light to vibrate in a single direction perpendicular on the polarizer. The analyzer can be slotted in and out to allow moving from crossed polarized light to plane light. When it is in crossed polarized light is produced, on the contrary plane, polarized light is on. However, when the analyzer is off, some anisotropic minerals can be identified as a result of their characteristic pleochroism (Leute 1987, p. 120; Kerr 1977, pp. 13–22; Rice 2015, p. 377; Tite 1972, pp. 216–217).

3.4 X-ray Diffraction (XRD):

X-ray diffraction analysis has been used widely in the study of pottery, and also in the examination of the impact of heat on minerals present in pottery and also on synthetic ceramic materials(Shepard 1985, p. 147). The crystalline structure of minerals, allows the XRD to identify different minerals and the chemical characteristics of the artifacts. In other words, XRD can grant data concerning the mechanical and thermal treatments the artifacts were subjected to, during the manufacturing processes. The presence or the absence of some minerals can be confirmed by XRD if indicated by other techniques such as Petrography or chemical analysis. XRD is utilized frequently to define the firing temperature, in combination with the re-firing of a single pottery sherd. To achieve the desired observation; the sample (pottery sherd) has to be divided into a number of pieces, each will be re-fired at a certain firing temperature, then analyzed by XRD, the different phases of the original sample has to compared with the re-fired pieces phases, and when we detect any change in the phases, we can obtain a range of the firing temperature lower than the re-firing temperature of the piece in compassion (Tite 1972, p. 300). Identifying minerals is the basis of x-ray diffraction. X-rays are diffracted differently by each mineral, relying on what atoms create up the crystal lattice and the arrangement of the atoms. The typical set of d-spacings produced in a characteristic X-ray scan offers a single "fingerprint" of the mineral or minerals present in the sample. When appropriately understood, by comparison with standard reference patterns and measurements, this "fingerprint" permits for recognition of the material. In X-ray powder diffractometry, X-rays are created within a sealed tube that is under vacuum. A current is applied that heats a string within the tube, whenever the current is higher the larger the number of electrons released from the string. In order to generate this X-ray a high voltage, normally 15-60 kilovolts, is applied within the tube. High voltage speed up the electrons, which then hit an objective, usually made of copper, which produces X-rays. Therefore; the wavelength of these X-rays is typical of that objective. These X-rays are aligned and aimed at the sample, which has been ground to a fine powder. After the X-rays strike the sample, it diffracts, then a detector detects the X-ray signal, the signal is then processed. X-ray scan is generated when the angle between the X-ray source, the sample, and the detector, is changed at a controlled velocity between preset limits(X-ray Diffraction Analysis: Principle, Instrument, and Applications).

3.5 Scanning Electron Microscopy (SEM) & Energy Dispersive X-ray Spectroscopy (EDS):

The Scanning electron microscopy (SEM) technique provides qualitative and quantitative details concerning the chemistry and the mineralogical structure of the studied samples. Moreover, it allows visual inspection of the microstructure lineaments with high magnification attains up to 100 000 times. SEM has the potential to examine the degree of vitrification, due to the firing temperature of the pottery, such as the glassy phase, and the progress of the pore structure as well too. Furthermore, Energy dispersive X-ray spectroscopy (EDX) permits the identification of the chemical composition of the matrix and the clay chemistry.

The basic principle of microscopy is, a sample is observed out of a series of lenses that magnify the visible light image. Nevertheless, SEM, in reality, does not offer a genuine image of the specimen, on the contrary; it generates an electronic map of the specimen that exhibits on a cathode ray tube. In addition, a ray of electrons is created at the top of the microscope by an electron gun. The microscope has a perpendicular passageway, allows the electron beam through, and usually held in a vacuum. When the ray starts traveling, it passes through electromagnetic fields and lenses, where it is oriented towards the sample. When the ray strikes the sample, electrons and X-ray are discarded from the specimen. Detectors gather these X-rays, backscattered electrons, and secondary electrons, where they get converted into a signal, displayed on a monitor screen (Pollard and Heron 2008, pp. 46–49; Creagh and Bradley 2007, pp. 14–15). In order to proceed by analysis using the SEM, vacuum conditions and electron are needed to produce an image; the sample has to be dry and conductive. Therefore, any non-metals material has to be coated with a thin layer of conductive material, such as carbon or gold, to allow the conductivity of the sample. Normally it is coated using a sputter coater device. The vitrification development of the microstructures can be investigated, and the bloating pores stage can be evaluated, as a result, information regarding the firing temperature can be obtained. The chemical compositions of the clay materials that have been utilized in the manufacturing of the pottery sample can be detected as well (Goodhew et al. 2000, pp. 4–14). The samples have been coated by a carbon layer by means of electron beam discharge for increasing the surface electrical conductivity to avoid charging effects.

4. Chapter Four: The Islamic Pottery of Northern Jordan.

4.1 Introduction:

Islamic craftsmen were famous due to the diversity and quality of their achievements in crafts making, such as the production of textiles, wood carving, ivory, stone, stucco, metals smelting and smithing, glass and ceramic production. Nowadays, there are diverse and high numbers of artifacts that are exhibited in major public museums and private collections. Surprisingly, craftsmen are rarely given their status and appreciation from their own societies. On the contrary Islamic law has a lot to state regarding the instruction of craft practices in urban markets. Scholars and Jurists have not admired craftsmen but considered them as low-status people although they were playing an important role in the maintenance of urban life. Handicrafts did not design their names as an artist responsible for the production of the artifacts, except for few and the manuscripts writers (Milwright 2014, p. 147). Therefore; to get introduced to Islamic handicrafts, the Islamic artifacts remained the only source of information for the sake of this research.

Pottery survives in greater numbers, compared to other types of artifacts, even the infrastructure for ceramics production, such as kilns are easily identified in the archaeological contexts. Pottery, in general, is assigned to a group of a common workshop or of the same region production, through their style and technical similarities, not by their inscriptions, even when inscriptions occur; they are mainly goodwill formulaic messages or moralistic sayings, except few potteries that have workshop marks. The dispersal of a certain pottery style, or technique, could be related to the mobility of handicrafts or artifacts. A variety of different types of artifacts were produced during the Islamic period, from simple wheel-thrown vessels, such as jars, bowls, large storage vessels, chamber pots, and drainpipes. Besides the simple wheel thrown pottery, potters did form less numbers of relief-molded slipper lamps and jugs, as well as a variety of glazed earthenware with splashed or basically painted decoration (Milwright 2014, p. 148; Magness 1997, pp. 481–482; Whitcomb 1988b, p. 53; Walmsley 1995, pp. 660–668; Milwright 2014, p. 148). From my point of view, the focus of the Islamic potters was to satisfy the day need of the residents of the Islamic world.

The Islamic pottery of Jordan has been studied with greater efforts in the past few decades. The basic pottery sequence, as known today has been first provided by the excavation teams at Tell Hisban: Umayyad (ca. A.D. 661-750), Abbasid (ca. A.D. 750-969), Fatimid (ca. A.D. 969-1071), Ayyubid (ca. A.D. 1174-1263), and Mamluk (ca. A.D. 1260-1516). The chronology of various pottery forms was confirmed by the results of excavations in several locations in Jordan. Archaeological remains from the early Islamic period (Umayyad period) are almost present in most of the excavated sites and regional surveys. Umayyad pottery has been identified by its appearance in numerous excavations with Umayyad coins, such as Amman Citadel. While the Abbasid and the Fatimid period's pottery is scarce compared to the Umayyad period. The Ayyubid-Mamluk periods are one of the most common Islamic periods of Jordan. Many local excavations and surveys confirmed the extensive settlement of the area during the Ayyubid-Mamluk periods. Many sugar mills from the Ayyubid-Mamluk periods were discovered in the Jordan Valley (Sauer 1982a, p. 83). Walmsley (2007) stated that the Early Islamic period in Jordan had its own regional centers for pottery manufacturing, and by the beginning of the 8^{th}century A.D. pottery production became more dominant in the region. Lately, the archaeological excavations and interpretation of Jarash site proved that Jarash was one of the major suppliers of local pottery in the Northern Jordan. Numerous pottery kilns were uncovered at the site of Jarash. Four kilns were excavated north of the Decumanus, used to produce different types of pottery artifacts, and near the Northern Theater and in the courtyard of Artemis Temple another set of kilns. All the pottery kilns were dated to the Islamic periods, mainly the Umayyad and the Abbasid. (Walmsley 1997, p. 348; Schaefer and Falkner 1986, pp. 411–413). Early Islamic pottery (Umayyad) did not have any different trait from the Late Byzantine period, which confirms the continuity of the Byzantine tradition during the Early Umayyad period (640 AD. to 750 AD.) (Sauer 1986, p. 301). The main observations of studying Early Islamic pottery, shows that pottery during this period was affected by many other pottery production traditions, such as Sasanian, Byzantine, Coptic, and Nabatean (Rosen-Ayalon 2016, p. 26).

The Ottoman occupation of Bilad ash-Sham started from (1516 to1918 AD.), excavations through the late nineteenth and the twentieth century in Bilad ash-Sham has offered evidence to make reasonably precise chronological separations in Islamic archaeological artifacts. Pottery and architecture are the most reliable records of human work in Bilad AI-Sham during the Ottoman period. The evolution of material culture (pottery) frequently shows little sensitivity to changes in central government. There is significant evidence for continuity in the production and utilization of many wares from the fifteenth century into the Ottoman period (Milwright 2000, p. 189; Hendrix et al. 1997, p. 70; Schaefer and Falkner 1986, pp. 419–435; Milwright 2000,

p. 189). The chronology that Whitcomb established for the Islamic periods was adopted by many scholars, as this study, the following subdivision, corresponds to the standard chronology, that has been utilized in the Levant as follows: the Early Islamic period (600-1000) AD.), corresponding approximately to the Umayyad, Abbasid periods, the Middle Islamic period I (1000-1200 AD.), covers the Fatimid, part of the Crusader, and Ayyubid periods, the Middle Islamic period II (1200-1400 AD.) is early Mamluk, the Late Islamic period I (1400-1600 AD.) is late Mamluk-Early Ottoman periods, and finally Late Islamic period II (1600- 1900 AD.), covers the Ottoman period (Walker 1999, p. 207; Whitcomb 1992 b, p. 386, 1997, p. 106).

4.2 Early Islamic pottery (Typological and Technological description):

The early Islamic pottery includes "Umayyad 661-750 AD, Abbasid 750-969 AD, and early Fatimid 969-1071" (Sauer 1982b, p. 329; Hendrix et al. 1997, p. 251; Whitcomb 1992 b, p. 386). Over the past 30 years, Umayyad pottery has undergone many changes in its chronological sequence. Many gaps of the seventies and eighties have been reviewed and reconsidered to be Abbasid and Fatimid rather than Umayyad (Walker 2012, p. 507; Walmsley 1997a, p. 3; Johns 1994, p. 9). The facial appearance of Umayyad pottery might be similar to the pre or the post periods, but we have to keep in mind that pottery carries developments from one period to another. The Umayyad Pottery in Jordan, mostly made of well-prepared clay and fired relatively at a suitable temperature. In general, Umayyad pottery has a smooth surface, because of the minor inclusions in the clay, the firing temperature and atmosphere were most probably stable, which is indicated by the absence of grey or black cores (Sauer 1982b, p. 332). In 2012 Walker, suggested that "There is now a consensus that there are regionally distinctive ceramic assemblages for the north and south of Jordan throughout the Islamic period". Jordan pottery during the Umayyad period, as most archaeologists illustrated, has many technical and ornamental characters of the late Roman and Byzantine pottery (Walker 2012, p. 508; Johns et al. 1989, p. 72; Sauer 1982b, p. 331; Walmsley 1995, pp. 660–668). Early Islamic pottery wares have a variety of shades, differ from light to dark, such as white, buff, pink, grey, brown, grey-black and black. The Early Islamic wares are relatively thick, and the hardness is relatively low (Sauer 1986, p. 305; Smith 1973, p. 230). The following section of this study demonstrates the most common forms (types and styles), and technology (surface treatments, forming techniques, of this period).

4.2.1 Umayyad Pottery wares and forms (661-750 AD.):

A very fine collection provided hallmark vessels of the Umayyad assemblage. Around 20 different pottery wares were demonstrated by Walmsley 1995. He suggested innovative introduced wares from outside of Jordan due to the high demand, which forced potters to adopt new techniques, such as glazed wares. Pottery ware means a group of pottery types classified according to paste and texture, surface modification, as burnish or glaze, and decorative motifs, rather than shape and color.

Fig.4: Different Early Islamic pottery wares from Northern Jordan.

The new production technologies, open the door for the invention of new aesthetic wares (Hendrix et al. 1997, p. 251). Different characteristics descriptions of Umayyad pottery, the following are general characteristics of the Umayyad period pottery:

1. Wares: have multicolors varying from light colors as buff, pink, orange-pink, white-to-cream, and dark colors as grey, black, grey-black, brown and red. Thin hard metallic wares, usually have a dark color, such as dark orange, or grey-red, many bowls were recovered from this ware(Hendrix et al. 1997, p. 252).

2. Inclusions and tempering materials: mainly Inclusions were observable, nevertheless, well-pulverize pastes were distinctive of fine ware(Hendrix et al. 1997, p. 252).
3. Manufacturing: in general wheel-made vessels were very common, except for; small bowls, kraters, and storage jars were handmade. As well as; some other vessels were molded such as Lamps(Hendrix et al. 1997, p. 252; Sauer 1982b, p. 332).
4. Firing: as mentioned earlier, Umayyad pottery was well fired, which is clear by the absence of black and grey cores, despite some thick bodies (Hendrix et al. 1997, p. 252).
5. Surface treatment: several procedures and techniques were followed for surface treatments: **A.** Slipping: diverse slip colors varying from white to cream shades, pale-pink, and deeper pink-orange. **B.** Burnishing: these techniques were usually used as surface treatments. **C.** Glazing: in general Umayyad pottery was seldom glazed. **D.** Painting: red painting was the most common during the end of this period, while white painting was used during the early Umayyad period, continuing from the previous period, some other colors were used as well, but not as common as the red and the white, such as purple and brown. Some Umayyad pottery motifs are red or white swirls painted or have a simple line band, or wavy lines, or geometrical patterns or finally floral designs, this type of painting is common on small bowls and cups. **E.** Impressing: it is done by introducing pressure of a finger, in some cases in combination with incising. **F.** Incising: mainly associated with large handmade grey ware krater, and large storage jars(Sauer 1982b, p. 332; Hendrix et al. 1997, p. 252).**G.** Combing: it is common in detailed designs. **H.** Ribbing: many vessels ribbed, even ribbing continued into the Abbasid period especially on cups. **I.** Paring: it was done by using a knife to cut different designs, such as squares, this type of decoration gave the name of this ware Cut-ware (Sauer 1982b, p. 332; Hendrix et al. 1997, p. 252). **J.** Molding and Inscriptions: it was the very common type of decoration on lamps.

The majority of the Umayyad period pottery is made by the wheel as the Late Byzantine period (Sauer 1982b, p. 332; Johns 1994, p. 19). The continuity of the Byzantine pottery forms during the Umayyad period encouraged the potters to develop and introduce new forms, which were widely spread and used to suit a particular function during the Umayyad period (Sauer 1986, p. 325). Nowadays, we rely on them to date the pottery sherds, since these forms portray this time period pottery (Sauer 1986, p. 325).

The most common wares and forms of the Umayyad period pottery are listed below according to Walmsley classification 1995. Walmsley has studied both Pella and Jarash assemblages carefully, and compared it with many Umayyad assemblages in the surrounding region:

Ware 1 (Fine Terracotta): Walmsley refers to this ware, as one of Hayes wares 1972 in his book the Late Roman Pottery, Hayes indicates that the sources of this ware could be from Cyprus, Asia Minor, and North Africa (Hayes J. W. 1972, pp. 323–345). According to Walmsley 1995; this ware rarely found after 660 AD. the most dominant forms of this ware are plates (Walmsley 1995, p. 660).

Ware 2 (Jerash Bowls): it is a reddish-orange fabric, originally from Jerash, has a graphical red and white painted decoration. Most probably this ware was common in the second half of the seventh century AD. the most dominant forms of this ware are bowls (Walmsley 1995, p. 660).

Ware 3: it has a coarse**-s**olid fabric, which means fired at an appropriate temperature; usually it is hand-made, and distinctive by the buff-brown color. The most common forms of this ware are bowls and large collared storage jars. It seems that this ware did not exist after the end of the seventh century AD. (Walmsley 1995, p. 660).

Ware 4 (Coarse Ware): it is soft, chaff-tempered ware, which means it was fired at a relatively low firing temperature, the color of this ware is usually light brown to red or reddish brown, suggesting an oxidizing firing condition, it was in use mainly before the middle of the seventh century AD., most of the pots were hand-made, and the common forms of this ware are flat-based basins and plain-rimmed ring-based storage jars (Walmsley 1995, p. 661).

Ware 5: this ware includes a diverse number of pot- types, mainly imported for their contents. The ware lasted until 660 AD., and then disappeared; the origin of this ware might be Gaza, Antioch/Cyprus, and Egypt. The ordinary form of this ware is amphorae (Walmsley 1995, p. 661).

Ware 6 (Sandwich core): it contains mica and white coarse tempering or (inclusions) materials. The presence of grey-brown core suggests; insufficient firing temperature, the origin of this ware is probably Gaza or Delta region Egypt. This ware emerged after 660 AD, instead of Gaza amphora form, and lasted until 750 AD., at maximum. The most dominant color of this ware is red-brown. Forms of this ware are mainly conical necked Jars, with a fine ribbing on the most upper body and extensive wide ribbing on the lower body (Walmsley 1995, p. 661).

Ware 7: this ware probably, due to its high porosity, was fired at a low temperature, it has a pale cream or greenish to light yellow-brown fabric, and it contains fine white, orange and/or grey tempering or inclusion materials. The type of surface decoration common on this ware is frequent incised decoration. The ordinary forms of this ware are large or intermediate sizes jars with either medium to thin walls, or jugs, and water flasks. It is noticeable that mainly larger pots have frequently broad ribbing. This ware could be local ware, due to the existence of similar clay in Tabaqat Fahl (Edwards 1992, p. 293), or it can be imported from Baysan (Watson 1992, p. 243). According to Walmsley, the first appearance of this ware as large ribbed water jars was after 660 AD., his observation was dependent on a comparative study between this groupware pots and the next century group wares, therefore; he dates this ware to the mid-eighth century AD. (Walmsley 1995, p. 661).

Ware 8: the clay ware contains medium size white and grey inclusions, in general, it has a light orange fabric, and from time to time it appears with white slip. Commonly forms of this ware are jars with ring bases, spouted juglets, bowls, and cups. Usually, it has surface decorations; such as bold reddish-brown painted loops, stars, wavy lines, arched pattern, and crisscrossed lines. Infrequently some jars of this ware started to appear by the beginning of the eighth century AD., but around the mid-eighth century in the earthquake level about 747 or 748 AD. they became more common. This ware concurrence with the “palace ware” that appeared before the end of the eighth century AD. and persist robustly through the ninth century AD. The source of this ware remains undefined, but it might be Northern Jordan (Duerden and Watson 1988, pp. 104–110; Walmsley 1995, p. 661).

Ware 9 (Biscuit ware): it is a coarse undecorated plain ware, the technology utilized for the firing of this ware seems to be advanced, probably downdraft kiln, due to the even firing of the whole pots bodies, and the identical shade of all pots of this ware, which is (light yellowish-brown), beside the range of the hardness which ranges between 2.5 to 3.5 on Mohs scale. The source of this ware remains unknown, but Wadi Jirm clay deposit close to Tabaqat Fahl seems to be companionable(Edwards 1992, p. 293). The common form of this ware is small one-handled juglet, and the date is mainly mid-eighth century AD. (McNicoll, Smith and Hennessy 1982:148; Walmsley, 1995:661).

Ware 10 (Fine Byzantine): it is a fine tableware, probably fired at a high temperature under oxidizing condition, due to the compact criteria and the orange color fabric, it contains fine white and grey tempering or inclusion materials, they do have very often light grey core (Magness 1993, p. 193). The common forms of this ware are cups, bowls, jars, jugs, and juglets (Magness 1993, p. 193). In general, the base and the lower body are pared, frequently with ridged spiral/ circle on the bottom. The origin of this ware Jerusalem region and the occurrence started around 660-750 AD. and lasted even during the ninth century with a slight difference of the base, the base ring disappeared and the incised wavy lines as well too(Walmsley 1995, p. 661).

Ware 11: it is a fine fabric ware, to some extent gritty, contains fine to medium white and sandy tempering or inclusion materials, some scholars call it metallic ware (Tarboush 2015, p. 34). The color of this ware is patchy orange/brown/grey. The surface decorations are usually banded wavy lines and regular strokes on rims and handles; in some cases, it has scalloped ridges on the body. The name metallic ware is driven by the imitation of bronze, which is clear on the handles, while the white paint may represent silver inlay work (Walmsley 2001b, 310). The most common forms of this ware are biansulate jars, spouted, one-handled juglets, small basins, small lidded casseroles, and rarely cups. This ware first appearance at the first half of the seventh century and by the middle of the eighth century it became more popular and lasted until the beginning of the ninth century (Walmsley 1995, pp. 661–664).

Ware 12: it is a thin durable ware, probably fired at a high temperature. The color of the fabric is grey/brown. White, grey, and brown inclusions are visible; the size ranges from fine to medium. Surface decoration is done by the application of white broad crisscross wavy lines and loops. The common form of this ware is light-weight jars. The origin of this ware possibly Baysan. The date of this ware is probably the eighth and the ninth centuries (Walmsley 1995, p. 664).

Ware 13 (Cooking pot): it is a granular ware contains a lot of white, transparent (quartz), and grey tempering or inclusion materials. The most common forms of this ware are casseroles with loop-handled lids and necked cooking pots. The origin of this ware is Jarash, this ware was common from 660 AD. until the 900 AD (Walmsley 1995, p. 664).

Ware 14: it is a hand-made ware, the fabric seems to be fired under reducing condition, due to the dark grey color of the fabric, it contains different types of inclusions, they vary in color and size from grey to white, to transparent, and the size from fine to medium. The common types of decoration are comb-incised and chiseled. Different types of forms are known for this ware, such as large collared storage jars, large basins with simply rounded rims, small basins or bowls with flat rims, and jar stoppers. The origin of this ware is probably Jarash, this ware first started to appear at the end of the seventh century through the first half of the eighth century (Walmsley 1995, p. 664).

Ware 15: it is an orange fabric covered by a white slip then glazed (Polychrome glaze), the most common form of this ware bowls, but regrettably it is origin is anonymous. This ware around the end of the eighth century started to appear and lasted through the ninth century (Walmsley 1995, p. 664).

Ware 16 (Coptic glazed): the fabric of this ware is reddish-orange, usually the interior of the pot is divided into many zones or variant; interior divided into zones via black lines painting with bubbly green and yellow glaze. The widespread form of this ware is carinated bowls; possibly it is a local ware, an imitation of Egyptian ware. This ware type started to appear in the mid-ninth century (Walmsley 1995, p. 664).

4.2.2 Abbasid Pottery wares and forms (750-969 AD.):

During this period, the Islamic capital shifted from Damascus to Baghdad, where most of the major sites that were occupied in the previous periods have been abandoned (Sauer 1982b, p. 332). As a result, the whole culture prototypes were affected, and the economy started to deteriorate (Whitcomb 1988b, p. 64; Walmsley 2013, p. 151). One of the main problems that face Early Islamic ceramists is that there isn't any clear boundary between the Late Umayyad pottery and the Early Abbasid period, plus the resumption of many wares, and forms. Close to the end of the Umayyad period about 747 AD., an enormous earthquake occurred in the Levant, which might be one of the main reasons that flipped the control from the Umayyad dynasty to the Abbasid. As resulted; many Umayyad sites were partially abandoned, particularly sites away from the pilgrim routes of Bilad Ash-Sham, except for small rural villages, that existed in the Jordan valley, and the north Jordan range (Walmsley 1992, pp. 379–380). Before the end of the eighth century AD., a variety of the Abbasid pottery emerged, but in the following centuries, it became extremely common. Most of the uncovered pottery sherds and pots, during the ninth century AD., demonstrate a strong continuation of the Late Umayyad pottery wares and forms. The Abbasid administration had a little cultural impact over Jordan in the rural centers (Walmsley 1992, p. 380). Islamic pottery of the eighth century until the mid-tenth century had its own identity, which is indicated by the huge variety of wares and forms, such as the widespread of glazed pottery (Grube 1994, p. 11). During the ninth century AD glazed pottery production, became widespread all over the Islamic world, suggesting a kind of cultural revolution in the development of glazed pottery (Watson 2004, p. 45).

The ninth century AD witnessed the introduction of the new pale creamware, all over the Islamic sites, as well as some changes to older styles (Schick 1998, p. 94). The spread of the incised and molded creamware was synchronized with the glazed pottery during the Abbasid period, which is considered the diagnostic key of the Abbasid pottery (Whitcomb 1988b, pp. 64–65). Abbasid pottery was prepared of fine clay particles, where it is hard to observe by visual examination any type of inclusions, as well as; firing temperature and firing atmosphere, were as excellent as the clay purity, which is obvious by the absent of grey cores (Sauer 1982b, p. 333). Generally; thinner and smoother bodies are common during the Abbasid period comparing to the previous period. The most widespread colors of Abbasid period pottery are white, yellow-white, brown, pink, greenish-white, tan, and black, Abbasid pottery was usually colored after firing (Sauer 1982b, p. 333; Hendrix et al. 1997, p. 266). The main propagation surface treatments of Abbasid pottery are incised band combing, thump impressing, cut ware, and molded lamps. The Abbasid technology of pottery surface treatment is different than the Umayyad technology, for example; the incised band combing tends to be shallower and finer. The incised band combing often escorted by new incising technique were small separated or interlocking incised circles present. A new type of thumb impressing techniques appeared, compared with the earlier period, the thumb impressing marks are deeper, this type of deep impressing appeared on pithoi.

Abbasid handmade cut ware bowls, are unpurified and deeper comparing to the Umayyad period. Ribbing technology remained in use during the Abbasid period, but often on cups, while red or white painting disappeared, instead a new type of polychrome glazed pottery emerged, mainly on the interior of the plates, different shades were used such as green, yellow, and purple (Sauer 1982b, p. 333).

Just to note that some of the wares recorded beneath are just continuation of the earlier periods. The most common wares and forms of the Abbasid pottery period are listed below according to Walmsley classification 1990:

Ware 1 (Metallic ware): it is a fine fabric ware, to some extent gritty, contains fine to medium white and sandy tempering or inclusion materials, some scholars call it metallic ware (Tarboush 2015, p. 34). The color of this ware is patchy orange/brown/grey. The surface decorations are usually banded wavy lines and regular strokes on rims and handles; in some cases, it has scalloped ridges on the body. The name metallic ware is driven by the imitation of bronze, which is clear on the handles, while the white paint may represent silver inlay work. The most common forms of this ware are biansulate jars, spouted, one-handled juglets, small basins, small lidded casseroles, and rarely cups. The first appearance of this ware was during the first half of the seventh century, and by the middle of the eighth century, it became more popular and lasted until the beginning of the ninth century (Walmsley 1995, pp. 661–664; Whitcomb 1989, pp. 275–277).

Ware 2 (Cooking pots ware): the common color of this ware is mainly red, with plenty of white paint over, also common with light gray-grey fabric including small sand grits (Najjar 1989, p. 314). Mostly it contains white, transparent (quartz) and grey inclusions. The most common forms of this ware are casseroles with loop-handled lids and necked cooking pots. The origin of this ware is Jarash, this ware was common from 660 AD. until the 900 AD (Walmsley 1990, p. 150; Walmsley 1995, p. 664).

Ware 3 (Dark grey fabric): it is a hand-made ware, the fabric seems to be fired under reducing condition, due to the dark grey color of the fabric, it contains different types of inclusions, they vary in color and size from grey to white, to transparent, and the size from fine to medium. The common types of decoration are comb-incised and chiseled. Different types of forms are known for this ware, such as large collared storage jars, large basins with simply rounded rims, small basins or bowls with flat rims, and jar stoppers. The origin of this ware is probably Jarash, this ware first started to appear at the end of the seventh century through the first half of the eighth century (Walmsley 1995, p. 664; Walmsley 1990, p. 150).

Ware 4 (Light orange fabric): this ware was probably fired in an oxidizing condition, in some cases this ware has a white slip, hardly inclusions visible with naked eyes, because they are fine size particles, generally; inclusions are white and grey color, mainly the surface of this ware is painted reddish brown. The most common forms of this ware are Jars and bowls (Walmsley 1990, p. 150).

Ware 5 (Grey-brown surfaced fabric): the most occurrence inclusions in this ware are white, brown and grey color inclusions, pots of this ware are usually decorated by white paint, the decoration patterns are broad intersecting wavy lines. The typical forms of this ware are jars, jugs, and juglets, the origin of this ware most likely is Jarash (Walmsley 1990, p. 150, 2001b, 310; Walmsley 1994, p. 14).

Ware 5 (Pale cream fabric): in general this ware contains multicolor inclusions white, orange, and grey; the porosity of this ware is high, which reflects a low firing temperature. The common surface decoration of this ware, if present is incised. The most common forms of this ware are thin-walled jars, jugs, and water flasks (Walmsley 1990, p. 150).

Ware 6 (Fine tableware): it is a compact fabric ware, probably fired at a high temperature, due to the compactness and the low porosity. It contains very fine inclusions ranging in color from white to grey; the color of the fabric is orange. The distinctive part of this ware is the pared base and the lower body of the vessel. The common marks of this ware are the grooved spiral/circle on the underside, mainly the ordinary form of this ware are cups (Walmsley 1990, p. 150)

Ware 7 (Kerbschnitt): this ware, in general, has a brown to orange color, the surface decorations vary from cut to incised and painted, if painted, the external usually have panels, while the internal have red and white painted lines. The ware contains multicolors of inclusions or tempering materials; such as white, yellow, grey, red and black, they vary in size from fine to large. The common form of this ware is handmade small basins with flat ledge handles, similar to the steatite bowls of the eighth century. The origin of this ware, unfortunately, is unknown, but the date of the first appearance is the mid-ninth century AD. (Walmsley 1995, p. 668; Walmsley 1990, p. 150).

Ware 8 (Glazed wares): polychrome and Monochrome Glazed bowls were ordinary during this period, the fabric color ranges from pink to light brown, or reddish yellow, or pale yellow. The vessels of this ware are glazed in the interior, in some cases the glaze splashes above parts of the exterior. The glaze usually applied over a white paint. The common glaze colors are yellow or green, in some cases yellow glazed bowls may be ornamented with Arabic scripts or with geometric designs (Walmsley 1990, p. 150; El Khouri and Omoush 2015, p. 18). If designs were present, they are painted with brown, and every so often, the outlines are completed with black paint using a fine brush. The bad condition of the brown decorations, suggests a poor quality paint, which does not fit with the condition of the glazed object(El Khouri and Omoush 2015, p. 18).

Glazed wares are divided into three varieties according to Walmsley 1990: A). Polychrome glazed ware previously discussed. B). Coptic glazed or variant, in particular, the inner surface of the vessels are divided into many zones by black paint lines, with bubbly green and yellow glaze, which suggests, a low firing temperature, due to the high viscosity of the glaze frit, which keeps the air trapped forming bubbles. The common colors of the fabric are reddish-orange, and the dominant forms of this ware are carinated bowls. C). Thick turquoise or blue glaze, this type of glaze is usually applied over a greenish fabric, and the common forms of this ware are jars (Walmsley 1990, p. 150).

Ware 8: it is a blue glazed ware on greenish fabric, unfortunately, the origin of this ware in undefined, but it is clear that this ware first started to appear before the end of the eighth century and became more in use during the ninth century (Walmsley 1995, p. 664).

Ware 9: this ware has a pale cream fabric, it is eggshell-thin, and it has high porosity. The visible inclusions in this ware are fine grey, and red particles, which could be grog. Variety types of decoration techniques are applied to this ware, such as impressing and incising. The most common forms of this ware are jars and strainer jugs. Unfortunately, the origin is anonymously, but Rosen-Ayalon 1969 in her study of Ar-Ramla excavation finds wrote about a workshop for producing molded creamwares. Walmsley 1995 indicates that Ar-Ramla assemblage of the eighth century AD., which comprises glazed and kerbschnitt pottery belongs to the early Fatimid period. The first appearance of this ware most probably was by the beginning of the ninth century AD. (Walmsley 1995, pp. 664–668).

4.3 Middle Islamic I pottery (Typological and Technological description):

The Middle Islamic period I (1000-1200AD.), combines the Fatimid, Crusader, and the beginning of the Ayyubid periods. Jordan during this time period lacks cultural material evidence that suggests the absence of a strong central government after the Umayyad descend. Transjordan suffered a speedy urban infrastructure collapse, which contributed to the increase in political chaos. The circumstances imposed the region to the greedy Bedouin pinch, which consequentially led to the depopulation of many rural sites, and economic regression, this is noticeable mainly in southern Jordan, while Northern Jordan had stable economy, due to the concentration and abundance number of rural villages (Walmsley 2001a, p. 528; Schick 1997, p. 75; Johns 1994, p. 14). Around 1011-1013 AD., some hajj caravans between Egypt and Mecca, which passes all the way through Aqaba, were totally interrupted. As documented in some brief accounts of political events, the intervention of the Bedouin tribes with the Hajj caravans eventually, led to the Battle of Uqhuwana in 1029 AD., which forced the Bedouin tribes to flee(Schick 1997, p. 77). The fluctuation of the political situation in Transjordan during the Fatimid period led to the retrogradation of the industrial manufacturing era. For instance, wheel-

thrown pottery, and hand-made pottery were made of coarser fabric, and fired at a lower firing temperature, which affected the hardness, and the durability of the Fatimid period pottery, during the Middle Islamic I. Estimation, understanding and interpretation of the pottery grade decline, opens the door wide, for the evaluation of the type of life, that Jordan community had during the Fatimid period. Concerning, what has been addressed earlier, it seems that, Jordan had a small, isolated community, despite, the rural boom of the sugar cane industry in the Jordan Valley, and the associated material culture needed for such industry, such as, large heavy bowls and jars (Walmsley 2001a, p. 544). Nevertheless, the Fatimid period archaeologically is superficially presented in Transjordan, and ceramic publications of this period are few (Hendrix et al. 1997, p. 278; Brown 1991, p. 229). The Fatimid pottery collection look alike, that of the previous periods, particularly the Abbasid period(Whitcomb 1988a, p. 222; Hendrix et al. 1997, p. 278).
The second period of the Middle Islamic I is the Crusaders period, the invading Crusaders defeated around 1097AD. the Seljuqs and the Fatimids, then they established their states along the coast of Syria-Lebanon, in Palestine, and in southern Jordan (Sauer 1982a, p. 78). The expulsion of the Crusaders during the fourth quarter of the 12^{th} century AD. led to the unification of Bilad ash-Sham with Egypt during the second half of the thirteenth century AD., which finally managed to eject the Crusaders totally in the 1291AD.
The following wares are dated from the beginning of the eleventh century until the early twelfth century AD., keeping in mind, that many wares of this time period were known earlier during the Abbasid Period, and continued to be produced during the Middle Islamic I:
Ware 1 (Cooking jars): it has a red color fabric, which suggests oxidizing firing conditions, with a wide strap, handles, frequently with clay lugs applied to the body and a glazed interior(Walmsley 2008, p. 522).
Ware 2: molded arcade lamps with bunched grape decoration.
Ware 3: glazed bowls, slipped with yellow, blue and green glaze.
Ware 4 (Earthen wares): it is a plain reddish-yellow to light brown fabric, mainly formed by the wheel; the most common forms of this ware are jars and bowls. The majority of this ware pots do not have any kind of decorations, with the exception of one example has white painted wavy lines(Walmsley 2008, p. 522).

Ware 5: it is hand-made; the fabric hues are light-brown to reddish-yellow color, occasionally, decorated by combing and thumb impressions. The common forms are thick-rimmed basins and storage jars with loop handles (Walmsley 2008, p. 522).

Ware 6(Bag-shaped jars): the shape and the light-brown fabric with body-combing are the main features of this ware (Walmsley 2008, p. 522; Northedge and Bennett 1992).

Ware 7(Islamic cream-ware (ICW)): the color off-white to pale yellow fabric, is one of the main characteristics of this ware, frequently ICW is thinly thrown with peeled bases, permitted by the utilization of high-grade clay. Jars, jugs, and bowls are the common forms of this ware. The common ornamentation of this ware is incision and molded decorative techniques**.** generally, jars have flaring necks and turban handles (Walmsley 2008, p. 522; Walmsley 2001b, 2001b, p. 306-308).

Ware 8: coarse hand-made ware of coil manufacture.

It is worth noting, that Walmsley proposed, that the pottery corpus of Amman citadel and the Pavilion building at Aqaba, represent mainly the development of the tenth-century material from Pella (Walmsley 2001b, 308). The second group of pottery wares represents the eleventh and the early twelfth century AD. is glazed pottery from the Pavilion building at Aqaba, the following wares have been addressed by Walmsley 2008:

Ware 9: the monochrome and polychrome glazed luster ware, probably of Iraqi or Egyptian origin. The dominant forms are bowls.

Ware 10: the splashed decorated monochrome ware, the origin of this ware could be Iraq or Egypt or north Syrian, the plash or dots-decorated bowls are very common, often with ring bases and everted rims (Williams 2013, p. 100; Walmsley 2008, p. 522).

Ware 11: imported Chinese celadons and porcelains, the majority normally fine Qing bai porcelains with comb decorated diversity.

Ware 12 (Arab-Sassanid): the common form of this ware is large jars, ornamented by incision, and heavy blue-green glaze, unfortunately, it was not found in Northern Jordan.

Just to note that, some of the wares that Walmsley 2008 addressed in his comparative study between the Citadel of Amman and the Pavilion building of Aqaba are almost the same except, for the type of tempering material, in Amman, chaff is frequently used, while in Aqaba chaff is not present, instead sand is there. To my understanding, I think those types of wares are local wares, due to the abundant amount of chaff existing in Amman, on the contrary, the absent of chaff in Aqaba, and the availability of sand prompt the potters to make use of the presence of sand, which is almost everywhere in Aqaba.

4.4 Middle Islamic II pottery (Typological and Technological description):

The Middle Islamic II (1200-1500) Mamluk era, in particular, is known by it is moderate wealth based on the rural economy. During the Mamluk period (13th-15th), the population started to increase, due to the stability of the Mamluk administration. Mamluks Jordan has made use of the castle-towns as a government and military centers, due to this fact; the hinterlands of these towns started to be structured, and rural live began to flourish. When analyzing the growth of older rural villages, generally agriculture developments and local markets are noticeable. The Mamluk state introduced intentional developments for the fortified centers in the Crusader and Ayyubid periods, to increase the demand on these towns until they become urban centers. They managed to increase the demand by providing a variety of public services, such as legislative and administrative rules for the economy and education (Walker 2011, p. 138).

Jordan during the late Mamluk period has been intensely occupied, and its land has been extensively cultivated. Evidence of Jordan occupation throughout different time periods, demonstrate, that Jordan has never been heavily occupied since the Byzantine period, as it was during the Mamluk period (Johns 1994, p. 2). The variety of ceramic wares, forms, and surface treatments show that Mamluks were behind the development of Jordan rural life, which is also projected by other repairs of the walls and towers of Kerak castle and the citadel on Tall Hisban (Walker 2011, p. 138). As Walker 2011 extends in trying to visualize the extensive Mamluk works, which synchronize with other major construction projects, renovations of shrines, and infrastructure investments. Walker stands out for the importance of the new economic strategy, which started to bloom in the fourteenth century. Mamluks understood the importance of security, which needed a substantial attendance, which is projected by garrisons (Walker 2011, p. 139).

The extensive amount of the Middle Islamic II material culture in general, and especially; the colored glazed pottery present on the surface of many sites of Jordan proves, the increase of population. Bilad ash-Sham continued to flourish, until the invasion of Timur-Leng (Walmsley 2001a, p. 516). Speaking of more than five hundred years starting from the amid of the late 10th century, until the beginning of the 16th century corresponds to the major changes, in the material culture of Jordan. Explaining the socio-economic regime of the Middle Islamic Jordan can be estimated by locating the changes in the material culture through the Middle Islamic period (Walmsley 2001a, p. 544). Pottery production traditions, generally; were not affected by political events and dynastic changes, while social and economic, encourage change, therefore; pottery is a valuable tool for the historian, since the developments of pottery production may be traceable over a wide cross-section of society (Walker 2009, p. 41). The most noticeable ware of the Middle Islamic II period of Jordan, is the Hand-Made Geometric Painted Ware (HMGP), this ware appears almost in every Middle Islamic II site (Walker 2009, p. 41; Kareem et al. 2000, p. 81; Johns 1994, p. 20; Brown 1987, p. 284), as well the appearance of sugar pots, and the local and imported glazed wares(Walker 2009, p. 41; Kareem et al. 2000, p. 83; Walmsley 2001a, p. 545). During the past decades, Mamluk pottery had been thought to be completely different from the pottery of the Early Islamic period, due to the fact that, there are some changes in the manufacturing technologies and ornamentation, specialized studies show the contrary, Mamluk pottery assemblages developments are traceable back to the Early Islamic period (Brown 1991, p. 232; Hendrix et al. 1997, p. 289). Pottery corpus of the Mamluk era, commonly; has specific characteristics represented by:

1. Unglazed vessels: this category is divided into subcategories, which include **a)-**Hand-made painted and unpainted wares, the most common forms of this category are bowls, jars, jugs, and cooking pots, sugar pot vessels, and basins. **B)-** wheel-thrown vessels were common also, a variety of forms were in use such as bowls, jars, jugs, and cooking pots, as well as storage jars. **C)-** mold-made vessels, the most common forms of this category are lamps, jugs, and lids.

2. Glazed vessels: a large number of vessels vary in forms and in glazing techniques were widespread almost in Bilad ash-Sham, to ease the understanding of this category, it was subdivided into the following subgroups **A)-** uncoated glazed vessels, include cooking pots and lids, saucer lamps, and unpainted bowls with thick transparence glaze. **B)-** coated glazed vessels, the common forms of this subgroup are painted bowls under a transparent glaze, glazed slipped painted bowls, coated glazed bowls, sgraffito ware, and slipped-glazed bowls with molded relief (Walker 2009, p. 41; Kareem et al. 2000, pp. 81–87; Hendrix et al. 1997, pp. 290–306; Brown 1987, p. 284).

The characteristics of each ware will be summarized relying on previous studies of Middle Islamic pottery of Transjordan. As is typical during the middle Islamic II period in Jordan, lead-glazed pottery with green or yellow color, hand-made geometric painted, and plain hand-made and wheel-made pots dominate the Mamluk assemblage (Porter 2010, p. 7; Walker 2009, p. 44). During the Mamluk period, certain types of pottery wares were very common in use, such as the yellow or green glazed bowls, and hand-made geometric painted ware (HMGP) (Walker 2009, p. 44; Walmsley 2008, p. 526). Mamluk pottery wares are easily distinguished, over the pottery corpus, during surveys and excavations in Jordan, Due to the modification of the manufacturing technique, and surface treatments, as well as, the majority of the Mamluk pottery looks very dissimilar from the preceding periods (Hendrix et al. 1997, p. 291). The following are the most common wares of the Middle Islamic II:

Ware 1 (Hand-Made Geometric Painted Ware (HMGPW)): this ware is usually slipped, and occasionally burnished, in cream or pinkish color, the fabric color ranges from reddish to pinkish, rarely green fabric was noticed, the clay paste contains small, medium, and large limestone, basalt, and grog grits, in many cases chaff impressions are visible to the naked eye, vessels made of this ware are usually decorated with monochrome designs, in red and brown or black and blue, the common forms of this ware are bowls and jars (Gabrieli R. S., Ben-Shlomo D., Walker B. 2014, p. 194; Stern 2013, p. 189; Walker 2009, p. 44; McPhillips and Walmsley 2007, p. 131; Johns 1998, p. 69; Brown 1991, p. 232).

Ware 2 (Hand-made coarse ware): a variety of different forms and sizes of jars, jugs, and bowls, mostly vessels of this ware are thickly walled, contain a high percentage of non-plastic materials large in size. The majority of the vessels are slipped and burnished from the exterior, and in many examples they had evidence of burning from the interior and exterior, which indicates the function of this group as cooking pots (Stern 2014, p. 73; Kareem et al. 2000, p. 82; Walmsley and Smith 1992, p. 195; Brown 1988, p. 232, 1987, p. 284; Franken and Kalsbeek 1975, p. 167; Sauer 1973, pp. 53–56; Smith 1973, pp. 74–75).

Ware 3 (Sugar pot ware): this ware consists exclusively of large ribbed jars, as well as straight-sided bowls, constantly; the fabric has a yellow color, soft, and contains very fine inclusions. Jars made of this ware were usually used for the final product of sugar as containers(Walker 2003, p. 244; Kareem et al. 2000, p. 82; Steiner 1998, pp. 145–150; Smith 1973, p. 237).

Ware 4 (Plain unglazed ware): the fabric contains some limestone inclusion or tempering materials, similar to the thinly painted ware, even though they have miner whitish slip occasionally. The group includes bowls, jars, and jugs. Most of the closed forms have looped handles, few models demonstrate elongated and thickened cylindrical necks a company with interior filters(Stern 2009, p. 229; McPhillips and Walmsley 2007, p. 133; Sarley-Pontin 1997, p. 189; Avissar 1996, p. 155).

Ware 5 (Redware): it is a durable, and dense ware, the common colors of this ware are pale or dark reddish to gray, it is produced out of a well-levigated clay. The durability and the use of well-levigated clay, suggests a high firing temperature. The widespread forms of this ware are medium to large bowls and jars with thickened rounded rims and moderately thin walls(McPhillips and Walmsley 2007, p. 133; Tushingham et al. 1985, pp. 142–151).

Ware 6 (Thin painted ware): it is a fine ware, contains very fine limestone inclusions, commonly the popular colors of this ware are reddish-yellow to pink, in most cases, the rim, handles, and the body freehand painted in reddish-brown to brown-black, sometimes the paint is applied over a white or yellowish slip. The most common forms are jars and jugs with vertical loop handles. This ware fabric and decorative technique are similar to the earlier Islamic pottery(Stern 2009, p. 229 (McPhillips and Walmsley 2007, p. 133; Walmsley 1995, p. 661).

Ware 7 (Monochrome glazed ware): it is a durable fabric ware, mainly the fabric color is yellowish red or pale yellow, the fabric is well levigated with the exception of very fine inclusions. This ware forms the majority of Mamluk glazed ware in most of the Mamluk sites. A variety of forms represents this ware, such as footed bowls with incurving or everted rims. Regularly; pots of this ware have thick green, yellow, or brown color lead glaze layer, applied over a white slip (McPhillips and Walmsley 2007, pp. 133–134; Walker 2005, p. 79; Brown 1994, p. 456).

Ware 8 (Slip painted ware): it is a fine homogenous fabric, contains few visible inclusion. The underglaze slip painted ware is considered the second most common glazed ware of Mamluk assemblage. The common form of this ware is carinated bowls with incurving thickened rim(McPhillips and Walmsley 2007, p. 134; McPhillips 2005, pp. 241–242; Milwright 1999, p. 170; Pringle 1986, pp. 149–150).

Ware 9 (Glazed incised ware): it is a lead-glazed ware, usually have a simple geometric incised decoration over a white slip, under a green or yellow glaze. Not so often, some pots have more than one glaze color, which suggests a kinship of splashed glazed ware(McPhillips and Walmsley 2007, p. 135; McPhillips 2005, pp. 251–252; Avissar 1996, p. 96; Grey 1994, pp. 57–59).

Ware 10 (Stone paste ware or fritware): generally; the pot body is white covered by alkaline transparent glaze layer, colored by the supplement of specific elemental oxides, such as Copper (Cu), to produce turquoise color. The paste is usually prepared using almost one part of pure clay (Kaolin), mixed with around ten parts of quartz and one part of glass fragments fine ground(Grey 1994, pp. 57–59). The dominant forms of this ware are fine bowls and small jars. Stone-paste ware does not need any kind of preparation prior the application of glaze layer such as slip, due to the nature of the body, which reflects light through the glaze layer, allowing the glaze color or any underglaze decoration to be seen. A variety of geometric or vegetal painted decorations are visible in numerous combinations of colors, such as, black, cobalt blue or turquoise under a colorless glaze, and black or cobalt blue under a turquoise glaze (McPhillips and Walmsley 2007, pp. 135–136; Tonghini and Franken 1998, pp. 52–55).

Ware 11(Relief molded glazed ware): the common form of this ware is a bowl, always accompany of distinct incurving rims and epigraphic relief, as molded decoration on the external surface. This ware always have a thick, glossy glazed layer, made of advanced standard of lead-glaze, Yellow, green, and brown color, while the body sections are pale red (McPhillips and Walmsley 2007, p. 136; Walker and LaBianca 2003, pp. 464–466; Milwright 1999, p. 184; Avissar 1996, p. 102).

4.5 Late Islamic pottery (Typological and Technological description):

The Ottoman subjugation of Bilad ash-Sham around 1516 AD has been disruptive on many levels, but not so instantaneous for the material culture. The Ottoman period is known as the late Islamic period. During the early Ottoman period (16th century AD.), it is noticeable, that at least two particular Mamluk pottery wares have continued to be widely in used, which demonstrates, that the production, the consumption, and the distribution of these specific wares have been unaltered after the Ottoman imposed their rule in the region (Walker 2009, p. 40).
Archaeological evidence confirms that many rural villages have been totally abandoned, while some remained occupied and the village life continued as before without any obstruction. Ottoman occupation of Bilad ash-Sham overlaid the processes of transformation, but nevertheless, the superstructures of continuity were the result of the Ottoman governing Arab provinces (Walker 2009, p. 40, 2004, p. 119).
Ceramic chronology of the Late Islamic period emerged when several excavations in the 1980s showed high interest in establishing a concrete chronology for the Late Islamic period. Many

sites have been excavated since then, the following sites have been studied extensively, in order to pave the trail of ceramics chronology for the Late Islamic Period, Khirbat Faris, and Tall Hisban both are rural villages, al-Wu'eira, Shobak Castle, and Karak Castle. In addition, several regional surveys from the 1970s until 1990s have added to our knowledge of Late Islamic settlement, such as, Northern Jordan, Southern Ghors, and the Northeast Wadi 'Arabah, Wadi Hasa, Roman Limes, Byzantine and Islamic-period sites in Jordan, Hisban region, Madaba Plains Project, Central Moab, the east Jordan River valley, Karak Plateau, and northwest Ard al-Karak (Walker 1999, p. 209). There is incomplete harmony between scholars who study Mamluk and Ottoman periods, because there are some Mamluk wares, like the handmade-painted ware, the green glaze ware and the elephant-eared cook pots, sustained during the Early Ottoman period 16th century AD., whereas most of the imported glazed wares from Syria, Egypt, and Italy ceased, besides some local glazed wares, such as sgraffito, and bichrome-glazed progressively vanished (Walker 1999, pp. 221–224). Excavations sites across Transjordan have recovered numerous diagnostic sherds, and complete pottery pots, which have been arranged into typologies. It is quite obvious, when analyzing Ottoman assemblage to notice, that there has been a remarkable decrease of import wares, while HMGP and monochrome wares (green-glazed wares), continued to be produced and consumed through the Ottoman period (Walker 2009, pp. 40–46; McQuitty 2008, p. 551; Milwright 2000, p. 194). HMGP and monochrome wares have been collected from Malka survey 2003 season, as well as, during the 2006 survey season in Saham and Hubras mosque excavation, around 30% of these wares belong to the Ottoman period (Walker 2005, p. 81).

Even though these two wares have been common during both periods Mamluk and Ottoman, it was not so hard to differentiate between the Mamluk wares and the Ottoman wares, for example; the Mamluk repertoire of green-glazed pottery have a rim form usually (in-turned, and carinated), while the Ottoman repertoire rims are (upright, out-turned, folded over, Hooked, and T-shape), as well as, a change in the base form (heavier, lower ring-foot, and sharp incised edge), changes also have been noticed in the glaze quality, glazes became (dark, glossy, no slip, and streaked) or in some cases brittle thin green glaze applied over a white slip (Walker 2009, p. 41; Walker et al. 2007, p. 437).

The following wares are the most common Ottoman wares:

Ware 1 (Fine glazed -wares): this group conjoins lead-glazed ware, Chinese porcelain, and European porcelain, the date and the place of manufacturing of these wares are well attested, therefore; it is easy to illuminate any chronological divisions and trading patterns. Fine Ottoman wares consist of four well-known wares; unfortunately, none of the following wares have been recovered in Northern Jordan. **1)-**Miletus ware, it is a blue and white underglaze-painted earthenware, and sometimes a combination of blue and purple/black, the common motifs appeared on this ware are natural floral patterns, occasionally combined with birds, which shows the imitation of Chinese, and Parisian products, apace with the habitual Islamic geometric interlocked patterns on a background of crowded spirals. Rarely, other colors were used for decoration processes, such as red and turquoise, this ware was produced in Iznik, and it is usually found in the earlier Ottoman levels, associated with the true Iznik ware, the latest production of this ware is 1520 AD., unfortunately, the initial production date is undefined. The common forms of this ware are dishes with plain sloping rims, dishes with the flat horizontal rim, rounded body bowls with plain rim, rounded body bowls with the straight steep sloping rim, and maybe jugs (Walker 2009, p. 48; Hayes 1992, pp. 238–243). **2)-** Iznik ware, generally; it is a lead-soda monochrome glazed ware with a small amount of tin oxide, the body fabric is hard-compact comparing to earlier Islamic wares, it is made of a very fine ground quartz-frit and white clay, frequently, the coating glaze layer is very clear, sometimes uniformly colored in light shade, the coefficient of expansion between the clay body and the glaze layer is almost the same, therefore; the outcome of this combination is a solid compact continuous mass, with no kind of crazing or flaking of the glaze layer it has underglaze-painted designs in blue, white, and red. The first appearance of this ware dates to the early Ottoman period around 1520-1530 AD and lasted until the middle of the 17th century AD., then the quality started to decline, clearly, noticed by the poorer discolored yellowish body, less standardized body structures, and often crazing and flaking of the glaze layer. During the second half of the 17th century AD., some delicate changes occur in the application and the shade of the blue color on this ware. The common vessel forms consist of standardized shallow plates with horizontal rims turned distinctly upward at their tips and thin-walled, as well as, deep bowls with an inner led. Another related fabric most probably belongs to this group is the unglazed goblets (Walker 2009, pp. 48–60; Hayes 1992, pp. 244–256). **3)-**Kütahya ware, it became popular in the 18th century, it is an underglaze-painted frit ware, comparing to Iznik ware, the paintings are made of lower quality, the main purpose of producing this ware was to serve directly the coffee industry, therefore; the common forms of this ware are thin-walled coffee cups, jugs, and coffee pots (Walker 2009, p. 48; Hayes 1992, pp. 266–268). **4)-** Canakkal distinguished ware was popular during the 18th and 19th centuries, it is characterized as folk art, it is easily distinguished by its thickness, and the polychrome slip-painted designs, such as, flowers, ships, palaces, etc.. frequently it has yellow-green glaze layer, and infrequently Baroque-like relief ornamentations, commonly distributed forms of this ware are some appliqué jars, and coffee cups (Walker 2009, pp. 46–47; McQuitty 2008, pp. 552–553; Milwright 2000, p. 202; Pringle 1986, pp. 88–90; Harrison and Firatli 1966, p. 230).

Ware 2 (coarse wares): it is a very diverse set of pottery, perform around 21 locally and regionally made wares, date from the 15th century until the 17th century AD. The lead-glazed vessels are made of earthenware clay, and they share almost the same sort of forms such as simple bowls, stemmed cups, two-handled jars, and ibriqs. Usually, the glaze color is green, but in a wide variety of shades, as well as in yellow. They are distinguished by their glaze quality, besides the occurrence or lack of an underlying slip, and other surface decoration such as (sgraffito designs, staining through the addition of a glaze of another color, rouletted patterns. These wares constitute the majority of the Ottoman period vessels, found in sites and off-sites (excavations, and surveys), normally, wares are low-fired, which corresponds to the fragility of vessels made of this fabric. A variety of forms are common in most of the Ottoman sites, such as bowls, jugs, and table jars festooned by cream or a pink slip and monochrome-painted in black, or bichrome–painted in red and black. HMGP, which continued through the 16th century AD., differs slightly from the Mamluk HMGP. Its coarsely made fabric, and the large quantity of chaff present in the clay material. Geometric patterns range from dense to complex, to more open freestyle motifs (Grey 2012, p. 354; Walker et al. 2009, 16; Walker 2009, p. 44; McQuitty 2008, p. 553; Kareem et al. 2000, p. 82). The second major Coarse handmade ware with least, or without painted ornamentation belong to this tradition is difficult to distinguish from medieval HMGP if not securely stratified.

Ware 3 (clay pipe (bowls), Chibouks): it is a fine filtered fabric, modification of the size, shape, color and decorative techniques is the base of chronology, according to Hayes study1992, chronologically there are three grads of clay pipe bowls: **A).** fine light grey fabric dates to the 17th AD.it has a small size bowl in general, frequently it is made of white clay, fired under reducing conditions, therefore; it is often grey, the bowls are characterized by their narrow stems, thin walls, and stepped-ring shaft ends, as well as, their surface are usually rouletted (Walker 2009, pp. 49–50; Simpson 2002, p. 160)**. B).** red-brown ware, dates to the 18th century AD., it has a smooth surface, occasionally; it has a splash-glazed layer, the fabric is coarser comparing to the fine light grey ware, and slightly burnished (Walker 2009, p. 50). **C).** red burnished stamped ware, dates to the 19th century AD. it has a bowl shape mainly lily or disc shape, mostly, the outer red clay surface is heavily burnished, the size is larger and thicker compared to the previous pipe wares (Saidel 2011, p. 75; Walker 2009, p. 50; Simpson 2002, p. 164).

Ware 4 (Syrian polychrome): it is an alkaline-glazed stonepaste ware, the common paint colors used underglaze are blue, turquoise, purple, and green. The origin of this ware might be Persia as Lane suggested in 1957 a&b, the common forms of this ware are bowls, jugs, and jars. The common decoration patterns of this ware are usually floral and vegetal, sketched out in black. Even though it is stonepaste ware, the body is moderately soft and brittle, and the glaze layer is frequently, contains cracks, due to the high thickness, which indicates lower firing temperature (Milwright 2000, p. 201).

Ware 5 (Gaza ware): it is a wheel-thrown pottery, probably fired under reducing conditions, due to the gray color fabric. Frequently, slipped into black or dark grey (Rosen and Goodfriend 1993, p. 143). During the 19th century AD. Gaza ware was illustrated in details in the ethnographic study of Gatt (Industriellesaus Gaza 1885), the ware is considered identical to the late Ottoman period. Therefore; the ubiquitous of Gaza ware in the late Ottoman occupation, almost all over the archaeological sites in Jordan and Palestine, encouraged archaeologists to use this ware, as an indicator of late Ottoman occupation in Jordan and the region in general. Certainly, Gaza Ware clay material was red color clay, which means high concentration of iron, but as mentioned earlier fired in a reducing atmosphere, and if titanium oxide is present, at a certain temperature ferrous titanate spinel forms, which will mask the entire vessel in black or gray color (Singer 2013, p. 465). A variety of vessel forms include large jars and ibriqs, with their characteristic collared mouths, strap handles located high on the shoulder, sharply bring out transitions from neck to body, and omphalos bases, cook pots, bowls, basins, tabuns, lamps, and chibouks (Walker 2009, p. 54; Gatt 1885, p. 71). Gaza ware surface decorations are very tiny, except some ribbing on jars, and the irregular addition of internal glaze layer in (Rye 1976, p. 773; Walker et al. 2007, p. 458). The appearance of additional surface decoration on some vessels, perhaps belong to local derivatives.

Chapter Five: Results and Discussion

The Islamic pottery production, distribution, and consumption of Northern Jordan: the contribution of archaeometry.

5.1 Introduction

The main focus of this study is the contribution of archaeometry (ceramic petrography)to problems and questions of archaeology, history, and conservation of cultural heritage. Northern Jordan Islamic pottery has not been comprehensively studied by means of archaeometric methods, except for few studies which concentrated on either specific Islamic time periods or on certain types of pottery ware. The current study is focused on surveyed Islamic pottery from three major sites in Northern Jordan. Selected archaeometric methods have been utilized to examine the technology, provenance, type of raw materials, and communal identity of Islamic pottery from Umm Qais (Gadara), Qweilibeh (Abila), and Umm el-Jimal. The application and understanding of these techniques and their underlying scientific basis posed a particular challenge. It required acquiring comprehensive knowledge and expertise in a highly interdisciplinary scientific field; a prerequisite to share, compare and evaluate the archaeometric data and results obtained by other research teams. This study intends to demonstrate the importance and need for interdisciplinary scientific research for our understanding of mankind's cultural heritage, and also the establishment of a rational basis for future work.

A major objective of the archaeometric study was to explore Islamic pottery production and trade, by determining its origin, i.e. whether it was domestic industry or simple commodity production (Rice2015, p. 337). The craftsman technical skills, the organization of pottery production, and the reconstruction of pottery distribution from production centers, all may be specified by means of archaeometric research, i.e. by ceramic petrography, X-ray powder diffraction (XRD), and bulk chemical analysis. Exchange, trade, consumption, and the function of pottery in focus, all may be investigated by analyzing the material properties of the ware and deciphering the characteristics of pottery production. Moreover, archaeometric data may provide valuable insights into the environmental, technological, economic, socio-political, cultural-ideological and historical situation, in which the pottery was produced, distributed, and consumed/utilized. The comprehension of pottery production technology requires direct and indirect approaches. It evaluates and interprets notably the material properties of ceramics based on hypothesis, ideas, political institutions and processes (Rice2015, p. 338).

Pottery production thus is a result of negotiating cultural preferences since the technical production approach is just a part of a broader cultural system constantly in change. Therefore, the technique used for the production of pottery may provide practical detailed information about the society that produced and utilized the ceramics; on the other hand, it reflects the society's appreciation towards the development of new forms and techniques of pottery production. Pottery represents the most widely spread cultural materials in archaeological sites. Archaeologists, when studying pottery, describe the external attributes of the artifacts, e.g. their shape/design, color, and any type of decoration. The archaeometric analysis considerably extends such macroscopic description by providing comprehensive information on the material properties of the ceramic artifact, e.g. bulk chemistry (major and trace elements, isotopes), mineralogical composition (precursor, refractory and newly formed phases), and microstructure (fabric). It also provides valuable information on the properties and provenance of raw materials used for the production of pottery. During firing processes, with rising temperature and changing kiln atmosphere, the raw materials of pottery (green bodies) pass through different stages and types of transformations, which remain preserved when the firing processes are over. Archaeometry has the potential of extracting the data preserved in the pottery objects post-firing. These data provide information regarding the manufacturing technology, the objects functions, and the raw materials provenance (Tite1995: 38; Tite 2008: 216; Seccoet al., 2011: 809). In the following sections, the results of the petrographic examination of the pottery sherds are laid out separately for each individual time period.

Before addressing the results, prior preparation has to be conducted to allow the identification of the different characteristics and the major and minor constituents. Sampling strategies differ from one analytical technique to another, therefore; it is of great importance to follow the right procedures. In the case of petrography (based on thins-section examination), the identification of rock minerals (non-plastic materials) can only be securely carried out by polarized light microscopy if the thin-section was ground to a standard thickness of 30µm. It is important to stick to this thickness because it standardizes the observation of interference colors of anisotropic minerals in cross-polarized light (CPL) mode, as well as of the absorption colors in plane polarized light (PPL). Unknown minerals can be identified based on their morphological and optical attributes as observed under the polarizing microscope using reference tables of mineral optics (Reedy 1994, p. 115). Archaeologists and conservation scientists, apply thin-section analysis to study the inorganic materials used for the production of cultural heritage objects. Beyond its potential of mineral identification, this technique allows grouping of similar fabric objects based on their mineralogical composition and fabric attributes. The petrographic analysis allows identifying the geological origin of the studied samples, i.e. the determination of the source of the raw materials or part of it. Pinpointing the manufacturing technology (hand-made, wheel-thrown)and firing conditions (temperature and atmosphere) is a further strength of thin-section analysis (Reedy 1994, p. 115). For full advantages of thin-section analysis, training and extensive experience are needed to obtain meaningful information on the study samples. Petrographic microscopy is considered a most useful and inexpensive tool for the reconnaissance study of solid materials, notably when the samples are further studied using more sophisticated and expensive analytical techniques.

To prepare a thin-section, a finely polished slice of the sample has to be mounted on a glass slide by epoxy resin. After hardening the thin-section has to be ground to the desired thickness of 30µm. When studying pottery samples under the polarizing microscope, four scientific questions have to be addressed: 1) Is the pottery imported or local? 2) Does the pottery differ from one time period to another? 3) Is it possible to deduce the manufacturing technology based on the ceramic attributes? 4) What type of alteration occurred to the object during firing processes and the conditions prevailing at the burial site?

When examining the thin-sections under the polarizing microscope, a spectrum of optical and morphological properties of mineral components, lithic fragments, and temper components are observed. In the plane polarized light mode (PPL) the following are the main properties to be observed: transparency vs. opaqueness, color, pleochroism, refractive index, relief, morphology, and cleavage. In the crossed polarizers mode (XPol) additional important determinative properties are observed: isotropism vs. anisotropism, birefringence, extinction angle, and the presence or absence of other features such as zoning, twinning, undulose extinction, and anomalous interference colours (Quinn 2013, p.23; Kerr 1977,p. 152; MacKenzie et al. 1982; Reedy 1994, p. 116). Further important characteristics concern the microstructure and texture (i.e. fabric) of the ceramics and the modal abundances of identified constituents (Reedy 1994,p. 116). The mineralogy and fabric of archaeological ceramic materials provide important clues concerning (1) the nature of the raw material, (2) the intentional addition of temper material (inorganic clasts, grog, organic components), (3) the manufacturing technology (wheel-thrown, handmade or molded), and the temperatures and redox conditions of firing.

Sample preparation for X-ray powder diffraction analysis, compared with thin section petrography does not demand a long-term practical experience. The samples are crushed and, using an agate mortar ground to a fine powder with a particles size below 63 µm. The powders are then pressed on the sample holders, which are introduced to the X-ray source. For scanning electron microscope (SEM) well-polished cross-sections are coated with a thin carbon film to ensure conductivity; this is done by using a sputter coater device.

5.2 The Petrographic characterization of the Early Islamic pottery from Northern Jordan (Gadara, Abila, Umm el-Jimal)

5.2.1 Introductory remarks

The examination of thin sections under the polarizing light microscope is considered as a prime tool for identifying the mineralogical constituents and the fabric of any ancient ceramics (Quinn 2013, p.251). This classic mineralogical method of analysis is widely used to this day in geology and material science geology to investigate the mineral constituents, phase relations and structural attributes of natural and synthetic materials. As the major and minor properties of pottery are mainly controlled by the minerals, except for some organic ingredients such as chaff (straw), the identification and characterization of these constituents with the polarizing microscope is essential (Rice 2015, p. 292; Nesse 2003, p. 348; Quinn 2013, p.251; Raith, et. 2011, p 107). Petrographic inspection of the thin-sections, allows specifying the raw materials, and the manufacturing technology, utilized by the pottery-makers, and to deduce the firing conditions (temperature and kiln atmosphere), based on the nature of the non-plastic materials (temper and natural clastic components), and the textural and mineralogical characteristics of the clay matrix. In general, pottery consists of three main components: a clayey matrix, coarser grained clastic constituents, and pores/voids.

The mineralogical composition and the fabric (structure and texture), are the primary pottery properties, that polarized light microscopy can provide. Why is it important to identify the fabric? The nature of constituents (species, grain size, grain shape, compositional attributes), their spatial distribution and orientation within the ceramic body provides crucial information on the manufacturing technology (Stienstra1986, p.30). The processing and refinement of pottery raw materials, ceramic designs, and firing technologies probably have been the cornerstone of the development of pottery throughout the centuries. The petrographic analysis of material properties of pottery provides indispensable information for the reconstruction of the pottery lifecycle, i.e. from the extraction of raw materials and subsequent purification measures, the production processes, such as preparing the clay paste, forming the objects, drying the objects, firing the objects, and finally the finishing. Petrography further has the potential of revealing the lifecycle of pottery objects, from the date of manufacturing through the usage stage, until ultimate discarding, as well as, the deterioration processes during the burial stage until the uncovering stage. Ceramic petrography is a flourishing technique of archaeological pottery composition analysis and has become the method of choice for archaeometric research (Orton et al. 1993, p.140; Quinn, 2011). However, despite its great potential, widespread availability and low costs, this classic mineralogical technique reaches its limits when the usually fine-grained nature of ceramic matrices has to be resolved in terms of mineralogy and microstructure or the composition of mineralogical constituents determined. It is obvious that depending on the addressed scientific problems, microscopy must be complemented with material analysis employing more expensive sophisticated analytical techniques. Nonetheless, petrography expands our knowledge in the field of pottery research and offers innovative science-based inputs to the study of pottery in the societal context.

5.2.2 Petrographic description of Early Islamic pottery

The studied samples were chosen from the comprehensive collection of early Islamic pottery that had been recovered during the archaeological survey of Abila- Qweilibeh (June 2014), Umm el-Jimal (February 2015), and Gadara-Umm Qais (September 2015) in the framework of the DFG-funded project 'Historical land-use and landscape reconstruction in the Dekapolis region'. The samples cover the entire spectrum of the Early Islamic pottery from the three sites. They comprise all wares and forms of pottery manufactured during the early Islamic periods in Northern Jordan, such as bowls, basins (kraters), cooking casseroles, cooking pots, cups, jars, jugs, juglets, plates, and platters. Sherds were carefully taken from various parts of the vessels, such as base, body sherds, handles, and rims. A total of 88 samples were petrographically analyzed (Table 1, Appendix). To facilitate the comparison of petrographic data from the three archaeological sites, the microscopic description of ceramics followed a standard scheme. Major criteria were the bulk characteristics of the pottery (mineralogical composition, microstructure, texture) and the nature and properties of clastic components (species; size, shape, and angularity of grains and micro-fragments). For the sake of identification and classification of each macroscopic fabric, the characteristics of the clays from which the pottery was made were cautiously inspected by thin-section microscopy (Peterson, Betancourt 2009, p. 14).

Following the microscopic examination, the pottery sherds were classified and grouped according to their ceramic fabric, which is largely determined by the proportions of coarser clastic components and the fine clayey matrix. The clastic constituents comprise natural components (e.g. mineral clasts, lithic fragments, microfossil shells) and temper materials (e.g. grog, straw, mineral clasts). Petrography analysis facilitated the grouping of the samples depending on the general characteristics, such as the type of raw materials, and any fingerprints of the manufacturing technologies. Samples grouping authorized detecting the connection between different groups, which permitted comparing and interpreting the result. The fabrics of ceramic bodies have been mainly examined with respect to the processing of raw materials, such as tempering processes, and the firing conditions and temperatures (Doménech-Carbóet al. 2009, p.3; Reedy 2008, pp.146–148; Whitbread 2003, pp. 6–7).

The clay matrix is the essential ingredient and may form up to 70-90% of the ceramic body. Clay particles are very fine in size (about 2µm), and they vary in colors, due to the presence of Fe, and Mn oxides or hydroxides. The essential property that facilitates forming clayey materials is the plastic behavior, clay mineral structures can easily deform by translation (slip) of the basal (001) planes of their crystalline structure and they also easily slip against each other upon application of external stress (plastic deformation).

The non-plastic clastic components, whether temper or natural inclusions, usually make-up around10-30% of the ceramic body. A variety of non-plastic materials has been identified in the studied sherds. They comprise mineral clasts, fragments of rocks, grog, shell, and bone, as well as chaff, and microfossils. The role of non-plastic materials in pottery making is to control the plasticity of the clay, as well as to provide micro-pathways allowing an easy escape of pore water during drying of the green body and notably of the fluids which are deliberated from the dehydroxylating clay minerals during the firing process, without causing damage to the ceramic body. Moreover, non-plastic materials reduce shrinkage of the ceramic body. The addition of non-plastic temper components is in particular important if the pottery is frequently exposed to heat, as in the case of cooking pots. Phyllosilicates prevent the pottery from thermal shock, which may cause the pot to collapse, such as mica group, that consists of clay minerals like, kaolinite, illite, and montmorillonite; it may form in low-temperature sedimentary environments from illite group too (Derr et al. 1992:294-95; Ortega 2005, p.2).

While grog and organic matter are easily identified as added temper, the distinction of mineral clasts as intentionally added temper component from natural clastic components defines a difficult task. The grains size distribution and the shape of the grains may provide helpful clues: angular and coarse grains most likely could represent intentional additions by the potter, whereas fine and rounded to sub-rounded grains indicate primary components of the clay (Shepard 1985, p.27). Furthermore, non-plastic clastic components beyond of their key role in the ceramic manufacturing process are considered as important indicators of the source, and the nature of the raw materials used by the potters as well as of the temperature and atmospheric conditions achieved during firing of the ceramics.

The porosity of pottery is an outcome of different factors: (1) The size of the non-plastic clastic components. The presence of coarse clastic constituents influences the behavior of the objects during the drying processes, as they ease the escape of pore water, thus preventing the objects from cracking or even collapsing. (2) The firing processes. During firing the chemically bound water/carbon dioxide is released during the breakdown of clay/carbonate minerals at specific temperatures. The liberation of fluids during these de-hydroxylation and de-carbonation (calcinations) processes produces pores. (3) Organic matters decomposition. Combustion of the organic temper leaves pores which mimic the shape of organic constituents and which occasionally may still contain remnants of reacted organic matter.

5.2.3 Summary of the Early Islamic Petrographic Analysis

The Early Islamic pottery from the three sites based on their internal ceramic characteristics can be divided into two main groups: Sherds of the first group exhibit a fine ceramic matrix embedding fine-grained mineral clasts and lithic fragments, as well as rare organic temper. In contrast sherds of the second group exhibit a coarser ceramic matrix embedding coarse clasts of temper and/or natural constituents.

Sherds of the first group, in general, contain moderate amounts of non-plastic constituents comprising mainly quartz, chert, and plagioclase. Some samples preserve elongated pores with rounded tips that mimic the location of burnt organic temper. For estimating the modal abundances of minerals, the Terry and Chilingar method has been applied (Müller1967, p.142).

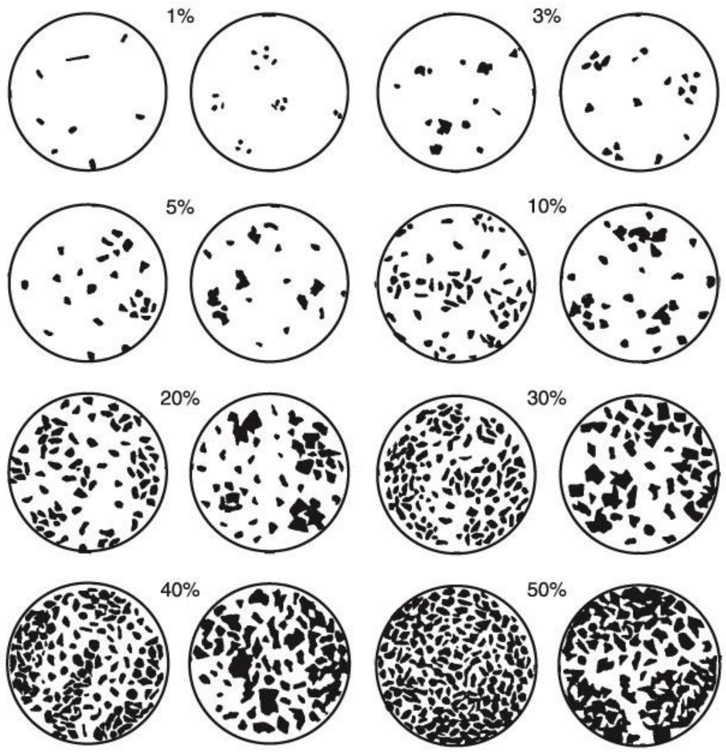

Fig. 5.1 Comparison chart for volume percentage estimation (after Terry and Chilingar, 1955).

Quartz is the major clastic component with an average content of ~30 Vol. %, whereas the modal abundances of the other non-plastic constituents such as plagioclase, chert, and organic materials, hardly exceed10 Vol. %. The fine-grained size and rounded or sub-rounded grain shape of the non-plastic constituents suggest that they largely represent a primary component of the clayey raw materials, which were once transported into the same sedimentation area of the clayey materials.

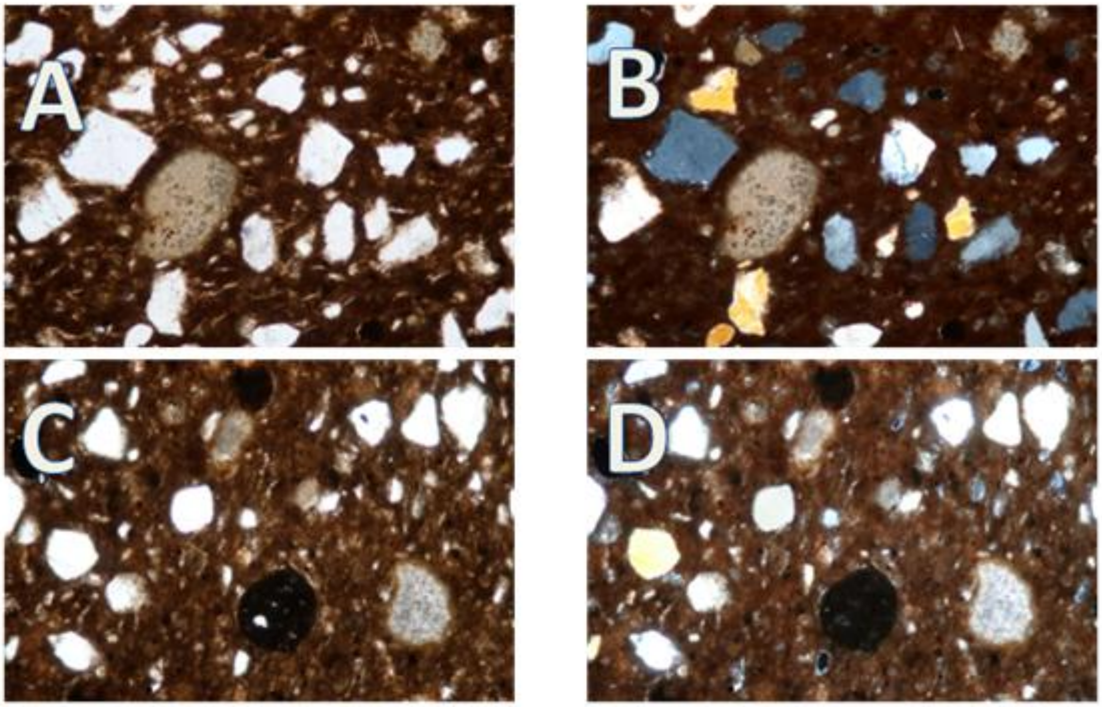

Fig. 5.2 Photomicrographs showing the texture and non-plastic inclusions in sample UJ340. a: highly sintered matrix contain sub-rounded coarse quartz clasts by (PPL) mode, image width 1mm. b: same image by (CPL) mode, image width 1mm. C: calcined limestone and rounded black spots by (PPL) mode, image width 1mm. D: same image by (CPL) mode, image width 1mm.

The second group is characterized by high modal fractions of quartz (~20 Vol. %) as well as of lithic (chert) and temper (grog) components (~15Vol. %). The coarse- to fine-grained clastic constituents show poorly sorted grain size distributions. The dominant angular shape (quartz) and nature (grog) of the clasts probably indicate their intentional addition to the clay paste (Rice2015, p. 76; Fargher2007, p.322; Stoltman 2001, p.301). Quartz is the modally dominant clastic constituent. The grains exhibit sub-rounded to sub-angular shapes, and in some samples show wavy extinction, a typical feature of strained quartz in metamorphic rocks (Deer et al. 1992, p.350; Kerr1977, p. 275). In few sherds, polycrystalline quartz fragments (quartzite) were observed, also indicating a metamorphic origin. The dominantly angular shape of the quartz grains could indicate that they represent crushed temper material. However, angular grain shape also characterizes detrital quartz grains that did not experience long-distance transport to the place of sedimentation (Maggetti 1982, p.131). The joint presence of grog and coarse angular quartz grains argues for a temper nature of quartz.

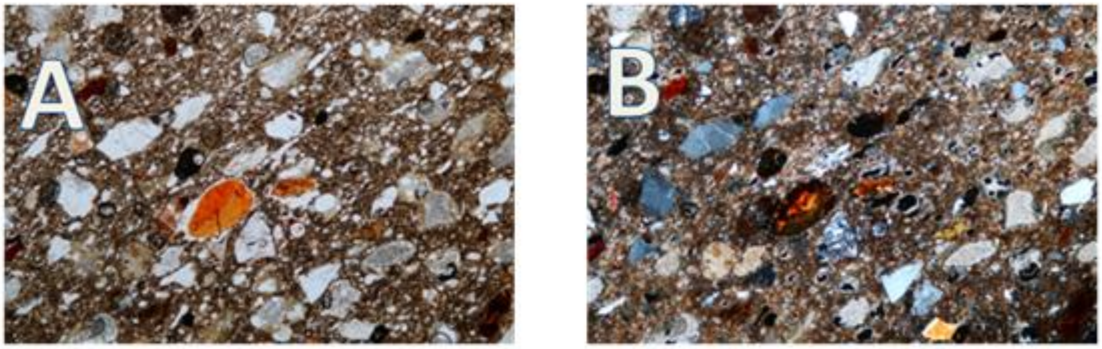

Fig. 5.3 Photomicrographs showing the texture and non-plastic inclusions in sample UJ560. a: clear shell twining by (PPL) mode, image width 0.2mm b: same image by (CPL) mode, image width 0.2mm.

The second most common mineral is calcite. It occurs in almost three-quarters of the studied Early Islamic samples. Besides forming a significant component of the fine-grained clayey matrix, it also occurs as distinct rounded to angular calcite grains, micritic limestone particles of varying size, and sometimes ubiquitous calcareous microfossils (foraminifera). It is thus obvious, that marine calcareous clays which are typical and widespread sedimentary rocks of the Northern Jordan geology provided the material of choice used by the potters. In cases where the firing conditions crossed the thermal stability of calcite, matrix calcite and clasts have been converted to lime. However, as lime is highly susceptible to back-reaction with carbon dioxide and water, the former lime particles have been converted to extremely fine-grained aggregates of calcite and/or portlandite shortly following the firing process. The microscopic examination further revealed that numerous sherds have been mineralized by secondary calcite due to interaction with calcium bicarbonate-bearing surface waters at the burial site, a process called re-carbonation (Maggetti 1982, pp.129–130; Kardoset al. 1985, pp. 89–91). Secondary calcite occurs as fine-grained fillings of cracks, as coatings and fillings of pores and voids, and occasionally as thin crusts on the outer surfaces of the sherds. Iron oxide-hydroxide phases are one of the most widespread minerals in nature, they occur almost in all types of rocks. They are present as primary minerals in many sedimentary rocks and their weathered equivalents. Clays commonly contain iron oxide-hydroxide minerals, and these are responsible for the colors of any pottery sample (Deer et al.1992, pp. 410–411; Hurlbut, Dana1971, p.282). Grog (crushed pottery) has been widely utilized as a tempering material to control the plasticity of clay and to reduce the shrinkage during drying and firing processes (Rye1981, p.33).

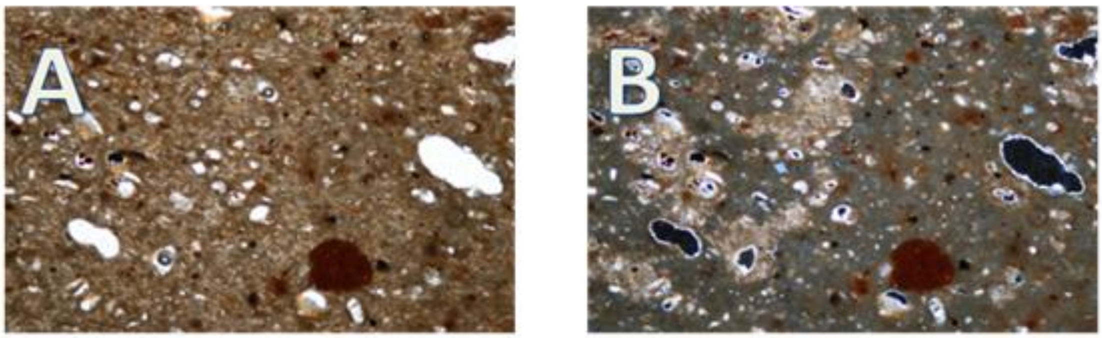

Fig. 5.4 Photomicrographs showing the texture and non-plastic inclusions in sample UQ20. A: secondary calcite precipitated around the pores and red spots related to iron by (PPL) mode, image width 1mm B: same image in (CPL) mode, image width 1mm.

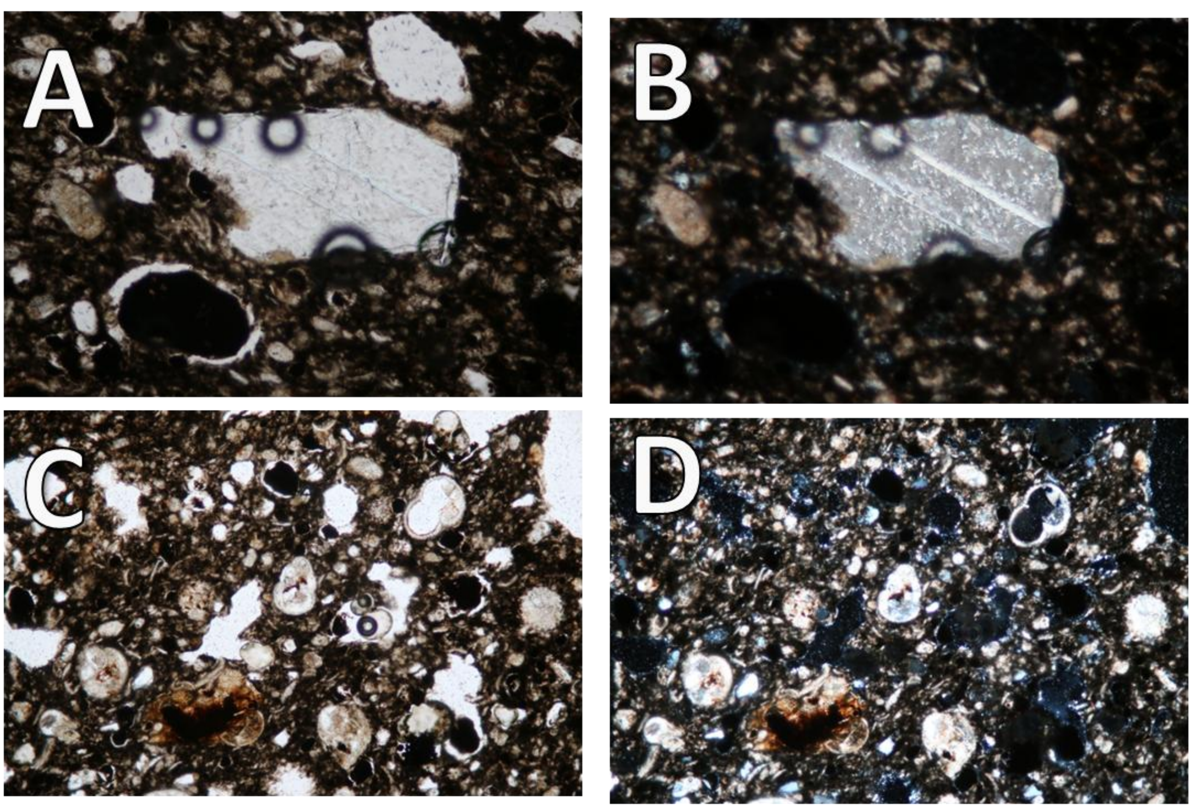

Fig. 5.5 Photomicrographs showing the texture and non-plastic inclusions in sample UQ137. a: primary angular calcite clast with clear twining in a dark matrix by (PPL) mode, image width 0.5mm. b: same image but in (CPL) mode, image width 0.5mm. C: microfossils undisturbed by (PPL) mode, image width 0.5mm. d: same image but in (CPL) mode, image width 0.5mm.

Different sizes of grog fragments have been distinguished, some still possess angular edges, which indicates grounding prior to addition.

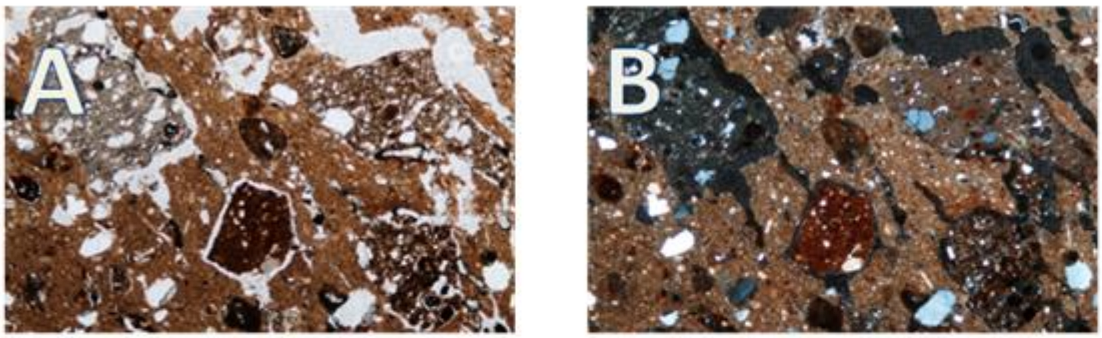

Fig. 5.6 Photomicrographs showing the texture and non-plastic inclusions in sample AB650. a: coarsely ground grog clasts detached from the matrix by (PPL) mode, image width 2mm. b: same image but in (CPL) mode, image width 2mm.

It is worth mentioning, that in some of the samples in which mullite was detected by X-ray powder diffractometry, optical examination reveals that the phase mullite occurs only within the grog fragments. Such recognition prevented any wrong estimation of the firing temperatures since mullite indicates firing temperatures over than 1000 C^{o}. Therefore; the existence of mullite within the grog fragments, can only reflect the firing temperatures of the grog fragments and not of the pottery. XRD results assured the presence of mullite in the samples, while petrography located from the sites it occurs. Basaltic fragments have been identified in some of the sherds, which is not surprising, as the three studied sites are located within the boundaries of the expansive basaltic area that covers the northern plateau of Jordan (Bender 1975, p. 17). Olivine particles have been identified, which is considered a major constituent of dark igneous rock (basalt, peridotite) (Deeret al.1992, p. 7; Kerr1977, p.382; Hurlbut, Dana1971, p.376). The occurrence of large elongate pores in some of the coarse-ware samples indicates the use of chaff as temper material. Although the former organic matter has commonly been decomposed during the firing process, in rare cases faint cellular structures are still visible. These rare organic remnants and the typically rounded pore tips distinguish chaff-derived pores from the elongated pores introduced by the manufacturing process, similar to the wheel-thrown pottery. Due to the forming process, with the presence of air within the clay body, some air gets trapped occupying spaces, which usually form elongated spaces, because of the pressure introduced by the pottery makers, but when the clayey material is being introduced to higher temperatures (firing process); air bubbles find their way to escape leaving elongated pores.

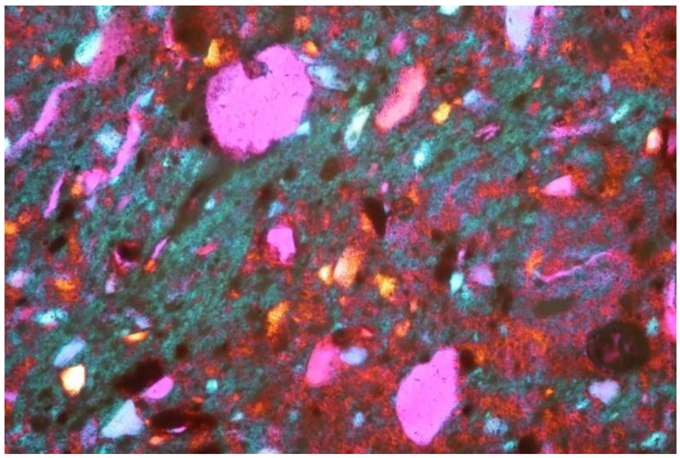

Fig. 5.7 Photomicrographs of sample UQ130 showing the green mullite veins in the matrix, image by (CPL) mode and lambda plate, image width 0.5mm.

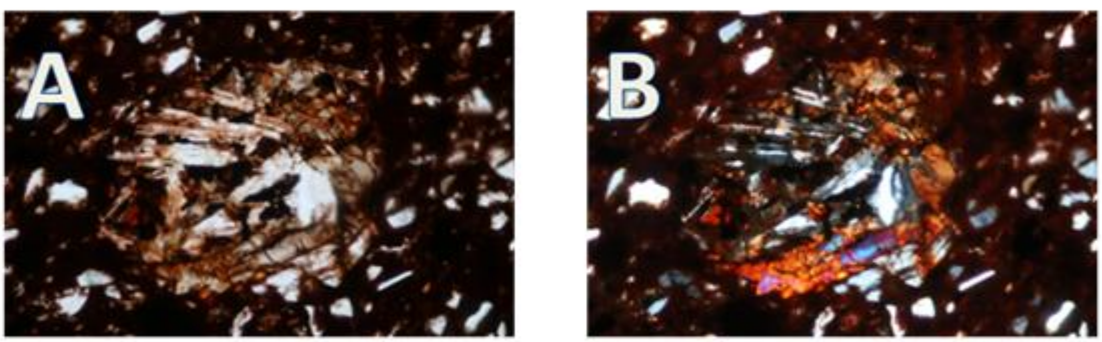

Fig. 5.8 Photomicrographs showing the texture and non-plastic inclusions in sample UJ617. a: basaltic clast (plagioclase + clinopyroxene) by (PPL) mode, image width 0.5mm. b: same image by (CPL) mode, image width 0.5mm.

The early Islamic samples from Northern Jordan exhibit, besides the coarse clasts and rock fragments, a substantial porosity, which may reach up to 20% of the thin-section space. Different origins of pores have been observed in the thin-sections, the following were the most common: first, very large related to organic matters (chaff); second, large to medium pores related to shrinking during forming, and drying process; third, small matrix pores, related to trapped fluids that were liberated during de-hydroxylation of clay minerals, and de-carbonation of calcite-dolomite; finally the fourth, fine rounded pores related to highly vitrified ceramic matrix. It is important to observe the size and shape of pores, even though pores mostly assume elliptical to spherical shapes, due to loss of plasticity water and the chemically bound water and carbon hydroxide.

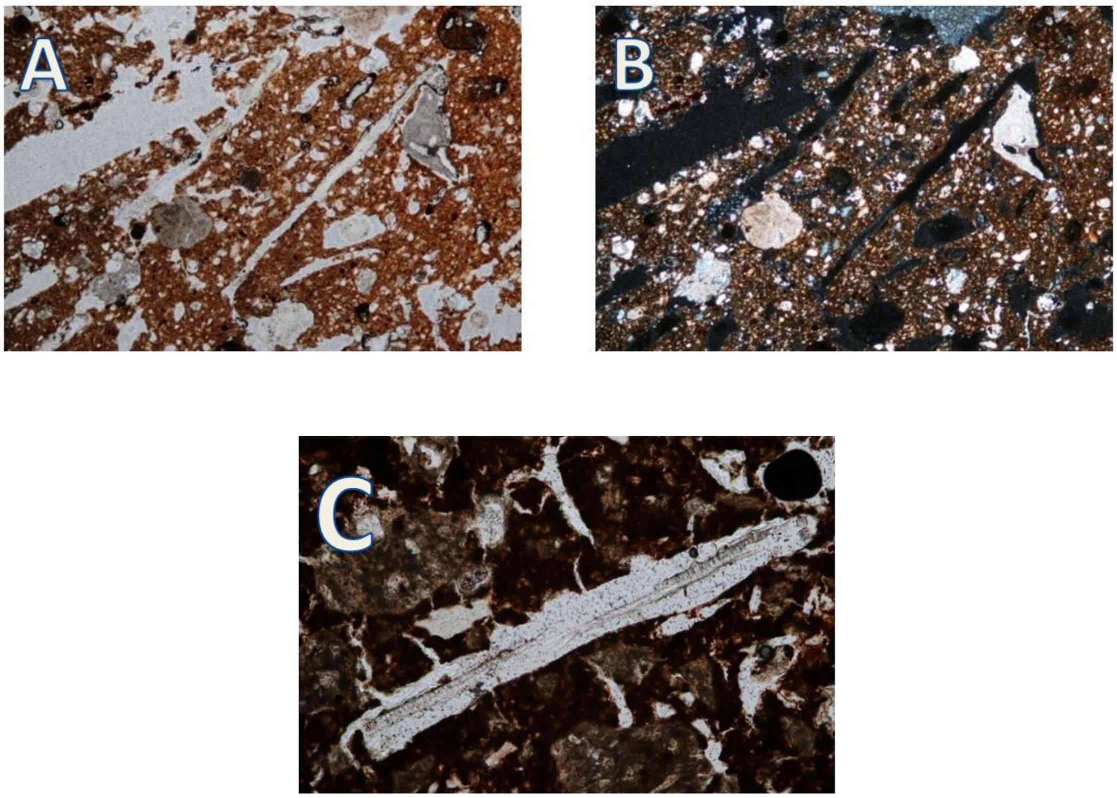

Fig. 5.9 Photomicrographs showing the texture and non-plastic inclusions in a and b sample AB172, and c sample AB441. a: chaff (organic) pores with rounded tips, by (PPL) mode, image width 2mm. b: same image in (CPL) mode, image width 2mm. C: chaff (organic) remnant added as temper by (PPL) mode, image width 2mm.

The distribution patterns of pores are very good indicators about the manufacturing process. Symmetrical movements and pressures usually introduce alignment in preferred directions, while asymmetrical movements and pressures introduce heterogeneous directions. Therefore, wheel-thrown pottery shows pore alignment in preferred directions (symmetrical), while hand-made pottery shows random pore trends (asymmetrical) (Felts 1942, p.239).

5.3 The control of calcium carbonate and quartz on the behavior of the clayey materials during firing processes

The comparison between pottery compositions is best achieved based on the (CaO+MgO)/SiO_2 ratios; these ratios differ considerably within pottery of the same geographical area. As being part of the non-plastic constituents commonly used by potters, their presence may allow insights concerning how they were introduced to the clay paste. The (CaO+MgO)/SiO_2 ratios strongly control the behavior of the clay-body during firing, i.e. the formation of new mineral phases (anorthite, clinopyroxene, gehlenite) and the vitrification reactions. Because of the strong control the CaO content (calcite, dolomite) has on the whole set of ceramic properties, clay-based ceramics are differentiated into non-calcareous ceramics (lime-poor) and calcareous ceramics (lime-rich). Lime-rich ceramics are easily differentiated from lime-poor ceramics by the occurrence of characteristic newly grown phases (anorthite, clinopyroxene, gehlenite), which were never present in both raw materials, and are not formed in the lime-poor ceramics. Potter's clays usually contain a variety of mineral phases, but not all of these phases participate in the ceramic reactions which take place during firing. The firing temperatures and atmosphere prevailing in the kilns produce distinct new phases. The ceramic reactions occurring in calcareous clays are largely defined by four major components, namely silica (SiO_2), alumina (Al_2O_3), lime (CaO), and magnesia (MgO). CaO and MgO, because of their chemical affinity, can in first approximation be considered as one chemical component. The phases occurring in the system and their compatibility relations hence can be illustrated in terms of the ternary phase diagram SiO_2-Al_2O_3-(CaO+MgO) (Figure 5.10). The ternary diagram depicts the compatibility relations among those phases, which are stable at high firing temperature. Phases in mutual equilibrium are connected through tie-lines (conodes), which combine to several three-phase stability fields. The compositions of most common ceramic ware plot into the following fields of three-phase assemblages: cristobalite/tridymite-diopside-anorthite, diopside-anorthite-gehlenite, and cristobalite/tridymite-anorthite-mullite (Noll, Heimann 2016, Fig. 3.2., pp. 25-31). The tie-line quartz-anorthite is important, as it separates the composition field of non-calcareous clays (crs,trd—mullite—anorthite) from that of calcareous clays (crs,trd—diopside—anorthite). The compositions of highly calcareous clays fall into the adjoining field diopside-anorthite-gehlenite. It follows that the (CaO+MgO) concentration of the clay paste exerts the major control over the newly formed phase assemblages. The following properties make calcareous clays the potter's material of choice for the production of ceramics: (1) improved paste mechanical properties. (2) high reactivity at much lower temperatures, which boosts the formation of the eutectic melt at a lower temperature of about 600 C^{o}, as it acts as flux. (3) paints stand prominently on pots. (4) the improved thermal resistance of the vessels during usage. It is worth noting, that solid-solid reaction in the matrix of calcareous clays also cause a change of the matrix microstructure by sintering, i.e. without the participation of a melt phase (Noll, Heimann 2016, p.29).

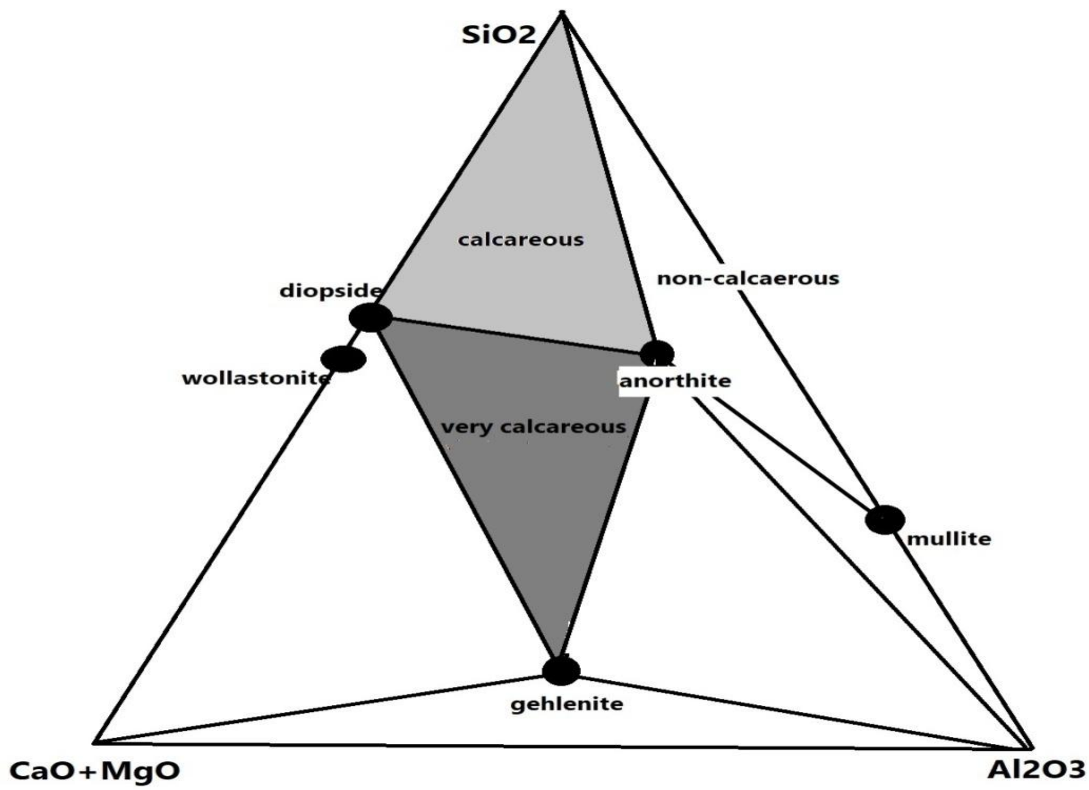

Fig. 5.10 Ternary phase diagram illustrates the compatibility relations between SiO2-Al2O3-(CaO+MgO) (Noll, Heimann 2016, p. 27).

Even though lime-rich clays have been favored by the potters, due to the advantages addressed above, prolific melt formation within the lime-bearing matrix within a narrow temperature interval, leads to an unwanted decrease of ceramic viscosity that causes slumping or warping of the pottery vessel. Potters, who have been aware of this disadvantage, controlled the increase of firing temperatures and conditions. Besides the strong fluxing effect of lime, two minor components, namely the alkalies K_2O and Na_2O, contribute to the vitrification of calcareous clays. Their fluxing action, however, is masked by the strong effect of lime (Noll, Heimann

2016, p. 31). By contrast, alkali-bearing minerals (illite, muscovite, alkali feldspar) act as the main fluxing agents in non-calcareous clays.

XRD-Rietveld data have been used for the estimation of calcite concentrations in the entire studied sample set of Northern Jordan pottery. Regarding the interpretation of data, it is important to note that the estimated modal concentrations correspond to bulk calcite concentrations, and hence do not differentiate between primary calcite components (clasts, fossils, matrix calcite), and secondary calcite components (re-carbonated lime fragments, secondary coatings). Almost two-thirds of the studied early Islamic sherds from Northern Jordan (66 out of 88samples) contain calcite, with concentrations up to~40 Vol. % in some samples. This indicates that nearly 75% of the whole ceramic assemblage is compositionally related to the local geology of the district. We need not forget that only fine to coarse-grained calcite can be detected by polarized light microscopy, whereas very fine-grained fractions need to be identified by an alternative technique as XRD. Therefore, the combination of both techniques is necessary to draw conclusions concerning the composition of the ceramic matrix. X-Ray-powder diffraction analysis of the calcareous clay group of sherds indicates quartz and calcite as major phases, besides anorthitic plagioclase, clinopyroxene, and gehlenite, which were newly formed during the firing processes. These phases generally nucleated and grew at carbonate-silicate interfaces by reaction-diffusion processes (Cultrone et al. 2001, p.621). p.621). The presence of neoblastic anorthitic plagioclase, clinopyroxene, and gehlenite in the calcareous ceramics indicates that this group has been fired at temperatures between 900-1100^{o}C. In the non-calcareous pottery, the presence of spinel and mullite also suggests firing temperatures in the range of 1000-1100°C. Many rock fragments such as basalt, chert, and quartzite were observed during microscopic examination of the samples, indicating local sources of the clay-materials and hence a local production of the pottery.

5.4 X-Ray Powder Diffraction Analysis (XRD) of Early Islamic samples

Because of the fine-grained nature of ceramic matrices, which is not accessible to polarized light microscopy, the mineralogical composition and hence chemical characteristics of pottery sherds must be determined by X-ray powder diffraction technique. By identifying the mineralogy of the ceramic matrix, X-ray diffraction technique provide crucial information regarding the thermal and mechanical treatment, that pottery objects were subjected to throughout their fabrication processes (Tite 1972, p. 285; Rice 2015, p. 384; Leute 1987, p. 129). When applying X-ray powder diffraction to ceramic objects, a major purpose is to document the presence or absence of minerals that serve as indicators of the source material and notably the firing regime. X-ray powder diffraction is also utilized for the identification of phase changes in re-firing experiments on pottery, in order to determine the firing conditions (temperature and kiln atmosphere) achieved by the ancient potters. Crystalline phases present in a sample are identified based on their characteristic powder diffraction patterns (Garrison 2016, pp. 131–132; Rice 2015, p. 382; Peacock 1970, p. 380). Clay-based ceramic materials commonly contain a large number of mineral phases besides X-ray amorphous phases and therefore yield complicated X-ray powder diffraction patterns. In spite of such complexities, XRD-analysis using advanced software packages has the potential to provide qualitative and quantitative estimates of the mineralogical composition of the samples. Concerning the study of archaeological pottery, XRD remains one of the best techniques used to identify primary constituents, as well as phases that were newly formed during the firing process. X-ray analysis thus provides crucial information on the raw materials used for the pottery, and the firing conditions achieved in the kilns(Barclay 2001, p. 12).Using XRD demands a powder form of samples. Samples first need to be cleaned from any dirt or any weathering products to ensure that the sample is not contaminated. Commonly the outer and inner surfaces of the ceramic object are scraped mechanically. Then the samples have to be ground to a fine powder using an agate mortar and pestle to guarantee homogeneity. Commonly around 10-20mg are needed for the analysis (Cullity 2001, p. 113).

5.4.1 Early Islamic X-ray Powder Diffraction (XRD) Results

The bulk mineralogical compositions of the 88 samples dating to the early Islamic period have been analyzed by X-ray powder diffraction using a Siemens D5000 powder diffractometer at Steinmann Institut, University of Bonn. Diffraction patterns were recorded in the 2θ range from 4° to 70°, with a scanning step width of 0.02° and a 15s counting time per step. The X-ray powder diagrams were processed as follows. In a first step the mineral phases constituting the sherds were identified employing a “Search/Match” routine (EVA V4.1.1 DIFFRAC. Suite, Bruker AXS, 2015), which compares all intensities of the background subtracted X-ray powder diagram with all known X-ray powder diagrams of single phases, stored in the PDF-2 database of the International Centre for Diffraction Data (ICDD). In a second step, the weight proportions of identified mineral phases were calculated with the Rietveld Method (TOPAS V5.0, DIFFRAC. Suite, Bruker AXS, 2014). The results confirm the petrographic observations. The essential mineral phases identified by XRD are quartz, calcite, plagioclase (dominantly anorthite), clinopyroxene, gehlenite, alkali feldspar, muscovite, hematite, spinel, and mullite. The medium to coarse-grained clastic fractions of the early Islamic pottery as determined by microscopy includes mono-mineralogical particles (quartz, calcite, feldspar, mica), fragments of rocks and grog, fossils and remnants of organic matter. These phases show up in the X-ray powder diffractograms of the samples. Apatite $Ca_5(PO_4)_3(OH,F,Cl)$, was detected as a common accessory phase in a number of sherds produced from calcareous clays, which indicates the presence of minute fragments of fishbone.—Among the minerals forming the coarser clastic fraction of the ceramics, quartz preponderates. Due to its durability, abundance and resistance opposition to chemical alteration and mechanical erosion (Deer et al. 1992, p. 466). Concerning the quartz content, the diffractograms show a strong existence of this mineral, almost in all samples, but varying in concentration. , Therefore; the study concentrated on quartz content, regardless if it is a primary component of the clayey materials or added. The concentration of quartz allowed dividing the assemblage into groups; the first contains very high (V.H.) over 40%.

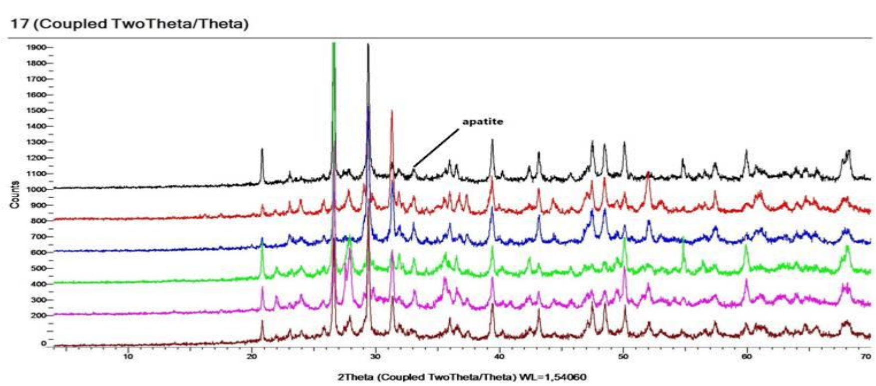

Fig. 5.11 X-ray diffractograms of six samples belong to UQ indicating apatite phases.

This group consists of 26 samples that form around 30% of the whole assemblage. The average of Quartz is 45%, which is rather very high in comparing with other minerals. The result confirms the petrography results, especially when the coarse grain group is concerned. The second group contains high quartz concentration, ranging between 30-39%. This group consists of 23 samples that form about 26% of the assemblage, while quartz average is 34%. The third group consists of 20 samples; all have a moderate concentration that varies between 15-29%, with an average of 23%, which makes about 23% of the whole assemblage.

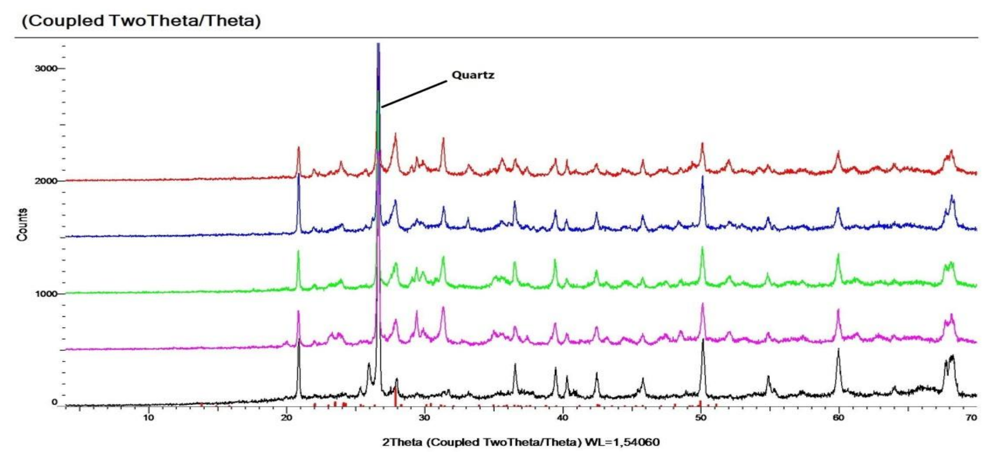

Fig. 5.12 X-ray diffractograms of five samples belong to UJ indicating quartz phases.

The remaining samples belong to the last groups that contain low quartz concentrations between (5-14%). Finally, the last group consists of 16 samples, holding an average of quartz about 9% that makes around18% of the assemblage. Therefore; quartz as a primary component or as the added component has an important rule pottery making. Noticeably; the concentration of quartz corresponds to the function of the objects. Thick bodied pottery objects, like big jars and basins, had a V.H. to H. concentration of quartz. While the concentration of quartz in smaller bodied objects had (M. to L.) concentrations. The study proved that the higher quartz concentrations are related to the higher tendency of having coarser angular quartz grains. The XRD results were confirmed by the petrography analysis observations, which reflect the intentional addition of quartz to manipulate the plasticity. Quartz as other no-plastic materials increases the porosity that eases the evaporation of plastic water and finally reduces the shrinkage ratio. The second most common phase, that diffractograms showed is calcite. Speaking of Calcite, it is one of the most important tempering materials, because of its availability, as well the favored properties, which calcite introduce to pottery, which potters configured by experience. The basic configuration of Northern Jordan crustal is mainly limestone. Calcite is a common mineral phase in Northern Jordan ancient ceramics, which reflects the local abundance of calcareous raw materials used by the potters, and finds its explanation in the widespread occurrence of the Santonian to Maastrichtian age Amman silicified limestone formation, which has a thickness between 50-70m (Bender 1974b, pp.78–79; Barjous 2003, p.40). The main primary sources of calcite are the micritic limestone component, shells, and microfossils. The modal amount and form of calcite in calcareous clay-based pottery provides crucial information concerning the provenience of clay and temper, as well the firing temperature and redox regime prevailing in the kilns (Noll and Heimann 2016, p. 93; Riederer 2004, p. 149; Felts 1942, p. 242). Calcite has been detected in 66 samples, in widely varying concentration. In most samples, the microscopic observations show that in most samples primary calcite has not been preserved but has been decomposed to lime. The calcinations reaction $CaCO_3 \rightarrow CaO + CO_2 \uparrow$ is controlled by two coupled factors, the firing temperature and the redox regime prevailing in the kiln. In an oxidizing kiln, regime calcinations starts already around 600°C, whereas at reducing conditions, e.g. as those controlled by the Boudouard equilibrium $C + CO_2 \rightarrow 2CO$, the reaction proceeds at significantly higher temperature, i.e. at 780°C.

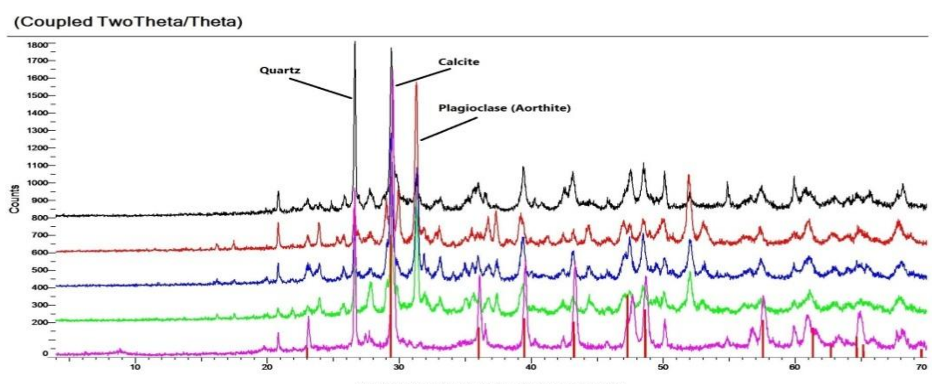

Fig. 5.13 X-ray diffractograms of five samples belong to UJ indicating quartz, calcite, and plagioclase (anorthite) phases.

Commonly the conversion ends around 700°C when all calcite converts to lime. Lime remains stable, until the temperature reaches about 800°C, as below this temperature reactive components, such as silica and alumina are not yet released to allow reactions with CaO. However, if illite is present, a reaction with lime takes place at a lower temperature because illite starts already decomposing around 700°C, the outcome of which is a highly reactive mixture of very fine reactive breakdown components, which eagerly combine with free CaO. As a result, calcium aluminum silicates are formed; first plagioclase, and if the temperature keeps on rising, gehlenite starts forming and eventually above 800°C diopside appears. The modal amount of the newly formed mineral phases, besides the control by the matrix composition, obviously is related to the rise of the temperature. Usually, they increase in modal abundance until the temperature reaches 1000°C. Above this temperature some of the newly formed phases, such as gehlenite may disappear, because they react with the reactive silica released from the decomposing illite, thereby producing anorthite according to the reaction $Ca_2Al_2SiO_7+2SiO_2 \rightarrow CaSiO_3+CaAl_2Si_2O_8$. This reaction causes an increase in the modal amount of plagioclase. As the temperature rises beyond 950°C, gehlenite will be completely decomposed, since this phase acts as an intermediate metastable product. Therefore; since the firing conditions essentially determine the conversion of calcite to calcium oxide, and thus the connected reactions, special attention should be always paid to the control of firing conditions (oxidizing, reducing). Depending on the redox-conditions of the kiln atmosphere, their action path of calcite decomposition differs greatly. If the firing atmosphere is reducing, i.e. when being buffered by the Boudouard equilibrium ($C+CO_2 \rightarrow 2CO$), the calcite breakdown proceeds at a higher temperature around 780°C, and if reactive form calcium aluminum silicates, such as gehlenite and anorthite, with gehlenite being formed at a higher temperature compared to the oxidizing regime. With further temperature increase, the modal abundances of the newly formed phases increase. Obviously, the temperature interval of calcite decomposition between the two firing conditions differs greatly. It is small in the case of reducing conditions, but large at the oxidizing conditions of a kiln open to the influx of ambient air. Understanding the decomposition of calcite thus is a prerequisite for a meaningful estimation of the firing temperature of calcareous-clay-based ceramics because it is very much tied to the CO_2 concentration of the kiln atmosphere. Without reliable constraints on the kiln atmosphere that prevailed during firing, only broad temperature estimates may be obtained for the microscopically ascertained de-carbonation of calcite (Noll and Heimann 2016, p. 96; Noghani and Emami 2014, p. 182). Beyond 950°C gehlenite will be immediately eliminated, and substituted by diopside, a reaction which occurs at around 150°C higher temperature than at oxidizing conditions. Calcite appeared to be present in three different forms as seen under the polarized microscope. (1) Primary calcite: micritic limestone fragment, calcite-crystal clasts, skeletons of planktonic creatures.

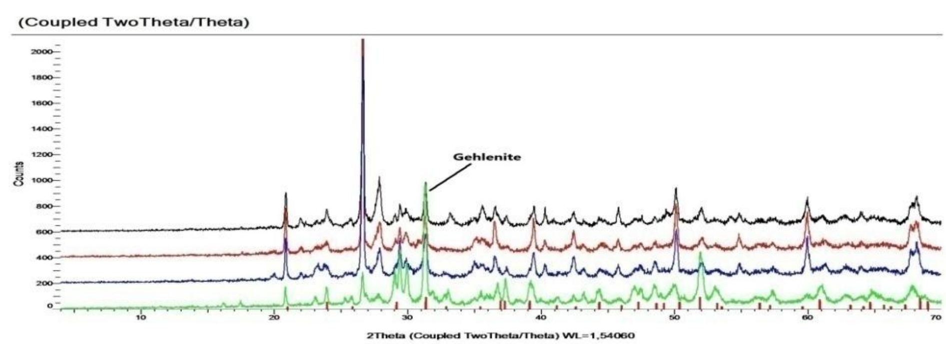

Fig. 5.15 X-ray diffractograms of four samples belong to UJ indicating gehlenite phases.

(2) Secondary calcite: very fine-grained aggregates formed through back-reaction of lime. (3) Secondary calcite coating fractures pores and voids when the sherds were exposed to bicarbonate-aqueous waters at the burial sites. It is important to note that it would not have been possible to identify the form of calcite only by XRD results. Therefore; it is always very important to look at both XRD data and thin-section analysis.

In almost 75% of the early Islamic assemblage, calcite is present but in different forms. The concentration of calcite varies within the samples. Therefore; the same classification and grouping criteria that have been conducted on quartz was followed to defined the calcite contents of the samples Calcite in the (V.H.) and the (H.) concentrations were only found in three samples, one for the (V.H.) and two for the (H.), While 9 samples had moderate calcite concentrations. Both the (L. and S.) concentrations group are composed of 22 and 31 samples respectively. Early Islamic pottery according to the calcite concentrations, around 75% contained this mineral, which suggests the source of the clay materials (calcareous clayey materials). Once more the XRD results confirm the petrography results, which correspond to the local geology.

Twenty-two samples do not contain calcite, which contrasts greatly from the first discussed group. The majority of the samples contain modal contents of quartz, as well as plagioclase. During firing, the non-calcareous clays undergo very limited reactions between 500-1000°C, except for the thermo-sensitive clay minerals, which are subjected to granular alteration (dehydroxylation) without interfering with other components (Noll and Heimann 2016, p. 97). The following charts demonstrate the different minerals constituents of the entire pottery assemblage that were separated into three groups according to the different Islamic time periods. Feldspars constitute a similarly significant group of ceramic constituents. They serve as indicators of clay and temper provenance, as prime fluxing agents (alkali feldspar) or, when newly formed (anorthite), as indicators of the firing temperature. Further important and diagnostic minerals in clay-based ceramics comprise silicates, such as micas, the newly formed pyroxene, gehlenite, and mullite, as well as Fe-oxides (hematite, magnetite) and neoblastic hercynitic spinel. Hematite is present in 43 samples with modal abundance varying between 13 and 1 wt%. Clinopyroxene is present in two samples that had moderate (M.) concentration, while it is present in 10 samples in low (L.) concentration, and in 4 samples in scarce (S.) concentration. The presence of clinopyroxene in calcareous clays is probably formed during firing, which is represented by complex solid solutions that grossly correspond to augite. Gehlenite typically forms as a neoblastic mineral in calcareous clays and furthermore is an important indicator of firing temperature. The existence of gehlenite in 56 samples indicates a higher frequency of using calcareous clay deposits, and it proposes that the pottery has been fired at temperatures between 800-950°C. Mullite occurs in minor proportions as a neoblastic mineral in 33 of the calcite-devoid pottery samples. Mullite typically occurs in clay-based ceramics around 1050°C, when it is formed through the breakdown of kaolinite and illite. It follows that pottery containing mullite must have been fired at a higher temperature compared to the calcareous-clay based pottery.

It is worth mentioning that in some samples mullite occurs only in high-fired grog fragments. In this case, the presence of mullite does not reflect the firing temperature of the pottery.

Muscovite has been detected as a minor constituent in 34 samples, where it probably largely represents the flakes observed under the microscope. Mica is a common constituent of clays, and the low concentration of mica in this group of pottery suggests, that it is primary in origin rather than being added with the temper (Noll and Heimann 2016, p. 35; Rice 2015, p. 85; Deer et al. 1992, p. 288; Maggetti 1982, p. 128). The presence of muscovite suggests firing temperatures below 800°C. It, however, cannot be excluded that the more reactive micron-sized illite fraction in the fine ceramic matrix of these samples has already reacted out.

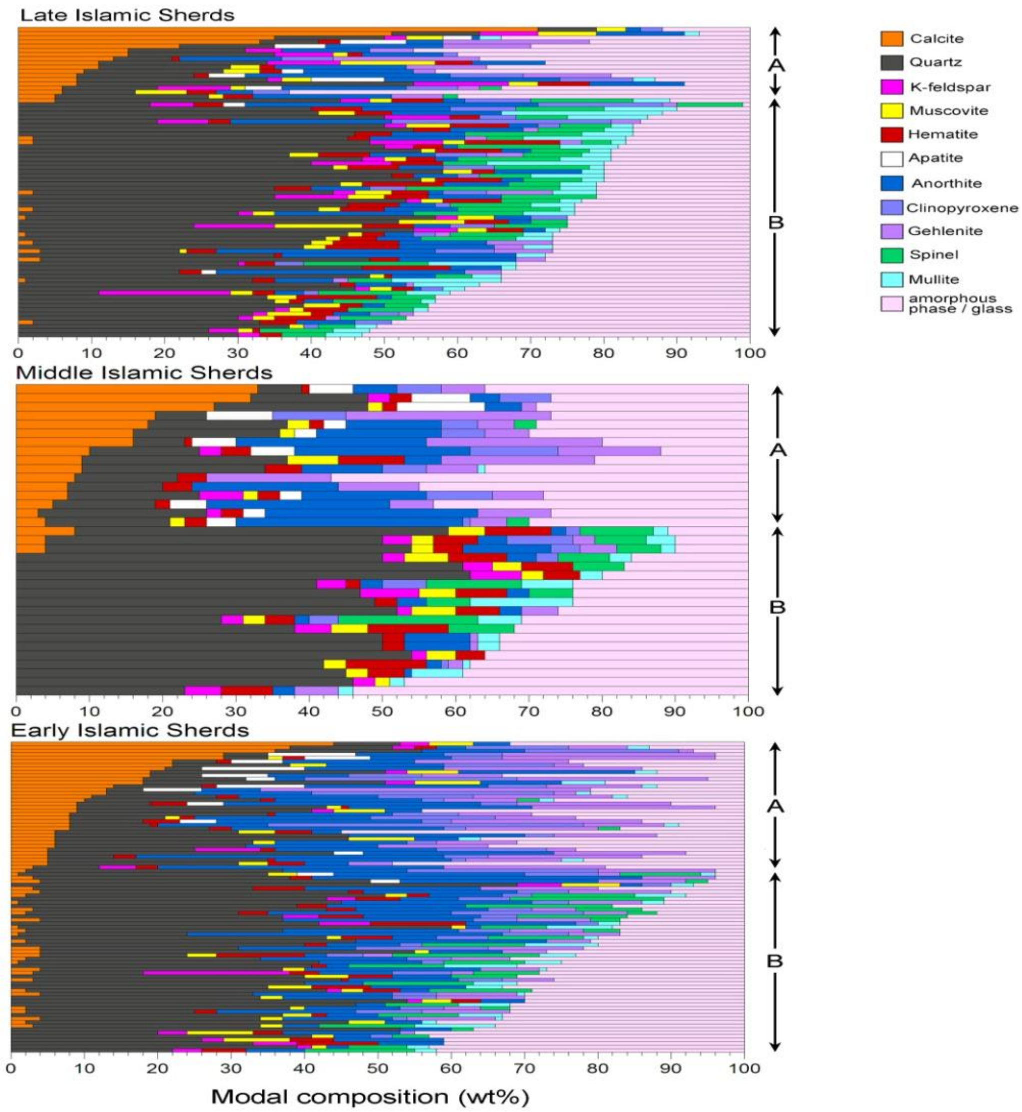

Fig. 5.16 Modal compositions charts of the different Islamic time periods showing both calcareous and non-calcareous pottery samples from the three sites.

Plagioclase of anorthite end member composition is present in all calcite-bearing pottery samples with modal abundances ranging between 43 wt. %. In this calcareous-clay-based pottery, plagioclase occurs exclusively as a neoblastic phase in the fine-grained ceramic matrix, indicating firing temperatures in excess of 800°C. Contrasting to this, plagioclase exhibits intermediate compositions and occurs mostly as mineral clasts or as a constituent of lithic fragments below 800°C. It, however, cannot be excluded that the more reactive micron-sized illite fraction in the fine ceramic matrix of these samples has already reacted out. Plagioclase of anorthite end member composition is present in all calcite-bearing pottery samples with modal abundances ranging between 43 wt. %. In this calcareous-clay-based pottery, plagioclase occurs exclusively as a neoblastic phase in the fine-grained ceramic matrix, indicating firing temperatures in excess of 800°C.

5.5 Micro-structural analysis (SEM) of Early Islamic:

The Scanning electron microscopy (SEM) is a powerful tool in the identification of the mineralogical and the chemistry of all pottery samples. SEM provides elemental and mineralogical qualitative and quantitative information on the pottery composition. Besides allowing close visual inspection of the microstructural characteristics through amplification of the sample, which may reach up to 100000 times? The main advantage of SEM is the possibility of analyzing the amorphous phase, and pore structures, which occur as a result of vitrification extent. Furthermore; the chemistry of the matrix can be investigated as well, by using the connected Energy dispersive X-ray system (EDX). SEM basic principle relies on viewing the samples through a sequence of lenses that amplify the visible light image. Keeping in mind that SEM does not offer a true image, but it rather fabricates an electronic map of the samples, which is projected on a cathode ray tube.

Using SEM for the examination of polished sections through the body and the surface of a pottery specimen provides valuable information regarding the raw materials utilized to the production. Additionally; it permits quantifying almost all the elemental constituents, and any surface treatment (Orton and Hughes 2013, p. 183; Tite 1999, p. 187). The chemical compositions and the complex body structures, of any kind of pottery, have become understood as a result of using SEM. The elemental composition of pottery is complicated. Therefore; to understand the existence of an element, a translation of the elemental composition to the mineralogical composition is needed. The translation eases the understanding of the results. For example, aluminum, potassium, magnesium, and titanium all are driven from the clayey, while silica and calcium are usually belong to the tempering or inclusions materials. (Orton and Hughes 2013, p. 184). On the other hand, SEM allows insights deep into the pottery fabrics by combining the visual aspect with the elemental composition. Nevertheless, SEM due to the logistical and technical reasons, besides the labor intensive, only a few representative samples were carefully chosen to be analyzed by this technique.

5.5.1 Early Islamic scanning electron microscope (SEM) results:

The chemical composition of the early Islamic samples proved that both calcareous and non-calcareous clay deposits were used to fabricate the pottery samples. Silica is the major element in the 17 early Islamic period samples. The silica concentration ranges between 19-30 wt. % and the average of 25 wt. %.

The second major element is aluminum Al ranges in concentration within all the samples between 5.7-8.5 wt. %, as the average is almost 7 wt. %. Calcium Ca, the content seems to be very low, since 4 samples had contained Ca in less than 1 wt. %, while the rest of the samples

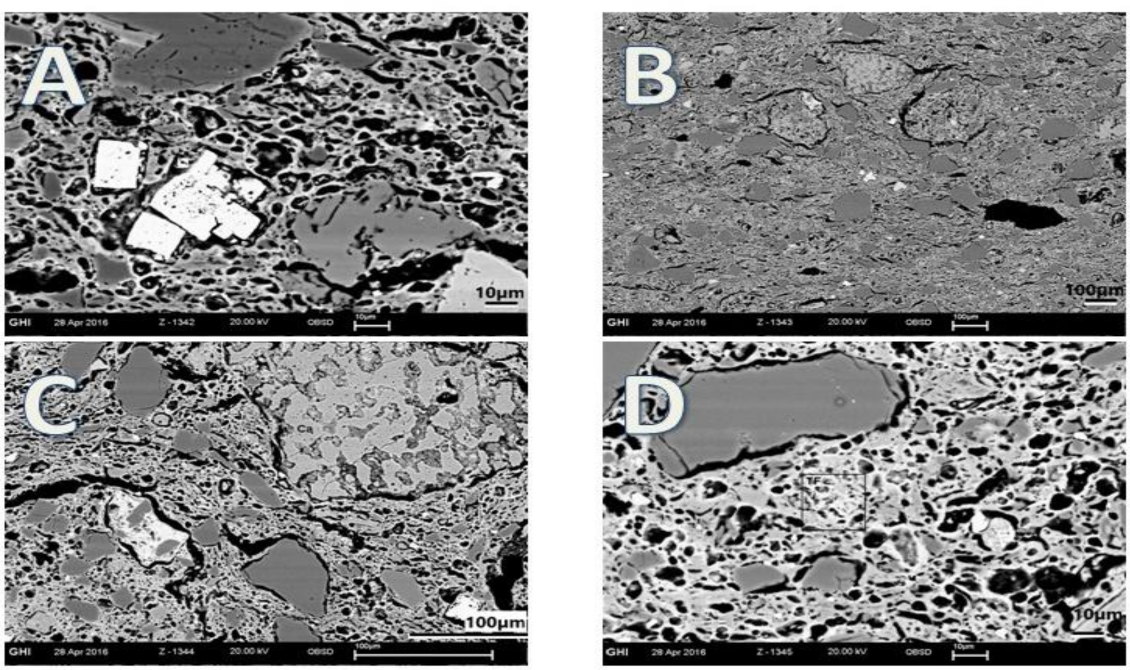

Fig. 5.17: SEM micrographs showing the microstructures and the major matrix constituents. A: angular quartz and calcite clasts. B: distribution of the additives within the matrix. C: matrix different micro-cracks. D: the pores size over 10 µm.

contained a bit higher concentration, although it was not high enough to suggest calcareous deposit.

Only 4 samples have had Ca between 5-7wt. % and the majority had it in less than 5 wt. %, and over 1 wt. %. The Ca average of all samples is less than 3 wt. %. Generally; the other minor elements in the entire samples had scarce concentrations. Fe and Mg are present in the entire samples in an average of 1.5wt.% Fe, and 0.8wt.% Mg, whereas only 4 samples had a very scarce concentration of potassium K, and the other 13 had both potassium K and sodium Na in a very scarce concentrations. The average of K in the first 4 samples is 0.8wt. % and the average of K/Na content for the other 13 samples is 1wt. %.

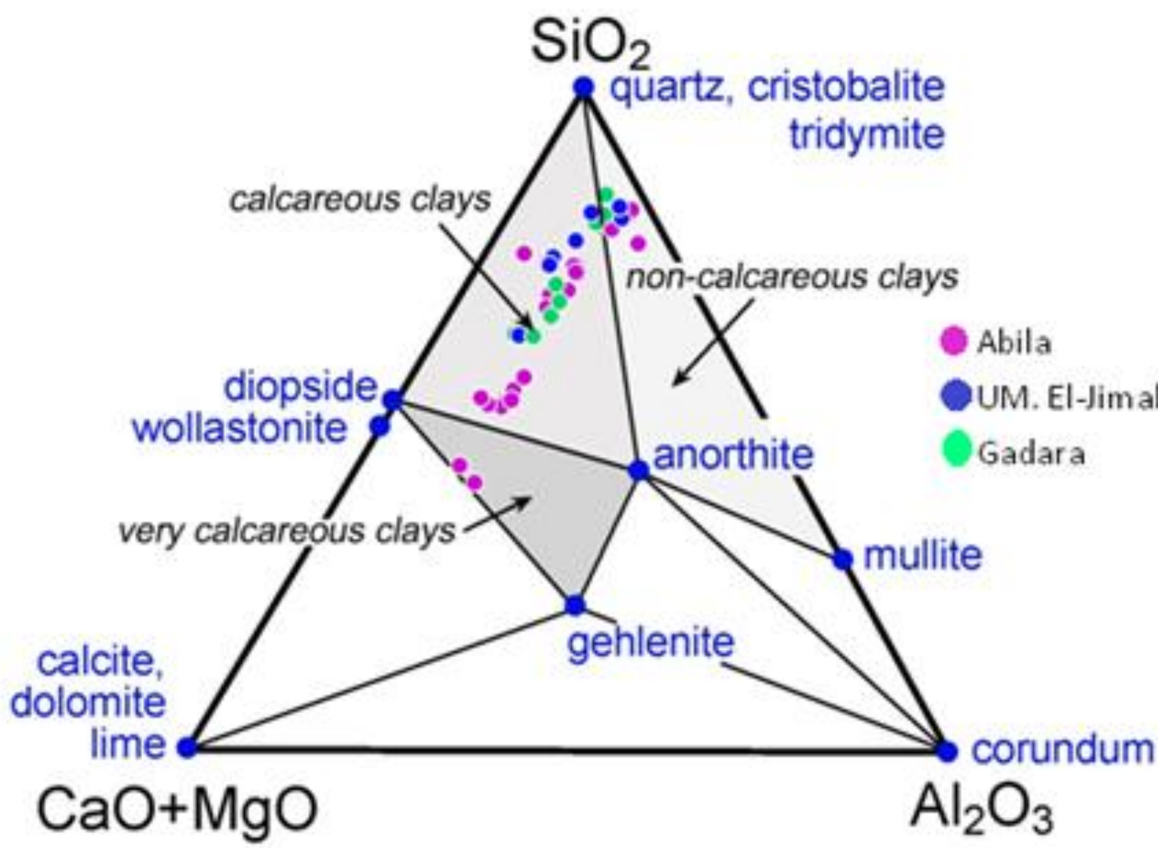

Fig. 5.18 Ternary diagram showing the major element compositions of the three studied sites ceramics indicating calcareous clayey materials mainly, except few samples manufactured from non-calcareous clay.

Assessment of the pottery matrix assembly of the entire pottery body points out that there is a little chemical divergence in any of the samples. I believe that these changes are owing to the amount and nature of the tempering materials. As addressed earlier, the Si/Al ratio provides data concerning the clay type utilized to produce clay matrices. The chemical and the petrographical analysis, of the early Islamic pottery assemblage, proved that the frequently utilized clay materials for the production of the pottery matrices were illite and calcareous illite clays, usually were tempered using diverse materials, such as coarse fragments of chert, quartz, and feldspars in some cases, and with organic matter in the others. The quantity of the fluxes, that were identified in the clay to produce the pottery assemblage such as, alkali earth, alkali and iron oxide exceeded 15 wt. % in the non-calcareous and the low calcareous illite clay, while in the calcareous illite clay the amount attained 40 wt. %. The clayey materials are usually tempered using diverse non-plastic materials. The following ternary chart demonstrates the distribution of the studied samples related to their chemical compositions. Generally; clayey materials contains a quantity of flux, such as alkali earth, alkali and iron oxide. whether in non-calcareous or in low calcareous clayey materials, the number of fluxes exceeded 15 wt. %, while in the calcareous illite clay the amount attained 40 wt. %. Therefore; the non-plastic inclusions and any organic matters as tempers added to the clayey materials supplies hardness and preserve the shape of the pots while firing. Experimental archeology has shown that the plaster structure does not show any change in structure at firing temperatures ranging from 850-1050 ° C.

5.6 Petrographic Characterization (Thin-Section) of the Middle Islamic Pottery:

To portray the mineralogical composition of the middle Islamic ceramics, the fine-grained clay matrix should be differentiated from the coarse-grained matrix. In some cases, it is hard to differentiate whether the coarser grains were intentionally added as a temper, or naturally driven from the clay deposit. The middle Islamic assemblage has been distributed into two groups, according to the petrographic identification. The description of each group was possible, after defining the main constituents of the pottery assemblage. Therefore; the distinction was made by observing each group characteristics, so far depending on the size of the additives. Petrography helped in determining the manufacturing technology and the contents, which illustrated the characteristics of each group. It would not have been possible to locate the relation between both groups throughout the entire time Islamic time period without such information. (Doménech-Carbó et al. 2009, p. 3; Reedy 2008, pp. 146–148; Whitbread 2003, pp. 6–7). Petrographic analysis revealed that quartz, calcite, grog, basalt, organic matters (chaff), and fossils (shell) are mainly the non-plastic materials present in the middle Islamic samples. The total number of the middle Islamic samples was 35 samples, the assemblage consisted of 12 mono-glazed green wares, 9 polychrome wares, 11 handmade geometric ware (HMGP), and 3 coarse plain wares. All the samples belong to Gadara and Abila, besides two samples were added to the assemblage, one from Hubras mosque excavation, and the other is from at-Turra survey 2010, the intention of this addition was to have a better view for the whole region. While the survey did not reveal close to Umm al-Jamal any Middle Islamic pottery, except for early Islamic pottery and only one piece of the Islamic period.

The archaeometry approaches that were utilized to conduct the analysis of all samples, did not focus on the glazed layers of the samples, because the glazed layers are out of the limits of this study, therefore; this study just documented the glaze layers by thin-section micrographs. As known, quartz is the most dominant and frequent non-plastic materials in pottery, all the samples exhibit quartz in varying concentrations, so far, it was possible to divide the assemblage into 4 subgroups according to their quartz concentration. The first subgroup consisted of 16 samples all characterized by (V.H.) quartz content, the average of quartz concentration within this subgroup is approximately 50%. The rest of the non-plastic materials such as plagioclase, chert, and organic materials if present, they hardly form between 10-15% of the whole volume of the sample. the sizes and the shapes of the non-plastic materials clasts were as fine, medium, and coarse, rounded to sub-rounded for the fine clasts and medium-size clasts, whereas the coarser are angular to sub-angular. The indication of the clasts, suggests, that fine and medium clasts were naturally introduced clasts in the clay materials, while the coarser size clasts, probably have been added by the potter, or did not travel enough from the mother rock, in order to lose their angularity. While the second subgroup consists of only one sample that had high quartz concentration, therefore; it would not be meaningless to enter this subgroup in the comparison study. The third subgroup consists of 11 samples; all are featured by their medium (M.) quartz concentrations, besides the compatibility of the forms of the clasts. The average content of quartz in this subgroup is about 21%, mainly characterized by sub-rounded to sub-angular clasts that likely suggest natural accumulation. Finally, the fourth subgroup consists of 6 samples, all of them had almost fine rounded quartz clasts, the average of quartz is about 10%, while the major non-plastic materials present in this subgroup is not quartz, and it is rather calcite.

Hematite, calcite, and plagioclase are mainly the major additives or natural accumulated materials, besides some chaff remain either as transformed organic matters, due to the firing process, or as elongated pores with rounded tips. Hematite was detected or observed as blackish or brownish reddish stains, under the polarizing microscope, which was also proved by XRD and SEM-EDX results. The average content of hematite in all subgroups ranges between 7-3%. The other major content is calcite; it is present in 19 samples in its three major forms as described in the previous section 5.4.1. The average of calcite is 13%, which indicated by Petrography observations that proved 15 out of the 19 samples had calcite as a major constituent. Regardless; both were added intentionally and driven from the clay source. The significance is important an abundant amount of different micro-fossils were present in many samples, such as foraminifera, shells, etc.

While in many samples undisturbed calcite was identified, which indicates low temperatures fired pottery. The second subgroup is characterized by calcined limestone that was easily differentiated by the polarizing microscope. Secondary calcite has been detected in some samples along the cracks and pores, and sometimes as a crust covering the interior and exterior surfaces, but this form of calcite was removed to exclude any contaminations if possible.

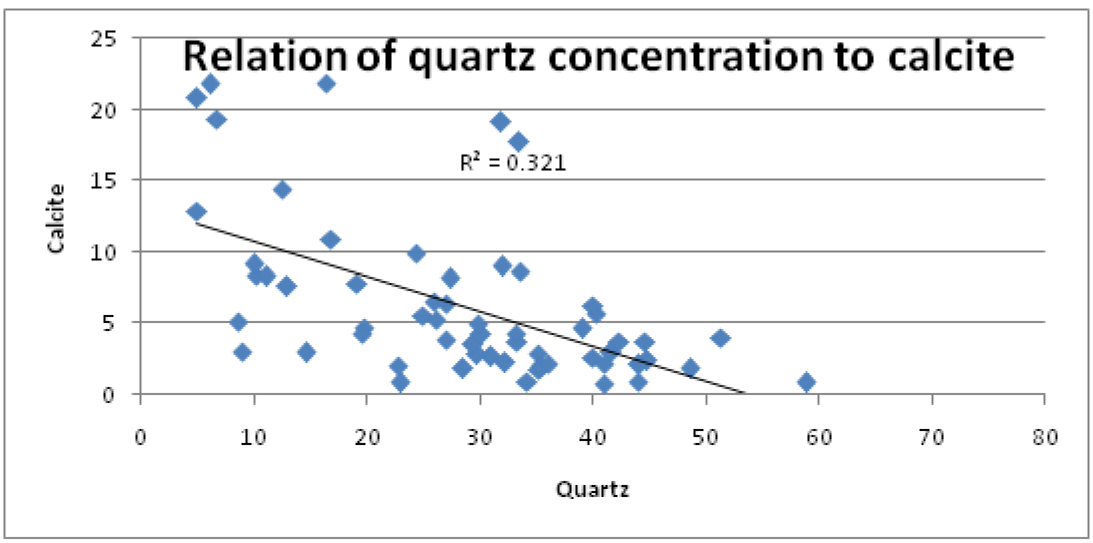

Fig. 5.19 The chart demonstrates the reverse ration between calcite and Quartz.

The common sense relation between calcite and quartz is very clear in the samples, whenever there is a high content of quartz in any of the samples; a low or scarce content of calcite is most probable and vise versa (inverse proportion). As quartz and calcite are the major additives, the following chart corresponds to the correlation between both of them in the samples. Besides quartz and calcite other coarser non-plastic materials are present in the samples, such as chert, basalt, quartzite, sandstone, and grog. Generally; they have different forms of clasts that range from fine to coarse.

According to the aligned internal structure of grog, which are parallel to the surface of the pots, and as well as their internal fractures, which are parallel to the longest length of the fragment, grog has been differentiated from clay lumps (Herbert et al. 2010, p. 5; Shepard 1985, pp. 406–407). The use of coarse angular grog, and basaltic fragments, besides the coarse sub-angular quartz, and micrite limestone, all indicate that these materials were artificially added to the paste. Since all of the tempering materials are present in the local geology of the region, most probably pottery was locally made. The contrast of the sintering processes and the identification of other aspects like calcined limestone clasts or detecting any partial diffusion of k-feldspars, or the development of mullite all were in focus, in order to reconstruct the initial firing temperatures (Noll and Heimann 2016, p. 29; Tite 1992, p. 124). It was possible to reconstruct the initial firing temperature range of most of the samples. According to the presence of mullite ($SiO_2 - Al_2O_3$) in 15 samples, it will be safe to suggest that the initial firing temperature of those samples ranges from 1000-1100^oC. Certainly, mullite was not observed as a major phase in the matrices of the samples, but in rather enough quantities to be used as an indicator of the firing temperature. In fact, mullite develops in two forms; mullite (2:1) that consists of a double ratio of SiO_2 according to the ratio of Al_2O_3, and mullite (3:2). The first form requires a firing temperature of less than > 1000 °C, while the second requires higher temperatures but less than > 1200 °C. Noting that the firing conditions could decrease the needed range approximately between 950 - 1000 °C (Reedy 2008, p. 118; Duval et al. 2008, p. 31; Noll 1991, p. 105). It is worth noting, that mullite is the byproduct of muscovite, and as temperature increases, the matrices starts to darken, which as a result lowers the birefringence, and if muscovite is present at about 800^oC, it starts transforming to mullite. It starts first developing bubbles inside the crystals, and as the temperature reaches around 1000^oC transformation ceases since all the crystals of muscovite had been transformed to mullite (Duval et al. 2008, pp. 28–29; Cultrone et al. 2001, p. 624). At last but not least, phyllosilicates in the matrices disappear at a higher temperature, leaving pseudomorphs after the former crystals. Usually, if the firing temperature crosses1100^oC, an empty space with dispersed grayish remains at the pore edges reflects, that calcite was originally present. Micro-cracks also starts to disappear, due to extended vitrification, but pores remain abundant and acquire new spherical form rather than ellipsoidal. While the orientation of the residual temper grains in planes parallel to the brick largest faces remains undisturbed (Riederer 2004, p. 157; Cultrone et al. 2001, p. 624; Tite 1992, p. 115).

5.7 The Middle Islamic X-Ray Diffraction (XRD) results:

XRD results confirm the petrographic observations. Since the entire medium to coarse-grained clastic fractions determined by microscopy includes mono-mineralogical particles (quartz, calcite, feldspar, and mica), fragments of rocks and grog, fossils, and remnants of organic matters all have correspondence phases in the XRD data. The essential mineral phases identified by XRD were all the same as the previous time period.

These phases show up in the X-ray powder diffractograms of the samples. Apatite $Ca_5(PO_4)_3(OH,F,Cl)$,was detected as a common accessory phase in a number of samples produced from calcareous clays, which indicates the presence of minute fragments of fishbone. Furthermore calcium phosphate could direct us to the source of the raw materials since it is one of the heavy minerals present in the rocks. Also attention should be paid for the other source of apatite that takes place due to the tendency of fired clay to absorb it from the soil. Amazingly; the presence of CaO in quantity over than 2% only, increases the possibility of having apatite. The porosity of the pottery sherds decides the quantity of apatite accumulations. The higher the porosity is reflective to the higher quantity of accumulations (Freestone et al. 1985, p. 173). The soil of the hinterlands of Abila and Gadara is well known for its fertility. Up to today many types of crops are being planted in that region; some annual plants like cucumber, tomatoes, okra, check-pea, and many others, as well as many groves like olive, grape, peaches, etc. It's worth to note that entire the Middle Islamic samples were collected from both sites.. Sanidine ($(K,Na)(Si_3Al)O_8$), 5 samples out of the Middle Islamic assemblage contained sanidine, which forms at a high temperatures over than 1000^oC, as a result of microcline decomposition, if it is present in raw materials. Sanidine occurs only if the cooling rate post firing is constant and very slow (Riederer 2004, p. 147; Cultrone et al. 2001, p. 624; Molera et al. 1993, p. 489). As expected, quartz preponderate the non-plastic materials, the average content of this mineral according to the quantitative XRD results indicate varying concentration. According to quartz content, the middle Islamic period samples can be divided into 4 subgroups. The first subgroup contained (V.H.) quartz concentration; it consists of 16 samples what equals to around 45% of the assemblage. The average of quartz in this subgroup is about 50%. The second subgroup unfortunately consists of only one sample, which has a (H.) quartz concentration, therefore; it was not possible to make any calculations, in order to draw any results. The third subgroup characterized by (M.) quartz concentration, this subgroup consists of 12 samples, which presents around 34% of the assemblage. Finally the fourth subgroup consists of 6 samples; all of them have had (L.) quartz concentration, which represents 17% of the assemblage, with an average of 10%. There is an abundant amount of Calcite present in Northern Jordan as limestone. Therefore; the ancient Islamic potters took advantage of the most abundant mineral in the region. Besides; the favored physical properties that introduces to pottery. Calcite has been detected in 19 samples what equals to 54% of the assemblage in varying concentrations, with an average of 13%, thus XRD results go along with the petrography analysis results. Plagioclase feldspars, and alkali-feldspars, are among the non-plastic group. Plagioclase; anorthite is the dominant form of plagioclase, it is present in almost all samples in an average equals to 15% of the entire non-plastic materials, while alkali-feldspars represented by microcline, sanidine, and anorthoclase, equal to 12% only. Obviously, the quantitative result of the XRD assured that plagioclase feldspars are more common, comparing with alkali feldspars, since the earliest group have been present in all samples, while the second group appeared to be only in 13 samples, regarding the concentration, the average of the first group makes up about 17%, while the second is only 12%. Muscovite and hematite are present as well, but in minor concentrations, hematite is present in 32 samples, with an average of 5%, while muscovite is present in only 20 samples, with an average of 4%. Finally, gehlenite and diopside both minerals are byproducts used as good indicator to the initial firing temperatures and the type of clayey materials. Gehlenite phase has been detected in 22 samples, with an average of 9%, while diopside is present only in 7 samples, with an average of 10%.

5.8 The Middle Islamic scanning electron microscope (SEM) results:

Both calcareous and non-calcareous clay deposits were common in use all over Northern Jordan, but the first type has been intensively utilized comparing to the second. The availability and the workability of the calcareous clay deposit, has been behind the intensity of consuming calcareous clayey materials. Especially when discussing the Middle Islamic assemblage, because of the high frequency of using it. During this period surface decorations were very much in common, whether as painting or burnishing or slipping, or glazing. Therefore; calcareous clayey materials are preferable because of their ability to display surface decorations. Fabricating decorated pottery vessels needs highly skilled potters. During the middle Islamic period, the demand for decorated pottery vessels increased. It became fashionable to have highly decorated pottery vessels, which encouraged the potters to be more innovative. Noticeable practices have been introduced to supplement higher quality decorated vessels. For examples, the additions of a microfilm of a lime wash as a slip over the exterior and the interior surfaces of the pottery vessel that are to be glazed. This practice allows the glazed layer color to be more prominent. By using optical microscopy or SEM such a practice is easily distinguished. The SEM/EDX authorized a comprehensible look through the major and minor constituents of the specimens, besides intelligible view at the non-plastic materials particle sizes, the matrices particles sizes, and the porosity shapes and sizes. 7 samples belong to the Middle Islamic period have been intensively investigated by this technique, samples were chosen from two wares, HMGP, and mono-glazed ware. The results showed that Si was the major element, which was proved by thin-section and XRD analysis, as Si enter the configuration of many minerals. The Si particles are ranging in size from (5-400µm), while the particles of the matrices range between (5-10µm). Both samples AB509 and AB152 had mullite network as the main phase in their matrices, which suggests a bonding phase that enhances the durability of the pots. The interlocking cuboid mullite network structures probably have been favored by ancient civilizations, due to the strength that it adds to pottery. At the same time, mullite has the capability of reducing the thermal expansion, rising the thermal shock resistance, and higher the creep resistance (Martinon-Torres and Rehren 2009, p. 58; Aksay et al. 1991, p. 2349). Mullite in alkali-rich areas caused by molten feldspars indicates a sustained firing temperature between 1000-1100^{o}C (Aksay et al. 1991, p. 2350). The porosity differs from one sample to the other, but in all samples, it ranges from (10-500µm), whenever the sintering is higher (higher temp.), the extent of the glass phase increases and porosity decreases (Tite 1992, p. 115). Therefore; the size and shape of the pores absolutely rely on the firing temperature attained, which as a result produces the amorphous phase. Subsequently controls the size and shape of the pores. Generally; porosity micro-cracks reduction is pragmatic at a higher temperature, because the vitreous phase partially fills up the pores, and continues accumulation until the raising of temperature ceased (Cultrone et al. 2001, p. 626).

Three types of microstructures have dominated the matrices, which are homogenous, heterogeneous, and bimodal. The main factors that affect the microstructures of the matrices are the type and size of the non-plastic materials present in the pottery. Besides; the homogeneity of the raw materials mixture prior to forming, the function of the pottery object, and finally the firing temperatures all are among the factors too. Area analysis (chemical bulk analysis) by means of EDX proved that as expected Silica is dominant, the average of Silica equals to of 20 wt.%, while aluminum Al average is 8 wt.%. Calcium Ca, the content varies within the samples, three samples had a concentration over 5 wt.% and less than 9 wt.%, while the other four samples contain Ca in the portion less than 5%, and only one sample AB152 had a very scarce concentration (0.6 wt.%). Prior drawing any results, the upper crust of north-west Jordan is well know by it is high content of calcium carbonate, therefore; it is not surprising to determine Ca in most of the samples, even though the concentration does not seem to be high enough, but it still reflects the local geology, except for sample AB152, that contains less than 1 wt. % Ca, which most probably was made out of non-calcareous clay materials. Generally; the 7 samples contained Fe, Mg, and Na+K, in low concentrations, the Fe average content is 1.78 wt.%, the Mg average content is 0.65 wt.%, and Na+K average content is 1.2 wt.%. Assessment of the pottery matrix assembly of the entire pottery body points out that there is a little chemical deviation in all samples. The deviation might be an outcome of the amount and nature of the tempering materials. As addressed earlier, the Si/Al ratio provides data concerning the clay type utilized to produce the matrices. The chemical and the petrographical analysis, of the Middle Islamic pottery assemblage, demonstrate the common consumed clay materials. Most probably it was calcareous illite, besides miscellaneous tempering materials, that added favored properties to Middle Islamic Northern Jordan pottery. Fluxes like alkali earth, alkali and iron oxide, had scarce average equals to 3.65 wt. %. This average demonstrates that CaO might have had the same role of the flux in the texture of pottery, which is very important for the vitrification process, and the reduction of the neighboring iron ions, due to piercing into spinel network and the release of FeO (Noghani and Emami 2014, p. 181; Meegoda et al. 2008, p. 8).

5.9 The Petrographic (Thin-Section) Characterization of the late Islamic Pottery of Northern Jordan:

Petrographic analysis of 74 Late Islamic period pottery sherds had been conducted to define the crystalline phases. The samples were selected carefully to be representative of the different pottery wares see Appendix C (Shepard 1967, p. 477). Essentially; as the previously discussed time periods, the assemblage contained both fine and coarse grain sizes, in some samples the distribution of the crystalline grains were almost equal in the matrices, while in other samples, it was heterogeneous. Both types (fine, coarse), demonstrate the technique utilized for the production, which suggests wheel thrown for the first type, and hand-made for the second. The porosity differ, pores which are isolated and close, indicate higher firing temperatures, and on the contrary, connected open pores, indicate lower firing temperatures (Riederer 2004, p. 157). Based on petrographic observations, quartz, as usual, is the main tempering materials, was three different magnitudes of quartz clasts have been identified. Perhaps the coarser clasts size, which is characterized by sharp and angular edges or sub-angular edges were crushed, then added as temper, while the medium and the fine clasts propose sedimentation. Most probably they were part of the source of raw materials. The observations of some quartz grains in some of the samples showed small size angular quartz clasts that could be attributed to grinding actions. Or as weathering clasts that did not travel only for short distance from the mother rock. Both case, small angular quartz may improve the mechanical correlation between quartz grain and clayey minerals, what is usually pursue by interface increasing. Furthermore; small size grains control the tension effect, which arises from polymorphic transition of quartz (α-quartz to β-quartz and vice versa) at 573°C (Felts 1942, p. 241). Closer inspections of any volumetric changes in the small size quartz grains didn't reveal any tension, which may introduce micro-cracks. The mechanical behavior of quartz-calcareous clay system is very responsive to the proportion of quartz inclusions. If the fractions are makeup less than 10 %, the system acts as a normal brittle ceramic, while at higher quartz content the material exhibits significant energy decadence (toughening) during fracture (Kilikoglou et al. 1998, p. 274). According to the concentration of quartz, four subgroups have been distinguished, the first subgroup consists of 30 samples, all of them had quartz concentration over 40%, while 50% of this subgroup samples belong to Abila, and the other 50% is from Gadara. The coarser quartz clasts of this subgroup are characterized by sharp and angular or sub-angular edges. Thus; signifying that quartz most likely was ground prior adding to the raw materials mix. The moderate and the fine quartz clasts are characterized by rounded to sub-rounded edges, symptomatic of natural sedimentation (inclusion). Adding such a high concentration of quartz to the raw materials mix probably has been intentional to improve the physical properties of the pottery, especially the durability. The second subgroup consists of 19 samples all of them had different sizes of quartz grains, as the previous subgroup. According to the number of the samples of this subgroup, exactly 50% of the samples belong to Abila and 50% belong to Gadara. In my understanding, this is attributed to the technology of production in both sites. Another possibility would be sharing the same raw materials deposit or produced at the same shop. Abila and Gadara are side by side the distance between them is less than 15km. Both sites belong to the same geological zone. Which is obvious due to the similar mineralogical composition? Generally, both sites mineralogical composition is in harmony with the petrologic nature of the direct vicinity of the sites. Quartz is the major phase of both sites pottery assemblages, suggesting intentional addition rather than naturally occurring. The high concentrations of quartz contradict the geology of the area. The study area is dominated by limestone rocks. Therefore; assuming that skillful potters by experience knew the benefits of adding more quartz to the mix to have a higher durable pottery is safe. The homogeneity nature of the forms and the compatibility of pottery composition suggest the existence of interregional centers for pottery mass production of daily use. Some samples contain clasts of metamorphic rocks and sandstone. As in fact, potters were dependent on the local wadi sands, as the main source of their raw materials, and different proportions of the local non-plastic component. Therefore; the presence of sandstone and metamorphic clasts indicates that they were imported. Which proposes Jarash as the origin of the samples? The size and the ratio of the non-plastic clasts correlate to the size of the pottery pot body. Consequently; bigger pottery bodies do not require sieving of the wadi silty clayey materials, while smaller pottery bodies require sieved silty clayey materials (Gilead and Goren 1989, p. 7).

A diverse number of inclusions and tempering materials have been identified by polarizing microscope. Different magnifications were utilized to observe the different properties of each type, such as basaltic clasts, clinopyroxene, a wide range of micro-fossils, pottery fragments (grog), and chaff. It is worth noting, that large clasts of quartzite have been observed in few samples, which point's metamorphic rocks zone.

5.10 The Late Islamic X-Ray Diffraction (XRD) results:

XRD analysis is highly valuable for studying the different pottery wares, especially when speaking about highly fired wares. This method allows insight at all the new artificial minerals that have developed in the fabric. The diffraction patterns may possibly be an idyllic mode that provides fingerprints of the origin for different pottery (Peacock 1970, p. 380). Nonetheless, even though the method allows approaching all the crystalline substances in the matrix, it remains powerless in replacing petrography analysis, since it can't provide data concerning the distribution of different minerals in the paste, which is perfect to obtain fingerprints about the manufacturing techniques. The major detected minerals in the Late Islamic samples, according to the result of the XRD analysis, are quartz, hematite, calcite, anorthite, augite, diopside, microcline, apatite, and spinel. Quartz; it has the most intensive peak of the samples that indicates the higher concentration. Likewise, quartz phase (2Ø) usually overlaps with mullite phase (2Ø), nevertheless, mullite has not been observed in high concentration in most of the samples that had mullite as one of the main phases. The maximum mullite concentration was observed in sample UQ7, it is about 22%, while the rest of the 45 samples that had mullite have an average of 6% only. It would be safe to mention that mullite has been located by thin-section analysis in some of the grog fragments only, which indicates the initial firing temperature of the grog fragments not the real firing temperature of the vessel. Therefore; it is important to link thin-section analysis with XRD results before interpreting, since both techniques fulfill each other (Reedy 2008, p. 118). Anorthite proved to present in 51 samples as one of the major constituents, either as primary anorthite from the raw materials, or as secondary product obliged to form at a higher temperature around 900oC, but only in a rich lime+silica matrices (Cultrone et al. 2001, p. 624). The average of anorthite within the 51 samples is about 11%, while the maximum concentration that has been detected was in sample UQ135; the sample contained around 40% anorthite, which means sufficient firing and high concentration of lime+silica. The second major byproduct is gehlenite ($Ca_2Al_2SiO_7$), this mineral was detected in 26 samples with varying intensities. Gehlenite (a melilite-group phase) starts forming at about 800 °C, with the presence of calcite and quartz, the intensity of gehlenite increases as the temperature reaches 900^{o}C but starts decreasing beyond this range (Noll and Heimann 2016, p. 29; Cultrone et al. 2001, p. 624). Out of the 74 samples that make up the Late Islamic assemblage, only 29 samples contained calcite, although the geology of the study areas is mainly made up of limestone, the low intensity could be attributed to the early decomposition of this phase. The presence of CaO in the matrix while sintering reduces the surface tension of the amorphous phase, which makes it trouble-free to diffuse in pores (Hara et al. 1991, p. 833). The incidence effect of the CaO goes beyond the surface tension, because CaO has fluxing capability, which indicates its role in the texture of the pottery (vitrification process), as well as CaO, reduces the adjoining iron ions when penetrating into spinel network, which releases FeO, besides the effect of CaO on pottery colors (Meegoda et al. 2008, p. 8).

Hematite was detected by XRD analysis in 64 samples. This mineral is responsible for the red to brown colors, besides gray and bluish-black colors. The colors are usually determined by archaeologists' using Munsell Soil Color Chart. Both Iron oxides hematite and magnetite reacts differently to the firing atmosphere. Reducing conditions produce dark bluish-black or grayish pottery. (Maritan et al. 2006, p. 7; Nodari et al. 2004, p. 120). Hematite varies in concentration within the assemblage, the maximum concentration is 13%, while the average of hematite in all samples is 5%, it is worth noting that iron also acts as a flux helps in vitrification processes (Maritan et al. 2006, p. 12). Diopside as gehlenite usually starts forming in a calcareous illite matrix at about 850-900^{o}C and reaches its maximum at about 1100^{o}C, but if the temperature continues increasing beyond the 1100^{o}C diopside decomposes (Noll and Heimann 2016, p. 29). Only 12 samples had diopside in minor concentrations, they had 5% average of diopside. Therefore; it is wiser to use other byproducts more common in samples for drawing results.

5.11 The Late Islamic Scanning electron microscope (SEM) results

SEM analysis did not add that important information regarding the specimens, except for the microstructure of the matrices. Thus it confirms the previous results conducted by petrography and XRD. The microstructure results proved that pottery vessels were produced using similar techniques, such as the processes of preparing the main ingredients, the methods used for forming and firing, and finally finishing. Correspondence of the analytical techniques has been almost ideal, bearing in mind the special capability of each of them. There is a slight difference between the samples, which was also confirmed by SEM. The differences could be attributed to the raw materials such as; the type of inclusions or tempering materials. The samples matrices inspection had revealed an amorphous phase, which is a result of high firing temperature in an oxidizing atmosphere. Such conditions permit the fast diffusion of oxygen into the matrix in the final stage of firing. therefore; secondary SiO_2 forms a passive layer preventing the continuation of the oxidation process, which preserves the amorphous phase in the matrix (Noghani and Emami 2014, p. 182). The main positive benefits of using multi-techniques are a).

confirm the results. b). make use of each technique advantages. c). conclude data that interpret the aims of the study.

Six samples from the Late Islamic period have been analyzed by SEM technique. The analysis provided information about the composition, and the distribution of both crystalline and amorphous phases. The micro and the macrostructures offered information concerning the selection and the processing of the raw materials. The recovered information pointed that potters used the ideal source of raw materials to add the favored properties. Therefore; the SEM analysis provided information about the relationship between the microstructures and the mechanical properties of the pottery. As expected the bulk chemical analysis proved that Silica is the major element, besides the frequent group of elements, which is usually present in any clay body materials. Each element contributes in adding different properties for the pottery. The size of the clasts acts as a major factor in controlling the speed of the reactions. The small size clasts evolve the reaction faster than coarse clasts, which as result reflect specific physical properties. Different particle sizes were detected for the Silica content, as well for matrices. The sizes of Silica ranges between 5-200µm, while the matrices grain sizes range between 1-20µm, such measurements portray two important properties of pottery, the first is the rigidity that affects the durability, and the second is the porosity, which is related to the achieved firing temperature. The porosity differs according to the size and function of the pottery pot. Potters were knowledgeable of the importance of using the suitable grain sizes and the right firing temperature to accomplish their desired goals. According to the SEM measurements, the porosity of the samples ranges from 1-500µm. The technology of production and the firing temperatures are the essential factors that control the porosity of the pottery ware. Hand-made pottery wares have usually higher porosity than wheel-thrown pottery wares, due to the addition of coarser non-plastic clasts. Comparing sample AB183 a hand-made pot, just by naked eye with sample AB291 wheel-thrown pot, shows big differences in porosity. SEM/EDX results allowed a view of the type of the main tempering materials and their sizes too. Quartz clasts were mainly the main tempering materials in samples no. AB291, AB165, AB120, quartz ranged in size between 100-200µm. Samples AB451, and AB319, both contained calcite clasts ranging between 100-500µm, and only one sample AB183 had plant fibers as tempering materials, the size of the plant fibers ranged between 300-500µm. The analyzed samples had different types of microstructures, in fact, four main types of microstructures were identified as homogeneous, heterogeneous, bimodal, and textured. Four types of microstructures have been recognized as homogeneous, heterogeneous, bimodal, and textured. The main remarks of SEM+EDX suggest the use of both calcareous and non-calcareous clay deposits to produce the pottery. The results propose the importance of both deposits for the Islamic potters, which indicates the technical knowledge of pottery makers. Whereas calcareous deposit is used for certain types of vessels (the function predetermine the source), and vice versa. Alkalis are scarce in general they were detected only in few samples.

5.12 Correlation between the three sites:

One of the main purposes of using archaeometry was to draw a line base for Northern Jordan Islamic pottery, which is of a high necessity. The comparison between the three sites in focus would not have been possible without it. The archaeometry comparison study allows locating similarities and differences between the sites. The symmetrical archaeometrical results provide evidence concerning the source of the raw materials and the producing technology. It is really hard to define securely the exact origin of the raw materials, but it can always be attributed to certain geology. Therefore; according to the statistical analysis, the correlation between Abila and Gadara is significant, which is indicated by the similar raw materials. Both sites are located in the same geological zone, and the distance between both sites is very close about 15 km, which corresponds to the similarity. This study is using Islamic pottery as an indicator for reconstructing the connection between the three sites in focus, throughout the entire Islamic period, which is located in Northern Jordan (Abila, Gadara, Umm el- jimal). For determining the correlations, the study focused on quartz and calcite concentrations that are provided by XRD semi-quantitative analysis. Although the number of samples differs between the three sites, meaningful results were still possible. The following charts demonstrate the different mineralogical concentrations within the three sites.

The correlation between quartz and calcite is clear by looking at the charts. To have better understanding of the results, samples were separated according to their calcite contents into two groups A, and B as clear by the charts. Abila, the total number of samples that had gone through XRD analysis were 78 samples. In most of the samples, the mineralogical phases are similar but the concentration differs. Quartz is present in very high concentrations in 27 samples. which equals about 35% of the samples. It is worth noting, samples with a V.H. quartz concentration, usually lack or have low to scarce calcite concentrations. Only 9 samples out of the 27 have low to scarce concentrations of calcite, the maximum calcite concentration within this subgroup was only 8%. Calcite as one of the major mineralogical phases, was determined in 41 samples in varying concentrations. The samples that had calcite as one of the major phases equals to 52% of the assemblage, but none of the samples had calcite in very high concentrations, and only 6 of them had H. to M. concentrations. The rest of the samples either didn't have calcite or had it in low to scarce concentrations. Petrography analysis proved that some samples have secondary calcite, therefore; the lack of other forms of calcite suggests the exploitation of non-calcareous clay deposit, on the contrary, samples that had H. to M. concentration probably were of made out of the calcareous deposit.

Gadara, 56 samples were introduced to XRD analysis, 23 samples had quartz in a V.H. concentration over 40%, which makes up around 41% of the entire analyzed samples from Gadara. The average content of the V.H quartz concentration is about 50%, which indicates for sure the intentional addition of quartz, as it was proved by petrography analysis.

Calcite as one of the major constituents of the samples was determined in only 26 samples, 15 samples out of the 26 samples had it either in L. or S. concentrations, while the remaining samples had M. or H. concentrations, except for samples No. UQ72 (71%), and UQ235 (51%). This extremely high concentration of calcite demonstrates the intentional addition. According to what has been addressed earlier, such an extreme concentration could never be a coincidence. Therefore; the favored properties that calcite adds to pottery are the facts behind having such an extreme concentration. Both sites correlate with each other from two main points of view: first, the typological studies shows the similarity of the assemblages in the same period, whether we are dealing with forms or surface decorations, or fabrics. The second archaeometry did show the same relation in most of the samples with the exception of the two samples that had extremely V.H. concentration of calcite. Umm el-Jimal, 73 samples were analyzed by XRD from Umm el-Jimal. All the analyzed samples date to the Early Islamic period (7th to 12th century AD.), by the typological mean. The location and the nature of the site differ greatly from the previous two addressed sites; the site is built completely out of basalt.

Umm el-Jimal is situated in the partially dry region of northeast Jordan, on the border of the basalt plain shaped by prehistoric volcanic epidemics, starting from the slopes of the Jebel

Druze, the plain is known as Southern Hauran, the southern Hauran plain consists of a thick layer of basalt bedrock, on top a reddish volcanic fertile soil, the annual rainfall is about 100mm, which is hardly enough to grow rain-fed wheat (DeVries 1990, p. 7). The Via Nova Traiana is about 6 km west of Umm el-Jimal, the site perhaps was constructed half a century prior to the roadway, which dates to 111-14 AD (DeVries 1998, p. 38). Umm el-Jimal is located on the margins between the Transjordan high plateau and the Badia (semi-desert). Therefore; lack of water is familiar, the inhabitants of the site managed to channel the rainwater and store it for the daily use and the agriculture purposes during the hot season.

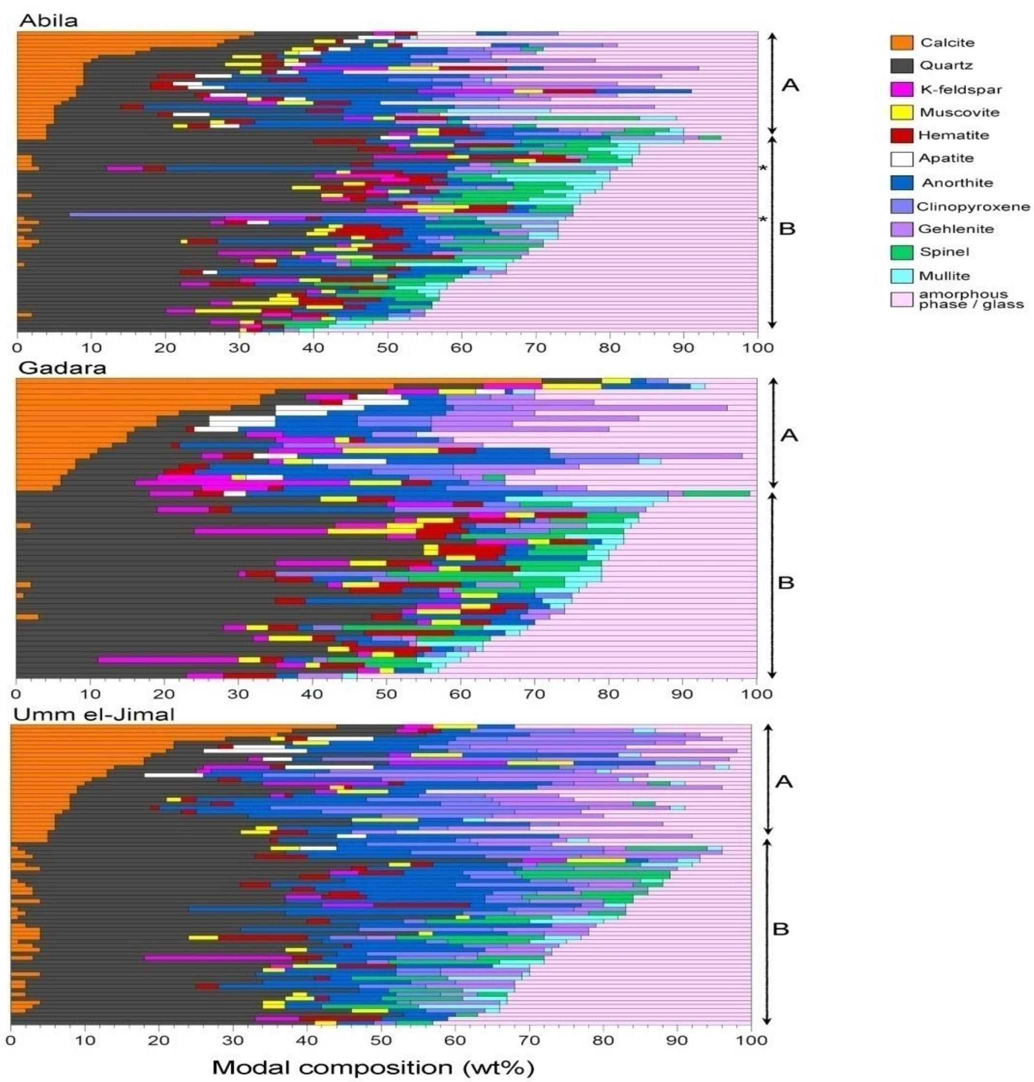

Fig. 5.20 Modal compositions charts of the three studied sites, showing the mineralogical composition of pottery sherds from each site.

They have created a sophisticated hydraulic system, which supplies the reservoirs of the city and the countryside; the system would make use of the winter rainfall water to the maximum, especially during January, February, and the beginning of March (DeVries 1981, p. 57). The city was established in the Early Roman period when it benefited substantial Nabatean influence, flourished as a frontier city of the Roman and Byzantine Empires, and continued to prosper in the Umayyad period.

Consequently; as the site is located on trade routes, it won't be surprising to uncover pottery from all over the region. Only 22 samples out of 73 samples had V.H. quartz concentration that equals to 30% of the assemblage. Comparing to the other sites it is rather low concentration. Two samples from Umm el-Jimal had an extremely V.H. concentration of quartz, sample UJ282 (59%), and UJ699 (69%). Calcite appeared to be present in 57 samples, but the average content of its presence is low, only 9%. Out of Umm el-Jimal assemblage, only 10 samples have had calcite as added tempering materials. The concentrations of calcite vary between H. and M. concentrations. The maximum content of calcite has been observed in sample UJ322 (38%). Most likely, and according to the petrography results, calcite in a High and Modarate concentrations was for sure added to the mix to manipulate plasticity.

A simple comparison between samples that had calcite as one of the main ingredients in the three studied sites, showed the generally higher concentration of calcite in both Abila and Gadara in comparison to Umm el-Jimal. It would be safe to assume that both sites Abila and Gadara, had an accesses to a clay source richer in calcite, which is expected, due to the nature of the geology in both sites, this is incased calcite was driven as inclusions with the clay materials, but if we are speaking of added tempering materials this would mean, the tendency of using higher content of calcite in the mix, probably was the decision of the potters. According to what was discussed earlier, concerning the importance of calcite in the production of certain types of vessels, there is no need to repeat ourselves. The following diagram demonstrates calcite concentration in the studied sites, which clearly shows the distinction between both Abila and Gadara in comparison with Umm el-Jimal.

Out of Abila samples, 41 samples contained calcite as one of the major minerals, 8% was the average content of calcite within the entire samples, while the maximum content of calcite 32% was present in sample no. AB86. Gadara had 26 samples that contained calcite as one of the major constituents, with an average content of 17%, samples no. UQ72 had the higher quantity of calcite, which was 71%, this percentage is extremely high, therefore; such a high concentration of calcite surely affects the outcome vessel negatively, from the durability point of view. UQ72 did contain a minor amount of quartz 8%, besides scarce amounts of anorthite 2%, augite 3%, and muscovite 4%, the mineralogical composition of this samples stresses absolutely the firing temperature. The typological study of the sample attributed the sherd to the Late Islamic period. It is a sherd of a large handmade jar (coarse terracotta); just by visual examination, non-plastic materials as calcite are easily distinguished. Whether such a high concentration of calcite was intentionally added by potters remains a mystery. Since none of the previous studies cited a similar case, neither this study did find other examples. Therefore; it is necessary to study a number of sherds that share the different physical properties.

Fig. 5.21 Sample No. 72 from Umm Qais.

Out of Umm el-Jimal assemblage, 57 samples contained calcite as one of the major phases, with an average of 9%, and the maximum content of calcite was located in sample no. UJ649, the sample contained 44% calcite, such a percentage fall within the normal V.H concentration of calcite (Raith et al. 2011, p. 31).

Chapter Six: Conclusions

The study main objectives are investigating the communal identity and the development or the decline of Northern Jordan Islamic pottery production grades. Archaeometry as a tool is capable of reading what is between the lines. In other words, the durability of pottery has the potential of preserving a huge amount of information that can be obtained using the right archaeometry approaches. Such a property can be compared to a un-destroyable notebook or at least slightly affected. Natural deterioration factors in the long-term can slightly affect pottery, which guarantees traces concerning the origin, the technology, and the potter's skills. It was essential to investigate the pottery composition and behavior to have a clear picture of the Northern Jordan Islamic pottery.

Discussing the limitations and the strengths of the data obtained by archaeometry surely enrich our knowledge concerning the technology developments of pottery making during the Islamic period in Northern Jordan. Therefore; this study could be the starting trail for future studies to advance our understanding of Islamic pottery. Despite the fact that this study focused on surveyed pottery, rather than stratified pottery, the study still goes together with the previous historical and archaeological studies. The study offered an important re-evaluation of the three sites during the Islamic periods individually, and like part of the wider settlements of the Islamic period in Northern Jordan. This study tried to set criteria of the communal identity relying on the socio-political and economic connections between different urban areas in Jordan and beyond. The relation between social networks and community can be manipulated through following the traditional approach (community as locality). This approach looks at contacts as bound to a certain geographic location. Despite, the fact that both the social networks and the community are far apart, the traditional approach is capable of linking them.

During the different Islamic periods, information describing the inhabitant's daily life is lacking. Therefore; it is important to study cultural materials, which allow insight external and internal factors that affect any part of the known population. For the sake of reconstructing the communal identity, it would be wise to look at the region through different aspects, then concentrating on pottery only. Certain choices are essential in order to establish an easy way to reconstruct the communal identity of a certain population. The alternative choices will be; first analyzing the trade routes of the region and how they connect the different archaeological sites, second analyzing the political situations. Caution has to be taken when looking at the degradation or the rise of the settlement, while keeping in mind that different sites offered interesting pictures about the socioeconomic history of Jordan. Prior discussing the communal identity, addressing the main remarks of the scientific analysis will be in focus.

The study provided a remarkable amount of information regarding many aspects, such as; the provenance of the samples, the technology utilized to produce the samples, and the potter's capabilities. Provenance study is considered highly important, since it may provide us with clues that link certain pottery pot with certain geology formation (site). Identifying the type of tempering materials and inclusions allow comparison with different geological formations, which usually provides glimpses concerning the origin. Firing process effect the original components of clayey materials, the effect differs depending on the type of raw materials and the firing conditions and temperatures. Consequently; new phases (Bi-products) emerge, which makes it quite difficult to obtain the exact inputs, concerning the origin of the clayey material. Therefore; it is more beneficial to focus on the non-plastic materials. Ancient civilizations interacted with their surrounding environment, as part of their daily life routine. Which supports the hypothesis that pottery makers used non-plastic materials from their surrounding environment rather than import it? Commodity exchange respectively; could prove cultural interactions between ancient societies living in Northern Jordan and related societies in the surroundings. Therefore; determining the origin of pottery (as a commodity), gradually it could supply glimpses about trade routes mostly. Understanding and determining the composition of pottery artifacts opens the door wide for re-visualization of the manufacturing technology that has been adopted by the craftsmen. In order to be able to obtain representative conclusions, representative samples were needed. The study samples have been chosen out of thousands of survey sherds. The sherds present different pottery wares; the studied assemblage was chosen with regards to the different time periods and the common most wares of those periods. Close inspection of the archaeometry results, shows definite integration of certain raw materials with certain manufacturing technologies were particularly utilized to manufacture specific types of pottery wares in Northern Jordan during the Islamic periods Pottery production generally; goes through a certain sequence of procedures, the final outcomes, require seven steps starting with first; the selection of the raw materials, second; processing the raw materials (purifying clay, grinding tempering materials, and mixing raw materials prior preparation the paste), third; paste preparation (adding water of plasticity), fourth; forming, fifth; decoration if present, sixth; firing, and finally seventh; finishing. Each different archaeometric technique provided a certain piece of information regarding the seven steps the firing temperatures and conditions were estimated rather easily relatively after identifying the different byproducts phases (minerals) present in the samples, which provided firing temperatures range. While the firing conditions (oxidizing or reducing), and certain types of byproducts projected the factors that provided the different pottery colors. Relatively; the raw materials of the analyzed samples match the surrounding areas geology formations, which suggested the source of the raw materials. Attribution of any type of clay materials to a certain area requires a comparison between both the type of non-plastic (inclusions and tempering) materials, and the local geology. As the non-plastic materials represent usually part of the area geology. The majority of the studied assemblage reflects the local geology. The compositions of Northern Jordan (Southern Hauran) geology formations, match the types of non-plastic materials present in the samples. Generally; scientific techniques (petrography, XRD, SEM+EDX) all confirmed that the studied assemblages from the three sites have distinctive characteristics. Although samples were from different Islamic periods they could be divided into subgroups. Sub-grouping according to the type of the raw materials used to produce these vessels. Even though the non-plastic materials did not differ greatly, there were still slight differences that allowed sub-grouping that showed kind of commodity transportation. Different archaeological studies proved commodity transportations and even went farther by reconstructing road networks. Therefore; the first subgroup that characterized by having distinctive types of micro-fossils (foraminifera), consists of 16 samples, 5 samples from Abila, 9 from Gadara, and only 2 samples from Umm el-Jimal. The majority of the samples dated to the Middle and Late Islamic periods, and only 2 samples date to the Early Islamic period both are from Umm el-Jimal, which is not surprising since all Umm el-Jimal assemblage was dated to the Early Islamic period. The distribution of the subgroup samples between the sites, suggests either one production center or consumption of the same source of the raw materials by the three sites. Suggesting the first choice is more convenient one production center. The other distinguishing factor of this sub-group is the similarity range of the firing temperatures. In most of the samples, the $CaCO_3$ did not decompose, which means relatively that the firing temperature did not exceed

850^{o}C. Such a fact to the production technology, suggests one production center rather than multi-production centers. The type of the raw materials characterizes this sub-group, suggests the same origin. Generally; the raw materials used to produce this sub-group samples probably the silty clay present in the surrounding Wadis (valleys). Gadara and Abila, both are located in the northern Transjordan highland plateau. Both are surrounded by Wadis, where plenty of silty clayey materials available on streams shore. While Umm el-Jimal samples could have traveled all the way to the site through the road networks since Umm el-Jimal located on the important caravan road. The second sub-group is characterized by having basalt fragments (plagioclase + pyroxene), which is probably driven from the same source of the raw materials. The second assumption would be contamination from the grinding mortars, which were usually made from basalt. Prior addition potters ground different types of non-plastic materials as it is desired, which might have been the source of basalt. This sub-group consists of 14 samples; four samples from both Abila and Umm el-Jimal, whereas six samples belong to Gadara. Basalt is present in the entire study area, in fact, the entire site of Umm el-Jimal is built by Basalt, as well as, in Abila and Gadara their architectures built from multi-types of stones, and basalt is one of the most used stones. For this subgroup, it is hard to distinguish its exact origin, but it would be safe to assume local production, despite that in none of the sites pottery kilns were uncovered yet. The third indicative subgroup suggests Jarash as the origin of the production, due to the correspondence of the composite non-plastic materials from the study area with the latest archaeometry study conducted on Early Islamic pottery from Jarash in 2015 by Tarboush. This subgroup is distinguished by having three main non-plastic materials (quartz, sandstone fragments, and chert fragments), such ingredients overlap with the Kurnub sandstone formation that dominates Jarash area (Tarboush, 2015; p.124). Therefore; the compatibility between both the mineral assemblages and the geology of the studied area, emphasizes local production for the first two subgroups, while the third subgroup points Jarash as a mass production center during the different periods. Even though although Jarash is well documented as a mass production center of pottery during the Early Islamic period only, but it may have continued the later Islamic periods (Middle I, II; Late I, II). The possibility of Jarash as mass production center continuation is high, due to the compatibility in the raw materials and the firing temperatures. Most possibly If not in the same center, it has to be somewhere close by or perhaps they have used the same source of raw materials. The determination of the firing technology is one of the main tasks of this study. It is possible to determine the mineralogical composition of the specimens, which gives indications about the firing technology. During firing processes several physical and chemical changes take place at different firing temperatures, which necessitate physical and chemical properties change. Certain phases (minerals) appear and some decompose at certain firing temperatures, which could indicate the firing technology and temperatures (Heimann 1982:90). The fortitude of petrography and XRD techniques has been behind delivering the clear pictures of the mineralogical composition of each sample, which allowed reconstruction of the initial firing temperatures for the entire assemblages. Therefore; through focusing on certain minerals, it was possible to suggest relatively initial firing temperatures range for all sub-groups.

One of the main indicators regarding the initial firing temperatures is calcite ($CaCO_3$), to prevent repeating (calcite decomposition process earlier discussed in the results and discussion section). Calcite has been found in many samples as primary calcite, which did not go through any decomposition processes. Some primary calcite grains have still clear twinning, while some other have still an intact cross section of micro-fossils. Finally some as a very fine grains as part of a larger limestone fragment, which absolutely have gone through calcinations or decomposition processes. Calcite (CaCO3) decomposition depends on two factors, the first is the temperature, and the second is the firing atmosphere. When the temperature reaches around 600oC in an oxidizing atmosphere, calcite starts decomposing until it's totally consumed at about 700oC. As the temperature rises the newly formed lime (CaO) remains constant until the temperature reaches about 800oC. If the firing processes continue lime starts reacting with the available siliceous materials producing new phases. The new phases are of importance, as calcite for the sake of initial firing temperatures determination. Concerning the second scenario the reducing atmosphere; calcinations processes starts at rather higher temperatures, around 200oC beyond the previous firing condition. Therefore; the substitution interval of calcite to lime does not exist, due to the presence of a huge amount of the siliceous materials. The newly phases are mainly composed of calcium aluminum silicates, which are of great importance for determining the initial firing temperatures (Noll and Heimann 2016, p. 96; Noghani and Emami 2014, p. 182). Consequently; all the samples that had calcite as primary mineral, whether as limestone fragments with the clear twinning or as undisturbed micro-fossils, must have been fired at a temperature ranging between 600^{o}C and 800^{o}C. The samples that crossed the initial firing temperature of calcite decomposition indicate the correlation that describes the relation of calcite to the new phases such as; anorthite and gehlenite, which indicate higher firing temperatures. According to the phase diagrams of the samples obtained by XRD analysis, gehlenite is present in 64 % of Umm el-Jimal samples. The samples all belong to the Early Islamic period, while only 43 % of Gadara samples and 49 % of Abila samples had the phase gehlenite. Regarding the presence of gehlenite, it seems that during the Early Islamic period, potters attempted frequently to achieve higher temperatures. The constant appearance of gehlenite in the early Islamic period samples reflects the desired firing temperatures, which are over than 800^{o}C and less than 1000^{o}C (Noll, Heimann 2016, p. 96). Therefore; the tendency of having more durable pottery during the Early Islamic period could have been the intention behind such a fine achieved firing temperatures. Regardless; the scarcity of surface decorations during this time period compared to the later Islamic periods. Generally; casual household's pottery wares like table wares and cooking pots of the Middle and the Late Islamic periods have less durability compared with the Early Islamic period. The second picture is more glamorous for the eyes, intentionally by the addition of diverse types of surface decorations, which makes pottery of a higher value 'more fashionable', regardless the durability of the pottery fabrics. Surface decorations like glazing and slipping are eyes attraction elements. During the Middle and the Late Islamic periods certain pottery wares as HMGP have been extensively produced and used that represent the previous picture. In spite of the degradation of certain pottery wares from a technical aspect, the middle and the late Islamic potteries still have numerous advantages. First, the appearance; surface decorations are dominant, on both Middle and Late Islamic periods potteries, which was probably the desired/favored folk-art more among the Islamic society. Keeping into consideration, some surface decorations have other functions besides their value as motives, like, glazing; which makes the pottery vessel water-tight perfect for storing solutions. From an economic point of view; purifying the raw materials and firing pottery at higher temperatures consume time, effort, and money. Therefore; in terms of savings, these might be the reasons that led Muslims (locals) to produce their own vessels. Accordingly; even though tableware Early Islamic pottery is of higher grade in comparison with the Middle and Late Islamic periods, it was demanding skillful potters and highly technical tools to be produced. Whereas some tableware of the Middle and the Late Islamic periods; were practical and attractive but more primitive. It is worth noting, without overstating, if black death748/1347 A.D. was one of the main factors that led to economic decline across the Middle Islamic period. Speculations concerning the Black

Death have to be reconsidered, and attention to other factors should be in accounts. Such as environmental factors, and peculiarities of Middle Islamic administration of the Transjordan (Walker 2004, p. 137). Different modes of production have been identified when comparing the Early Islamic pottery with the Middle and Late Islamic periods. The quality constancy of the Early Islamic pottery, likely proposes that pottery was produced in centralized pottery workshops, while the later periods pinpoint decentralized workshops. The presence of the same pottery wares in all over the studied sites, suggests that urban centers have been connected together by roads nets. Urban centers and villages

The colors of pottery are the responsibility of the iron oxides and the firing atmospheres. The valence of iron, the firing atmosphere and time are the factors that color the pottery pots. The two valence (ferrous Fe^{+2}, ferric Fe^{+3}) of iron is responsible for producing the pottery colors, that correspond to the chemical status of each. Ferrous oxide is responsible for dark colors (black, gray), while ferric oxide is responsible for red color shades. The presence of ferrous or ferric oxides is connected to the firing conditions; reducing conditions means ferrous oxide, which is in the form of magnetite, whereas oxidizing conditions means ferric oxide hematite (Goffer 2007, p. 119). Spinel and the metallic Fe are usually formed in firing conditions that have sluggish oxygen rates above 800°C. Both cause darker colors (black/gray) shades, whereas spinel and hematite form in rich oxygen conditions causing red color shades (Maritan et al. 2006, p. 1). Spinel has been found in many samples out of the three sites, which confirms that around (50%) of the entire analyzed samples were fired at a temperature over 800°C. The analysis proved that some samples were fired at relatively high temperatures over 1000°C. These samples contain mullite as one of the phases in their matrix, which proves that some Islamic potteries were fired at high temperatures. (Noll and Heimann 2016, p. 35; Rice 2015, p. 85; Deer et al. 1992, p. 288; Maggetti 1982, p. 128). In order to have highly fired pottery, up-draft kilns are the suitable type of technology needed. Up-draft kilns have the capability of reaching high temperatures, like what has been uncovered in Jarash archaeological site, which was discussed by many scholars earlier.[1] Finally, assessing the communal identity would be possible by combining the archaeometric data with the trade route nets, and the political situations of the region. The communal identity usually represents a group of people that have a relation describes itself, as it is described by

[1] For more information concerning the up-draft kilns of Jarash, see Jerash Archaeological Project 1981-1983, ed. Zayadine, F., Amman, department of antiquities of Jordan published in 1986.

others, because of a class separates it from other classes of similar arrangements (Dever 1995, p. 201). The distribution of pottery may be used as a marker of culture change through determining any change in settlement forms. Noticeably during Abila survey in June 2014, most of the Middle Islamic pottery has been located around 1.5 km away from the center of Abila. The pottery sherds were collected from the SW and NW fields, the first is close to Hubras, which was well documented as a Middle Islamic site farmhouse (Walker 2005, pp. 74–75). Sample analysis of both the survey and the site Hubras proved that they match in all technical aspects[2]. The higher concentration of Middle Islamic pottery sherds away from the center of the site, suggests settlement shift. While adapting different technical procedures of pottery production suggests culture change. The concentration of scattered sherds indicates the intensity and the distribution of settlements and land use. Therefore; the previous surveys of this study collected both onsite and offsite artifacts that were used as an indicator of the past behaviors, which revealed shifting in settlement forms from urban to rural during the Middle Islamic period.

It is well documented that the artifacts carpet decreases with respect to distance from the site, forming a different density of artifacts carpet in different zones (Wilkinson 2003, p. 5). Of the old times until today man uses their waste products as Manures. Documentation of certain wares or forms of certain types through different Islamic periods should have a socio-economical meaning and thus may comprise ethnic markers and culture continuity (Dever 1995, p. 204). Development either decline of Pottery production throughout the Islamic periods suggested the locality pottery. Regardless; of the use of the same techniques, this could reflect communal identity in the three sites except for pottery imports and imitations. Islamization of a communal or tribal group does not only mean conversion but many procedures en route for orthodoxy (Levtzion 1979, p. 21). If we assume that the archaeological architecture and artifacts can be used as a secret code eventually signs of the identity. Possibly any repeated variations in different regions and different times form a pattern that is not necessarily mentioned in textual resources but drawn by close archaeological remains analysis (Whitcomb 2004, p. 3). The shifting in culture boundaries of Northern Jordan during the Early Islamic period, certainly had an influence in remodeling the roads network, which is proved by the presence of abundance Umayyad Palaces. The Early Islamic period palaces are mainly located on the margin zones that

[2] see appendix H2

connect Transjordan highlands plateau with the Badia. So Muslim needed to create new roads that connect the margin zones with the highland plateau. Consequently; these roads were clear tracks suitable for foot traffic, as they were during the Roman period in big part of Bilad ash-Sham. Thus, the nature of the roads reflects the means of transportation, which was obviously packed animals, rather than wagons that have been utilized in previous cultures. According to the material commodity distribution (pottery), the radius of the economic networks could reach up to 100 km or three days journey (Walmsley 2009, p. 465). The commodity means in this study pottery. Generally speaking the existence of a certain pottery ware in a certain geographical area that consists of many archaeological sites during a long period of time suggests culture choice. According to that, the road network participated in spreading the pottery culture, which matches in the entire study area and beyond. Looking at this as a pattern allows inference the communal identity as the communal identity is reflected by cultures. This arrangement allows observing the compatibility between the identity and commerce. Northern Jordan as part of the province Jund al-Urdunn during the Early Islamic period presents two-thirds of the study area (Gadara and Abila). While Umm el-Jimal belongs to Jund Dimashq, but still fall within the radius of 100 km with the other study sites that represent the economic networks (Walmsley 1987, p. 59).

The pottery patterns in the study area, generally; exhibit similarity in wares and composition that reflect the connection between the three sites during the Islamic period. The compatibility allows predicting clues regarding the communal identity of Northern Jordan. The frequent variation in the archaeological sites in different times forms the pattern. This pattern would mean, for example, producing different pottery forms having similar surface decorations out of similar types of raw materials, produced by similar technologies, and sustained during a specific time period, presents the preferable cultural choices that indicate the identity of Islamic period in Northern Jordan. Yet such a theoretical discussion permits discussing probability rather than one opinion, which is sensible considering the lack of evidence, through characterizing the autonomy of local cultures, by looking at the material evidence and investigating facts in its local context before considering further away for answers.

Jordan during the Middle Islamic period mainly consisted of two provinces (Mamlakat Karak), and (Mamlakat Dimashq), both provinces had their strategic and economic importance to the

Mamluk state. Northern Jordan as part of Mamlakat Dimashq, had the main hajj (pilgrimage) route that crosses Jordan from north to south, Darb al-Qufūl and the old King's Highway (Walker 2011, p. 35). This may have been the reason for the spread of Islamic pottery culture throughout the region, which became culture choice by time, reflecting part of the community identity. In the fourteenth and fifteenth centuries, the district started achieving political stability gradually, which is recognized by shifting borders and district capitals to allow the local tribes accepting the sultan. Jordan had semi-nomadic tribesmen during the Middle Islamic period that helped in supplying the empire military troops during wars, and at the same time protecting and taking care of the roads within their territories for the state. Although a big part of the life in Jordan was semi-nomadic, the countryside's of Jordan had significant agricultural potential, which supplied economically the Mamluk state. The boom of Jordan's agriculture industry is attributed to the development of infrastructure during the Middle Islamic period (Walker 2011, p. 36). A diverse number of agriculture crops supported the local and the regional markets, such as; mutton, olives, vine, cheeses, vegetables, and nuts, besides other industrial activities like; olive oil, wool for tents, and some minerals reduction (smelting). Grains (wheat), the region until today is still producing to some extent wheat, which is well documented since ancient times, therefore; Jordan was one of the main wheat suppliers of Cairo, which progressively played a direct role in sustaining the state economic (Walker 2011, p. 38). The pottery industries accompany the agriculture boom left plenty of pottery wares until today well preserved. This study as many other studies obtaining preserved information from pottery, concludes that the pottery and other the culture materials is valuable because it allows extracting preserved information's. Northern Jordan during the Middle Islamic period had a network of attached villages, bordered by desert and deep Wadis. Cities and towns of Jordan had year-round markets providing different goods and services. Concerning the communal identity of Northern Jordan during the Middle Islamic period, demographically and administratively was considered rural, but serviced, by public services in the larger population centers (Walker 2011, p. 42). The favored nature in the Northern part of Jordan led to the high intensity of occupation, which led to construct roads to connect villages. The new roads network contributed to increasing goods exchanging between villages. Which were mainly local products? The Middle Islamic pottery reflects decentralization production, due to the popularity of some primitive hand-made wares.

The tendency of producing higher quantities of some pottery wares, as HMGP is considered a culture choice, which provides part of the communal identity.

While Jordan during the late Islamic period, at least through the first century of the Ottoman state, the administration and the management systems of landholding remained as it was during the Mamluk state. And even the social and the economic networks sustained as it was. Later on, the Ottoman Empire started having its own characteristics. Generally; the Late Islamic period had its own criteria if compared with the Mamluk predecessor. During the Ottoman rule the relationship between the state and the local society best described as disengagement, other noticeable criteria was cooption of urban elites (money, and positions). Besides integrating the region into the economic orbits of Damascus and Palestine, which introduced new ways of commercialization of agriculture and the economy. The relation between the state and the local, helped in developing the long process of give-and-take, as both tried to arrange and control the significant agriculture resources and their marketing. Over time the state changed and these changes were mostly felt by locals, such as the levels of controlling the use of the land.

To conclude looking in the Northern Jordan modern settlement roots and land use allows estimating the communal identity, but we should not forget that Jordan during the Islamic periods had migrations (Walker 2011, p. 283). During the Umayyad period (661-750 AD) period, Jordan prospered due to its proximity to the capital city of Damascus and its strategic geographic position. As Islam spread, the Arabic language gradually came to supplant Greek as the main language. The circumstances totally changed from the Byzantine to the Umayyad periods, which reflect the demographic change. Demography reflects communal identity; Northern Jordan had gone through many demographic changes in the Islamic periods. Newcomers often use their own pottery techniques, which may spread among community members if they are admired. Pottery in addition to its obvious value for chronology, it could portray implications for communal identity (Dever 1995, p. 204). A significant amount of information can be estimated by pottery like shifts in settlement type and distribution, continuity and change in local cultures, the degree of isolation or contact with other cultures, the level of technology, social structure, stratification in particular, subsistence, including adaptation to the environment and trade, and shared aesthetic and religious traditions.

7. Referances

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