Erasmus Mundus Joint Master in
ARCHaeological MATerials Science

SAPIENZA
UNIVERSITÀ DI ROMA

ARISTOTLE
UNIVERSITY
OF THESSALONIKI

UNIVERSIDADE DE ÉVORA

Specialized Ceramic Production at Tell el Far'ah North: the Metallic Ware

By Letícia Gondim
Matricola: 1903129

Supervisors

Laura Medeghini

Michela Botticelli

Academic year 2019/2020

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For all love, admiration, and strength,
this thesis is dedicated to my friend Marina Harkot (*in memoriam*)

Acknowledgement

I would like to thank my supervisors Laura Medeghini and Michela Botticelli for their great supervision, patience, and attention. I am glad to have had the opportunity to work with you both and further enrich my learning.

Thanks to Silvano Mignardi for reading and contributing to the writing of this thesis.

To the master’s programme and the ARCHMAT consortium for providing this incredible and important opportunity to improve my career.

To all my colleagues in the ARCHMAT 2018/2020 programme who were truly kind and caring to me. I would like to highlight Berenice Baiza, Islam Shaheen, Degsew Zerihun, Luka Bruketa, Tawanda Mushweshwe, my eternal thanks for all your help, affection and welcome, your support was essential for the completion of the master’s and this thesis

An incredibly special thanks to my Roman family Clemente Sabbatini and Roberto Mander who welcomed me, took care of me, and contributed to making my year in Rome even better than it could have been.

Thanks to my family for supporting me along my journey in life. I will forever owe my achievements to my dedicated, caring, and thoughtful family. I would not be the person I am today without your help.

To my Swiss Oppliger Pinto family for all their love, affection, and support.

To my Brazilian friends who always, despite the distance, were present and by my side.

An heartfelt gratitude to Fabio Lessa Peres, without his help this thesis would not be possible.

Thanks to my partner, my love and my best friend, Pedro Tiuna. Life is much better and much more beautiful by your side, thank you for that!

Abstract

This master thesis presents an archaeological study of the Metallic Ware from the Tell el-Far'ah North (West Bank) archaeological site, on ceramic fragments dating from the Early Bronze Age II (3000 - 2700 BC). Optical Microscopy and X-ray powder diffraction showed a Metallic Ware different from the North Canaanite one, produced with a calcareous clay with dominant quartz, common fragments of sedimentary and siliceous rocks, few feldspars, and nodules of iron oxides. The Metallic Ware quality was achieved by high firing temperature between 850-900 ºC. Tell el-Far'ah North was hypothesized as one of the main production centres of Metallic Ware.

Keywords: Tell el-Far’ah, Metallic Ware, Bronze Age Ceramic, South Levantine ceramics.

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Overview

This research has been divided into eight chapters. The first chapter is the introduction, in which the work and the aims are presented; then a summary dedicated to the object of this research, ceramics, from raw materials, tempers, production techniques and types of ceramics is the object of the second chapter.

The third chapter is dedicated to an overview of the archaeological site of Tell el-Far'ah historical and archaeological aspects, followed by a topic on Metallic Ware, a very characteristic ceramic spread throughout the Middle East during the Early Bronze Age II and III.

Geographical and geological aspects of the Tell el-Far'ah archaeological site and its surroundings are presented in the fourth chapter, a particularly important topic for understanding the relationship and use of natural resources for ceramic manufacture.

The fifth chapter is dedicated to explaining the analytical techniques used for the analysis. A detailed presentation of the results obtained by optical microscopy and X-ray powder diffraction is described in the sixth chapter. The discussion of the results, combined with scientific references on archaeological ceramics, is presented in the seventh chapter and finally the conclusions are drawn in the eighth chapter.

1. Introduction

Traces of human activity in the past surround us everywhere, but those with large dimensions are often the most evident, such as buildings and altered landscapes. On the other hand, most archaeological remains are much more modest because they are remnants from the daily activities of human existence, such as leftovers of food, fragments of pottery, fragmented lithic tools, traces formed wherever humans have developed their daily activities.

Pottery sherds are one of the most common evidence of human occupation. Through research and analysis on ceramics, it is possible to obtain a lot of information such as dating, displacement, commercial exchanges, diets, technological choices made to produce these artefacts in different chronological moments and geographic spaces.

In this thesis, archaeological ceramic sherds were analysed by an archaeometric approach. Archaeometry is intended as a process of interaction between different research areas with the objective of knowing the material culture of cultural heritage. It brings together archaeologists, historians, conservators, physicists, chemists, biologists, geologists, among others who apply different instrumental techniques with the aim of studying and analysing heritage objects to obtain technological, cultural and historical information.

The pottery sherds in this study are from Tell el-Far'ah North (biblical Tirzah), located in the West Bank, 11 km northeast of the modern city of Nablus. A group of small carinated bowls, from the EB II Metallic Ware repertoire of Tell el-Far'ah North were unearthed during the excavations carried out by Roland de Vaux between 1946 and 1960 on behalf of the French mission of the *École Biblique et Archéologique Française de Jérusalem.*

According to the classification made by Beck (1985), "Metallic Ware" is composed of a group of small carinated bowls among other types in smaller quantities in the EB II from Tel Aphek, produced in a very fine brownish-red clay, well-levigated with minute grits. These bowls have a different petrographic composition from the North Canaanite Metallic Ware, described by Greenberg & Porat (1996), characterized by non-calcareous matrix, shale fragments (added intentionally or part of the original clay deposit) quartz, carbonates, siltstones, basalt and fragments of volcanic rocks and oolites..

Optical Microscopy (OM) and X-Ray Powder Diffraction (XRPD) were used to identify the raw materials used in pottery production and thus define the typical feature of this Metallic Ware, highlighting similarities and differences with the Metallic Ware found in other sites.

2. Ceramic

One of the most common artefacts found in archaeological excavations is pottery, whether complete or in sherds. It was precisely the firing process that transformed the original soft clay into hard pottery that allowed these remnants to survive for so long and become an important key to further understand the complexity of ancient societies.

Ceramics are found everywhere in different sites and societies. Although one tries to search for the origin of ceramics, as Rice (1987) pointed out, this question seems to have several explanations, which suggests that ceramics did not appear in a specific time and place, but it is the product of experiences and experiments of ancient societies.

Although it is not known where and when ceramics appeared first, according to Rice (1987) early ceramics appeared in the so-called Neolithic technocomplex, which is also characterized by the introduction of agricultural activity.

This research is not an attempt to trace a timeline about the use of ceramics in ancient societies, nor to find out where and when it began, but it is important to emphasize that, through different researches carried out, ceramics continue to be a rich marker of the material culture of different societies. As advanced scientific techniques applied to archaeology are being developed and more research is being carried out, it is possible to confirm that the use of ceramics is older than previously thought (Rice, 2015).

The advances in the exploration of raw materials - and the development of artefacts through it - it is undoubtedly one of the most important technologies developed by humans. Each pottery found and analysed today in research such as this one, is part of a complex and well-structured process in the production chain of artefacts. It involves the location, the choice and the exploration of raw materials suitable for the production of ceramic artefacts (Montana, 2019).

The next steps, after having chosen raw materials, are shaping, drying and firing and, as a result, a well-finished artefact with very particular morphological and functional characteristics is obtained, which consequently demonstrates mechanical properties quite different from the raw materials used to create these artefacts (Montana, 2019).

2.1. Raw materials

Ceramic can be included in geomaterials, i.e. products of geological origin, such as rocks, sediments, or soils, which have undergone modifications. In the case of ceramics, human action induces modifications, in the creation of a finished artefact and the starting raw material corresponds to the clay, which is composed of clay minerals, other minerals and accidental materials, tempers and water.

2.1.1 Clay

Concerning the depositional context, clays are sedimentary deposits with secondary origin, resulting from the weathering and disintegration of older rocks and not from original processes related to rock formation. The classification of the clay is possible by locating the decomposed materials on the parent rock; thus, the clays are classified as primary or secondary - also known as residual or transported sedimentary clays, respectively (Rice, 1987).

The characterization of clays named as primary or residual is since their deposits are found around the parent rock which originated the clay. The formation of this type of clay occurs through different hydrolytic reactions which involve percolation of water and chemical action, in addition to climatic factors, such as freezing, which also contribute to these formations. The diversity of rocks, such as feldspathic rock, granite, basalt, diorite, and volcanic ash or tuff, and sedimentary rocks such as limestone or shale, contributes to the development of different types of clays (Rice, 1987).

The changes and decompositions that occur in the original rock are incomplete; therefore, regarding the formation of residual clays, these in their composition have thick, coarse and unchanged angular fragments. This factor contributes to the primary clays having low plasticity and low organic material content, around 1% (Rice, 1987).

Residual clays typically have coarse grains or clasts, usually in the shape of angular to subangular, when located close to their parent rock. Hence, the presence or not of coarse material in a natural clay is what helps to classify the texture of the raw material. Thus, a coarse-textured clay is more rigid and less plastic, which makes it more prone to cracking during ceramic manufacturing, because coarser clays tend to dry faster in comparison to finer clays.

On the other hand, the so-called secondary or transported sedimentary clays are found in remote areas from the likely parent rock. This distancing from the source is due to the movement through waves, tides, streams, wind, glaciation, erosion, or other forces. Unlike residual clays, secondary clays are more abundant and have a finer and more homogeneous texture, in addition to having a greater amount of organic material, which varies from about 5% to 10% depending on the clay deposition context. In this context, we can categorize clay according to "*the conditions or methods of deposition and* *transport, such as marine clays, fluviatile clays, lacustrine clays, aeolian clays, and glacial clays*" (Rice, 1987).

Another very important factor for the quality of the raw material is the granulometry of the clay: the greater the amount of small particles, the greater the plasticity of the clay. According to soil scientists, to be considered clay the soil must contain 35% to 40% of the finest particles (less than 0.002 mm), which determinate colloidal property and give plasticity to the clay. The origin of the formation deposit explains the proportion of clay-grade particles. These deposits can be easily accessed through soil maps that were produced by researchers. The research in these archives is not always satisfactory to identify the origin of the clay used to produce ceramics. However, they are a rich source, albeit a very general one, to understand and identify the clay deposits of a certain region. (Rice, 1987).

The properties that result in good quality material for the production and use of ceramics are linked to composition and chemical structure of the raw material. The most common clay minerals are phyllosilicates that are formed by tetrahedral sheets, formed by a silicon atom combined with four oxygen atoms, bonded to octahedral sheets formed by an aluminium atom attached to two atoms of oxygen and four hydroxyls.

The difference in the arrangement of these sheets, besides the substitution of several cations for aluminium, is expressed by the classification of planar phyllosilicates in three groups.

For example, the ratio of octahedral to tetrahedral sheets in the kaolin group is 1: 1, characterized by a layer of silica tetrahedra and a layer of alumina octahedra. Kaolinite is rich in alumina and is the result of the weathering of acidic, felsic rocks, such as granite or granite pegmatite (igneous rock that has a high concentration of feldspar and quartz) and micaceous shale (with muscovite in its composition). Its formation occurs in tropical or subtropical regions with high volume of rain and good soil drainage, which results in acid leaching, thus removing bases such as calcium, magnesium, iron, sodium and potassium - and further, silica is removed forming hydrated oxide clays that make these deposits rich in alumina – bauxite and gibbsite minerals - and also very resistant to impurities. Kaolinite has also refractory characteristic. Due to its large particle size, around 0.6 to 1.0 µm or more, other characteristics are achieved during ceramic production, such as a considerably low plasticity, low shrinkage during drying, and a luster that can be naturally enhanced without polishing (Rice, 1987).

The second, smectite group is characterized by three-layered clays 2:1, showing one layer of alumina octahedra between two sheets of silica tetrahedra. Smectites are known as "swelling" clay minerals, as they can retain a considerable amount of water in their structure. The most common mineral is montmorillonite (Montana, 2019). Unlike kaolin group, smectite is the product of low weathering, which involves rocks and basic minerals rich in calcium, magnesium, and iron, such as basalt and calcic plagioclases, or the decomposition of volcanic ashes. The climatic condition of formation is rather bad with respect to drainage, reduction, low rainfall, and leaching, especially if the ambient bases are relatively abundant in the weathered zone. Smectites are characteristic of a recent formation of sediments and makeup regions of acidic soils. Concerning their chemical composition, silica is found in greater quantities than alumina, causing smectites to be less refractory. Additionally, since crystals are thicker and smaller, compared to kaolinite, clays with smectite minerals give greater plasticity, lower gloss and higher level of shrinkage and cracks as they dry naturally (Rice, 1987).

A third group, illite, with alternate stacking of different layers, but also 2:1 composition, is a heterogenous group and rather complex to classify. The illite group composition is fairly like smectite, but geologically speaking it is more stable. Due to the substitution of one sixth of silicon by aluminium, a load deficiency is created, which is balanced by potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}) and hydrogen (H^+). The diameter of its particles revolves around 0.1 µm and 0.3 µm: they are small, poorly defined, and not expansive. These features make illite-containing clays ideal for pottery slips. This group is a product of the weathering of rocks rich in aluminium and potassium under high pH conditions in temperate climates or at high altitudes in the tropics. The deposits of this group are located at sea, more specifically offshore or in deep water. It is the most common mineral clay in calcareous sediments (Rice, 1987).

In addition to clay minerals, also other minerals and accidental materials are included in the clay. The other minerals naturally present in the raw material are often the result of incomplete weathering suffered by primary parent rocks. Among the accidental materials, organic materials (such as pollen, diatoms, plants and animal waste), fragments of rocks and fossils are included.

2.1.2. Tempers

These other constituents are not naturally part of the clay but can be intentionally added to modify physical properties during the manufacture of pottery.

The intentional addition of tempers demonstrates the ability of traditional potters in the manufacture of pottery. These constituents are added to modify the plasticity of the raw material, improve thermal properties, drying time, shrinkage factor, porosity, thus playing a particularly important role in the final product. The variability of materials that can be added to modify the properties of clay is quite large, from minerals to organic materials (such as plants or animal remains).

The three most common minerals in ceramics are quartz, feldspar, and calcium-based minerals.

The most common mineral is quartz and its derivatives, then followed by feldspars. When used as temper, feldspars act as flux agent because of its gradual melting point at a variety of temperatures, which determines the presence of a glassy phase at low temperatures, improving the strength of the ceramic body (Rice, 2015).

Finally, calcium-based minerals, such as calcite in limestones or aragonite in shells, are usually added to give strength to the ceramic structure which, due to its porosity, then allows the application of a surface layer. Ca-based minerals also play an important role in the final colour of the artefact, which is usually lighter (Rice, 2015).

Organic materials may be intentionally added to the paste by the potter to increase plasticity due to the presence of organic colloids (which impart a darker colour in the ceramic raw material) and are generally used in the manufacture of light vessels that are easy to transport. One of the advantages of using organic tempers is their availability and ease of being ready for use. However, during pottery firing, organic materials may suffer partial or complete destruction, thus creating pores in the ceramic. These pores make ceramic permeable, light, resistant to temperature changes and hence suitable for cooking and food storage (Lippi & Pallecchi, 2019).

Grog, a chemically inert material, consists of burnt and ground ceramic fragments, and can also be identified as artificial temper. It was added to modify the plasticity of the clay, reduce the shrinkage factor during drying, give resistance but also and decrease expansion and contraction during firing, at the same time improving clay workability.

The tempers chosen and added in pottery manufacture are the product of traditions, abundance or availability in the surroundings and technological strategies adopted by potters. In addition to these points, the identification of temper provides information on the geography and ecology of the place of production, farming practices and natural deposits of raw materials, enriching the understanding of the relationship of ancient societies with the environment in which they developed.

2.2 Production Process

The making of pottery involves many subjectivities and complexities of past and present societies that continue having ceramics as part of their tradition, their history.

Although it requires common raw materials, such as clay, temper, water, each location, and society have its production, which involves the choice and selection of material, shape, and decorations. The ceramic workshops could be either on small or large scale. Therefore, the location chosen for the establishment of these workshops was in accordance with the availability of the primary materials needed to produce ceramics. The availability of raw materials for the manufacture of ceramics does not mean that they can be used as such in manufacture. The clay often undergoes many modifications. As Rice (2015) pointed out, the process of purifying ceramic is overly complex, elaborate and involves many steps such as drying the clay, grinding, winnowing, or sieving it.

Different production techniques can be later applied to the clay paste, the most common of which are coiling, pinching and/or drawing, slab modelling, moulding, casting and throwing. In addition, the potter's wheel must be considered. Moreover, in pottery manufacturing, many techniques can be applied together, named as compounds or composite methods. Due to the complexity of the issue, it is sometimes difficult to identify the applied procedures (Rice, 2015).

Other techniques can be applied before the final firing stage. These include partial rewet drying of the pottery which allows various finishing procedures. Finishes include the paddle and the anvil: both techniques, once applied, serve as an improvement of the vessels that were for example manufactured in coil-built, thus eliminating the marks of these procedure or other irregularities; these tools can additionally modify the shape of the vessel, thin its walls or smooth surface finishes.. Other finishing techniques as important as beating, scraping, and trimming that, once applied, complete the manufacturing process, smoothing and modifying the surface texture of the artefact. These finishing techniques are usually associated with the chosen process for making the ceramic vessel.

After the application of these finishes or without, the next step in pottery manufacturing is drying and, in some cases, preheating before the final firing. Drying is related to the characteristics of the clay, the environment, and the weather in which the artefacts are produced (Rice, 2015).

Another point that deserves to be highlighted in the production of pottery is surface improvement: as indicated by Rice (2015), many treatments can be applied in pottery; some are classified as "decorative", others as "functional", but the dichotomy between the two is not so simple to understand, because treatments considered "decorative" can also have various functions, utilitarian and symbolist. Some types of decorations can modify the shape by simply modifying the surface of the piece; on the other hand, some types of decoration can improve the usefulness and quality of the ceramic. Among the different superficial treatments we can include impressing (using a tool, it can be a natural object or a specific tool), cutting (a more free design on the surface of the ceramic), appliqués, surface colouring (pigments or colourants that can be added before or after burning, here affecting the final colouring of the pottery), painting (glaze, postfire painting, resist and negative painting), slip (a dense liquid mixture of clay and/or other materials suspended in water, which forms a thin non-vitreous coating) and glaze (a technique applied to ceramics for the same reason as slip, that is, to give colour and reduce permeability).

Finally comes the firing, that is an essential step. In fact, if not carried out with care, it can compromise the entire process and final quality of ceramics. The firing process can be carried out in kiln or open firing, depending on the technology and tradition applied by the ceramic producing populations. A kiln allows the control of atmosphere and heating rate due to the spread of fuel between and around the ceramics; it protects the ceramics from air currents, reaches high temperatures, long firing periods and the process is gradual. Two types of kiln - updraft (attained temperature is usually 900-1000 °C) and downdraft kiln - are known for their use in ancient times. The mixed firing is characterized by the realization of the firing directly on the surface of the ground and ceramics must be positioned on the fuel. Another type is the bonfire, where pieces of items such as metals or sherds, among others, are used as partial protection to retain heat during the firing, which is directly on the ground surface. Semi-underground burning (shallow digging places) and firing pits (with separate places for fuel and ceramic) can be also cited as firing practices (Rice, 2015).

Mixed firing has a very fast firing increase and generally a poor temperature control, low temperatures of 700-900 °C. The variability of fuel types used, their size, quantity and positioning, determines the highest temperature, the time needed to reach it and the duration of the firing. The highest temperatures are normally reached after fuel consumption (Rice, 2015).

2.3. Types of ceramics

Ceramics are classified in different groups, either by their composition, firing temperature, surface treatments, but in general and more broadly the differentiation is between vitrified products, i.e. items subjected to high firing temperatures, such as stoneware and porcelain and non-vitrified, low firing-temperature ceramics, such as *terracotta* and earthenware.

The ceramic known as *terracotta* is relatively coarse, with a high degree of porosity (30% or more). Its firing temperature is usually below 900 °C. It is characterized by a reddish colour owing to the iron contained in the raw material that reacts with oxygen forming iron oxides. The oldest known ceramics are classified within this category. Normally *terracotta* products are unglazed; on the other hand, they may contain different surface treatments that improve their function and add aesthetic value.

Earthenware contains a slightly lower degree of porosity, usually between 10-25%, and the firing temperature is around 900-1200 °C. This type of ware may or may not be glazed, but it does not have a vitrified body. Typical earthenware applications range from bricks and tiles to more refined ware such as tin-enamelled majolica.

Another type of ceramic is the stoneware, which is much less porous than the others mentioned above: its porosity is around 0.5-2.0% and its firing temperature is 1200-1350 °C. The firing temperature in this type of ceramic is high enough to allow a partial fusion or vitrification of the ceramic body and this property depends on the composition of the material. The clay has fine-grained inclusions, high plasticity with low iron content and refractory. The stoneware, as explained by Rice (2015), can be glazed, or have glaze in lead or salt.

The type of ceramic named "China" has a porosity below 1% and its firing temperatures range between 1100-1200 °C. Typical application is in tableware. It has a white colour and is glazed. Porcelain on the other hand represents, at least in technical terms, the great prominence in pottery work. Porosity in porcelain is almost zero and the firing temperature is the highest reached (1300-1450 °C). It has a hard body, it is fine, white, and translucent, highly refractory and free of impurities.

3. Historical and Archaeological settings

The site of Tell el-Far‘ah North (biblical Tirzah; 32°17'14″N 35°20'16″E), currently located in the West Bank, 11 km northeast of the modern city of Nablus, has long been recognized as a crucial site in documenting the passage from the Early Bronze I (EB I) rural communities to the Early Bronze II (EB II) urban societies of the early-3rd millennium BC in the Southern Levant. The ancient settlement, which turned out into a fortified town at the beginning of EB II, was located in a strategic position on a rocky ridge in the fertile valley of the Wadi Far‘ah (Figure 1) (Medeghini et al., 2019).

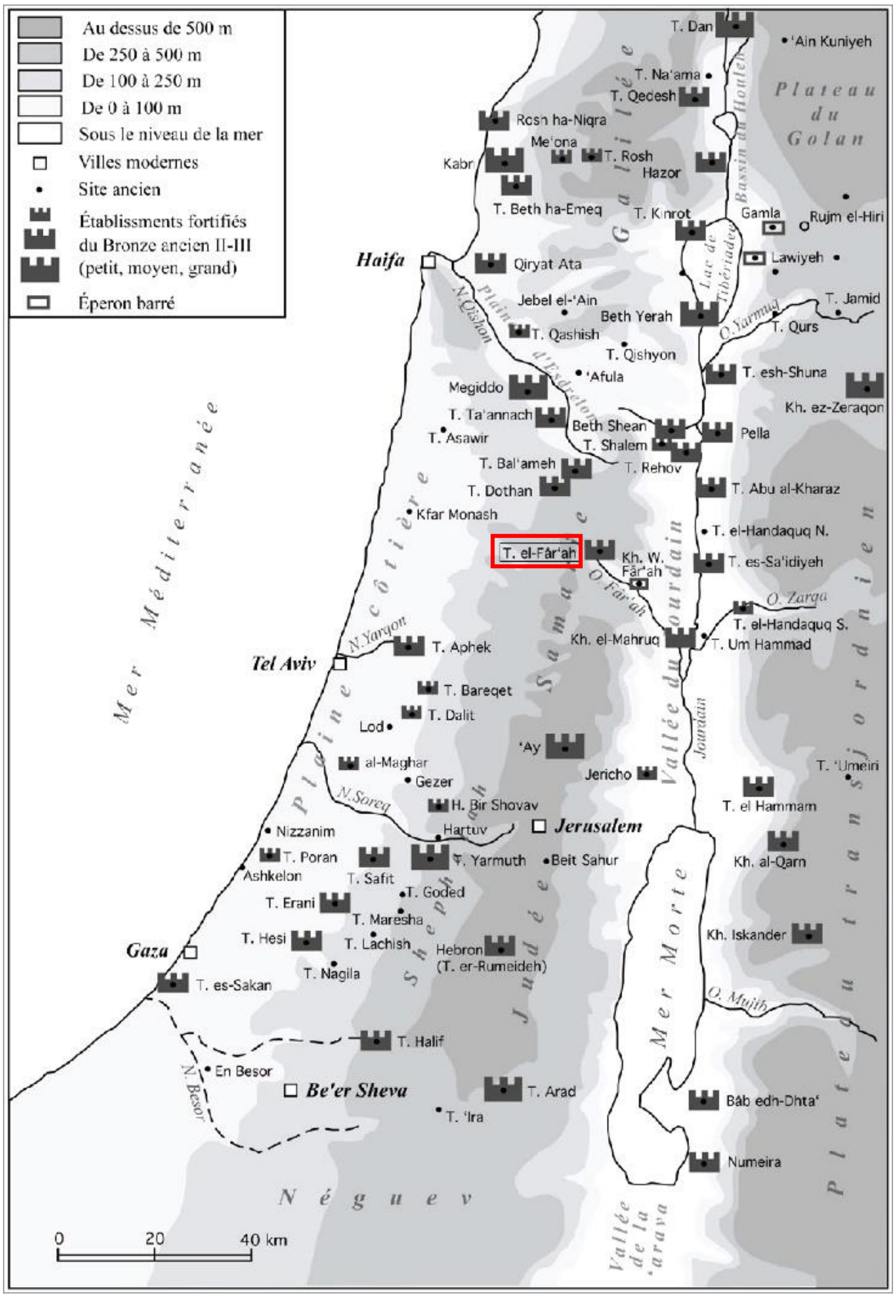

Figure 1: Localisation of the archaeological site of Tell el-Far‘ah North (modified after Medeghini et al., 2019).

During the Early Bronze Age (EBA) occupation in the region, political and socio-economic changes, with respect to the traditions that have been maintained and those that have faded, are noticeable in the material culture, and in particular in the pottery industry and in its technological developments. At Tell el-Far‘ah North, the presence of a two-story pottery kiln (de Vaux, 1955) suggests the existence of professional potters at the site and it is associated with the appearance of Metallic Ware vessels during the EB II period. In fact, the appearance of Metallic Ware was probably connected with technological achievements in the pottery industry, as improved sieving procedures in the preparation of clays and the introduction of close kilns in the firing process (Medeghini et al., 2019).

About the EBA ceramic production in the southern Levant, it is difficult to speak of a mass-production in one place and a subsequent distribution in large quantities over a considerable distance. EBA pottery industry is generally characterized by a prominent regionalism and by a production at a local level, in villages during the EB I or in major centres in the following EB II–III urban period. In this respect, the Upper Jordan Valley, and adjacent northern regions of Galilee, Jezreel Valley, Golan plateau, northern Transjordan and Lebanese Beqa‘ during the EB II, provide a rare example with the diffusion of a distinctive class of North Canaanite Metallic Ware that was distributed to sites as far away as 100 km. Since Metallic Ware industry appears in conjunction with early urbanization in the area, a study of this ceramic production may provide valuable insights into the far-reaching changes that occurred at that time in the socio-economic system and craft organization (Greenberg & Porat, 1996).

3.1 Archaeological Investigations and Historical Occupation of the Site

The archaeological site of Tell el-Far‘ah North was first identified by William Foxwell Albright. Most of the collected information comes from the French mission by the *École Biblique et Archéologique Française de Jérusalem*, carried out between 1946 and 1960 and coordinated by the archaeologist Roland de Vaux. The excavations at the site began in 1946 and were suspended in 1951 due to the discovery of the Dead Sea Scrolls. The work was resumed in 1954 and continued until 1960. Preliminary publications of excavation results were made by Vaux, director of the French mission. After his death in 1971, Alain Chambon and then Joël Mallet published in the 1980s the final reports on the Middle Bronze and Iron Age strata (Jasmin Michael, 2013), whereas the EBA occupation is still largely unpublished.

Four areas were excavated, three of them (II, III and IV) were located on the western side of the site and one (I) on the northern side; the central and eastern sides were not researched (Finkelstein, 2012). Thanks to the archaeological excavations, it was possible to identify a long-term occupation at the site, from the Neolithic to the Roman period (Miroschedji, 1993).

At the beginning of the EB II (3300–2700 BC), the site seems to have developed fairly abruptly, until the EB IB village became a fortified town and massive fortifications surrounded the mound, a feature characterizing many contemporary settlements in the southern Levant. Through archaeological research and excavations, there is evidence that the fortifications were rebuilt several times and were connected to a monumental city gate. Dwelling quarters consisting of rectangular houses and specialized craft installations were also built. The EB II occupation at Tell el-Far‘ah North exhibits a continuous growth: at least six building phases are recognizable before the town was abandoned around the mid-third millennium BC (Miroschedji, 1993). This abandonment is not a unique feature of Tell el-Far‘ah, but rather a process that occurred in many other areas of Southern Levant, where fortified towns disappeared at the end of EB II and the territory was incorporated into the socio-economic system of larger EB III city-states (Jasmin Michael, 2013). However, the focus of this research is more specifically at the beginning of the EB II, a period in which the presence of Metallic Ware was identified in the region.

The mound of Tell el-Far‘ah North was reoccupied only centuries later, during Middle Bronze II. The remains show an occupation in a village phase, until around 1600 BC a new fortification system was built. This evidence shows that the perimeter of the new fortifications was much smaller than the one built in the EBA, despite it followed the same line to the west, in area II (Jasmin, 2013).

Tell el-Far‘ah North is also recognized as the first capital of the Northern Kingdom, “Tirzah”, between the late 10th and early 9th centuries BC, also referred in the Bible as one of the cities in the Canaanite region during Joshua’s conquest (Joshua 12:24). This makes Tell el-Far‘ah North an important site for the research on the early years of the Northern Kingdom (Finkelstein, 2012).

3.2 Metallic Ware: An EB II Specialized Production in the southern Levant

Metallic Ware has been long recognized a distinctive pottery production of the EB II period in northern Palestine and the adjacent regions, distinguished by its highly fired fabric. Despite its importance, Metallic Ware has not been described systematically in the archaeological literature. As Greenberg & Porat (1996) pointed out, several overlapping terms were used to designate Metallic Ware vessels, such as *Combed Ware* and *Abydos Ware*, but the identification and definition of this ceramic production remained somewhat vague. Characteristic of Metallic Ware is the fabric, that is, the composition and especially the high firing of the paste that helps in the identification.

Greenberg & Porat (1996) identified and described a specific class of North Canaanite Metallic Ware, which reveals a similar geological provenance (Lower Cretaceous formations that crop out mainly in the Hermon massif) and spread in the EB II in the Hula and upper Jordan Valleys, the Galilee and the Jezreel Valley, the Golan plateau, the southern Lebanese Beqa‘, the highlands and coast of southern Lebanon. Here, Metallic Ware constitutes a substantial part of the local pottery assemblage. It was found as far as Tel Ta‘anak in the south and Khirbet ez-Zeraqun in the east. There are some other archaeological sites in the region where it was retrieved on smaller scales (Greenberg & Porat, 1996).

Greenberg & Porat (1996) define this specialized production as follows: “*Metallic Ware is brittle to the touch, sounding a distinctive ring when struck. In section, it is generally uniform in appearance, rather coarse grained and evenly fired, with gray cores appearing mainly in large vessels*” (Greenberg & Porat, 1996). Fragments appear in varying shades of red, where thin vessels are usually almost yellowish or grey, whereas thicker vases have a grey or brown colour, which indicates a firing under reducing conditions. When observed under an optical microscope, one of its characteristics is its uniform appearance, with coarse grains and uniform firing, with greyer *nuclei* appearing in large vessels. The prevailing temper ranges from shades of red to grey and black. On the other hand, carbonates (white grains) are less prevalent and there is no evidence of the use of organic temper.

Petrographic analysis showed that several types of temper were found, where shale fragments were frequent and may have been intentionally added to the clay or part of the original leaflets. They were not well mixed with the other raw materials. Another temper found was quartz, its possible source being mature sandstone; carbonates were observed in milky colour due to high burning temperature; siltstones, basalt, and other volcanic fragments and oolites were also observed. As far as the matrix is concerned, due to the high firing temperature, it was found sometimes vitrified, with the silty components corresponding to quartz, iron oxides, carbonates, and mica laths (Greenberg & Porat, 1996).

Overall, the raw materials used for Metallic Ware differ significantly from those used in other contemporary wares.

As for the decoration, this type of ceramics is characterized by little decoration, except for pattern combing, thin slips and continuous (or, rarely, patterned) matte burnish. It seems possible that, due to the high firing temperature in the manufacture of Metallic Ware, the characteristic shine present on other EBA ceramics has been lost. From a typological point of view, Metallic Ware did not bring significant innovations. It duplicates the EBA repertoire of household forms (both open and closed shapes), except for cooking pots. Metallic Ware vessels suggest that they were designed aiming at greater functionality and simplified symmetry. Due to their thin walls, ceramics were relatively lighter and easier to be transported. The manufacturing process involved different techniques such as mould or the upside-down method and coils. Vertical burnish and pattern-combing were techniques used in the most practical and technical sense to soften, hide, and standardize joints between the coils. As highlighted by Medeghini et al. (2019), in the EB II a vast amount of ceramics was still manufactured in the coil-built technique; however, the upper part of carinated bowls, as well as necks and rims of jugs, jars and pithoi were often finished or shaped on the potter’s wheel, bringing innovation in the ceramic production technology of the EB II compared to previous EB I manufacture (Roux, 2009)

Archaeological research carried out in the region corroborates that North Canaanite Metallic Ware was dominant in EB II, has little in common with the ceramic production of previous EB I and its presence were drastically reduced throughout EB III. A typological innovation was recognized in EB III contexts: the “sharply everted feathered-edge folded rim and rope-decorated neck on pithoi”. In fact, some types of Metallic Ware vessels, and especially *pithoi*, continued to be produced in EB III, even when the production of Metallic Ware was already dwindling.

In a parallel development, a Metallic Ware production petrographically distinct from the northern vessels also spread to southern Palestine in the EB III. Southern sites where Metallic Ware was found are Tel Yarmuth, Tell el-Hesi, and Lachish (Greenberg & Porat, 1996).

Pirhiya Beck characterized as “Metallic Ware” a group of EB II small carinated bowls (and other bowl types in lesser quantities) from Tel Aphek and other sites in the central hill country, produced in a very fine brownish-red clay, well-levigated with minute grits (Beck, 1985) These bowls have a different petrographic composition from the North

Canaanite Metallic Ware described by Greenberg & Porat (1996), but the high firing temperature gives the vessels a characteristic metallic quality.

The archaeological site of Tell el-Far‘ah North is one of the sites where a minor quantity of Metallic Ware sherds was identified by Greenberg and Porat, but no petrographic analyses were carried out (Greenberg & Porat, 1996). Moreover, Pirhiya Beck recognized at Tell el-Far‘ah North specimens of her “family” of metallic ware bowls (Beck, 1985).

Among the vessels with a metallic quality, a group of small carinated bowls sometimes provided with a small horizontal lug handle, produced in a highly-sieved brown-reddish ware, self-slipped and hand-burnished both externally and internally, may be preliminary distinguished in the EB II pottery repertoire of Tell el-Far‘ah North (Medeghini et al., 2019). Aim of this research is to analyse petrographically these bowls, to identify the raw materials used in pottery production and thus to define this class of Metallic Ware, which possibly characterized the central region where Tell el-Far‘ah North was one of the major centres.

4. Geographical and Geological setting

It is not possible to infer about the development of society and material culture in the region of Tell el-Far'ah North without considering the geographical and geological characteristics, climate, water, and other natural features. As previously mentioned, the archaeological site of Tell el-Far‘ah North is located in the Nablus district, in the northern part of the West Bank. In this region, the occupation of artificial hills known as *Tell* was common. The *Tell* had an average area of 7-20 acres; the smallest known is half an acre, while the largest, Tel Hazor, measures 200 acres. These occupations took place for periods between one and two thousand years, which generated distinct stratigraphic layers that help and are important to understand the occupations and the populations that lived there (Mazar, 1992). The archaeological site of Tell el-Far'ah North is located on an expressive *Tell* under a rocky plateau of 198 m altitude. Its extension is around 600 m long by 300 m wide, which reaches an area of around 18 hectares (Fenollós et al., 2017).

For the occupation and development of ancient cities, some basic requirements were necessary, such as a possible natural defence, communication route and the place should be well supplied with water and natural resources. In the case of Tell el-Far'ah North, it was located on a hill on the route that connected the Jordan River valley (27 km west) with the region of the ancient city of Shechem (currently Tell Balata, in Nablus) and nearby natural watercourses, such as Ain ad-Dlaid and Ain al-Far'a, were present. Generally, these chosen places were occupied for long periods and for different generations (Fenollós et al., 2017).

The geological area (Figure 2) is formed by Cretaceous and Tertiary marine carbonate sedimentary rocks (limestones, dolostones, chalks and marls) along with Jurassic formations outcrop nearby the archaeological site. Both Jurassic formations, the Lower Maleh (limestones with basalt) and the Upper Maleh Formation (marl or chalk with chalky limestones) overlie a basic igneous basement. The Ramali Formation (Lower Cretaceous) consists of sandstone and outcrops in the Wadi Far‘ah, mainly composed of craggy limestone. The Beit Kahil Formation (Cenomanian) is composed of limestone, alternated with sandy marls and shales which outcrops in the Wadi Far‘ah. The upper part of this formation consists of dolostones and chalky, marly limestone. Over this, the Yatta Formation with marl, chalky limestone, clay and thin interbedded dolomitic limestone is covered by the Hebron Formation with blue-green limestone and dolomitic limestone. The Bethlehem Formation is the last Cenomanian formation consisting of dolostones, limestones, chalks, and marls. The Jerusalem Formation (Turonian) is mainly represented by limestones, dolostones and chalk. Tertiary rocks consist of the Jenin subseries (limestone and chalk) and the Bayda Formation (mainly represented by conglomerates). The first formation, widely spread, covers one third of the Nablus district. During the Quaternary, the Lisan Formation (laminated marls and gypsum), the alluvium (unconsolidated marls with siliceous sand) and the Nari Formation were deposited (Medeghini et al., 2019).

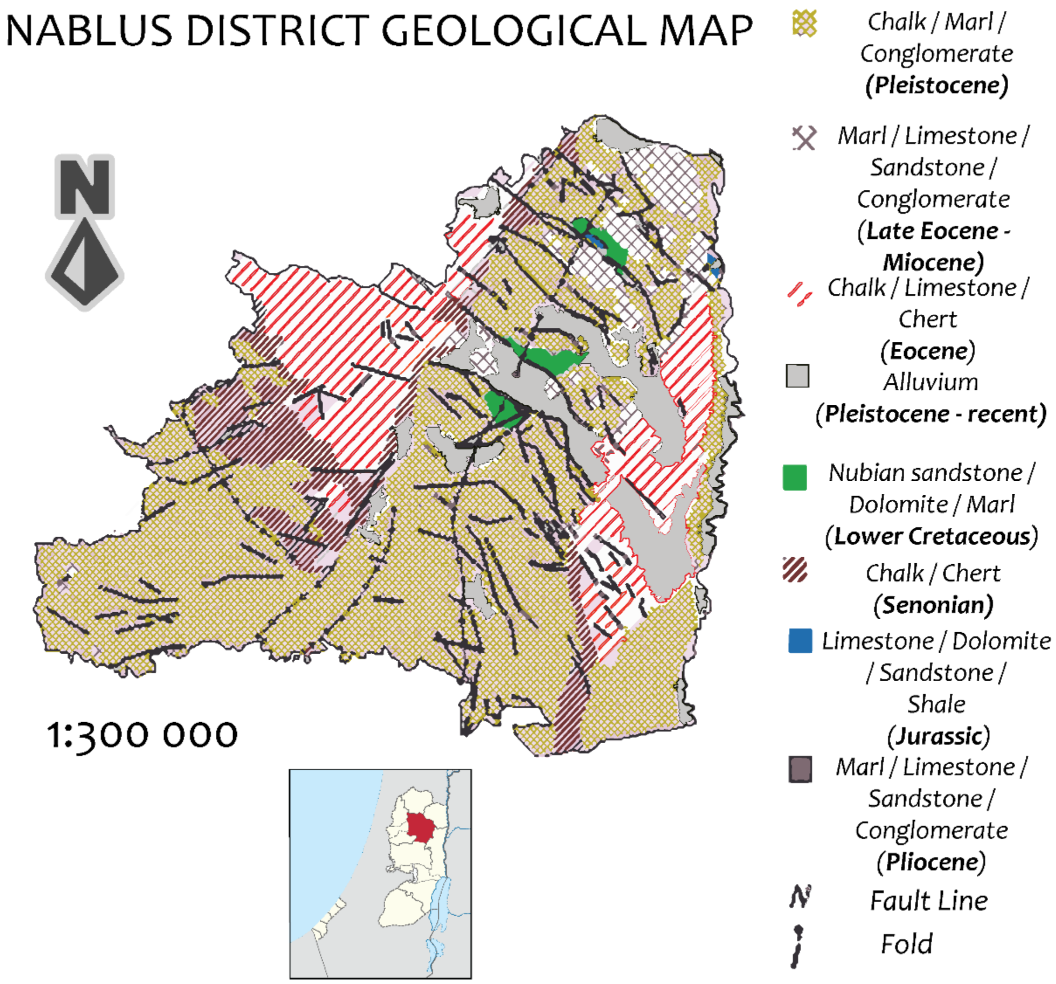

Figure 2: Geological map of the city of Nablus, where the archaeological site of Tell el-Far'ah North is located.
(Adapted from Applied Research Institute of Jerusalem, 1996 by L. Drahotusky-Bruketa).

5. Materials and methods

5.1 Materials

Ten sherds of a distinctive highly specialized production identified as Metallic Ware from the archaeological site of Tell el-Far‘ah North were analysed for this thesis project. Only the sample TFN.1947.L.84/2=F.718 was previously analysed and published in Medeghini et al. (2019). This sample was included for comparison because it was the only Metallic Ware sherd analyzed in that study and showing completely different features from other samples.

The assemblage of ceramic sherds collected and analysed consists of samples from the EB IIA–B (3000–2700 BC). The analysed pottery sherds are parts of small bowls with a simple or thinned rim, a rounded base and a carinated wall at times provided with a small horizontal lug handle applied at the girth, as illustrated in the Figure 3. All these bowls are characterized by a burnished decoration both inside and outside.

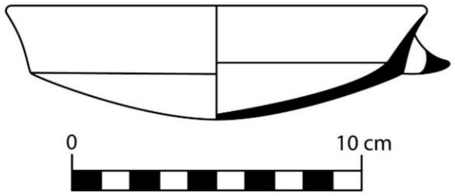

Figure 3: Example of a technical drawing of the carinated bowl typology (Sketch by Felipe Tadeu Gondim, 2020)

Sample TFN.1958.L.652/1 (EB IIA)

This sample is a fragment of carinated bowl including a very thin rim and rounded base, with a reddish-brown colour both in fracture and in surface.

Figure 4: Sample TFN.1958.L.652/1 (EB IIA). (Image, 2020)

Sample TFN.1958.L.656/15 (EB IIA)

This sample is a fragment of carinated bowl including a very thin rim and part of the base, with a reddish-brown colour both in fracture and in surface.

Figure 5: Sample TFN.1958.L.656/15 (EB IIA).
(Image, 2020)

Sample TFN.1959.B.658/2 (EB IIA)

This sample is a fragment of carinated bowl including a very thin rim and part of the rounded base, with a reddish-brown colour both in fracture and in the surface.

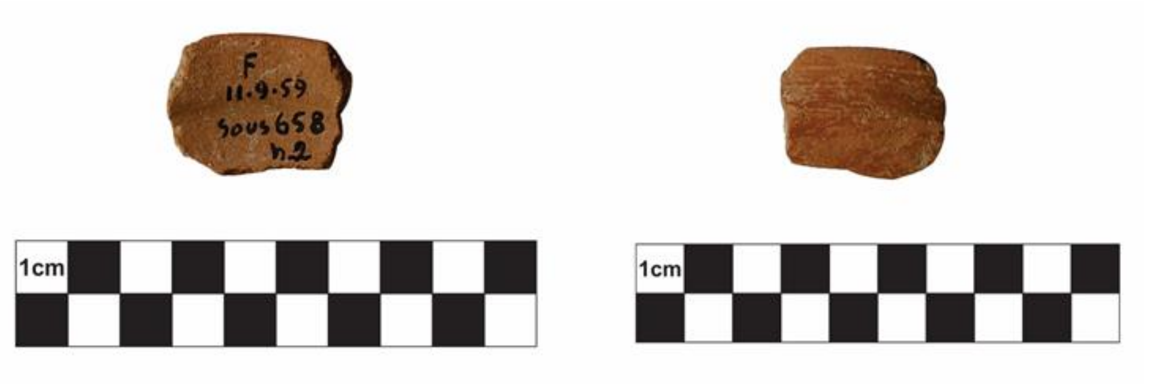

Figure 6: Sample TFN.1959.B.658/2 (EB IIA).
(Image, 2020)

Sample TFN.1954.L.270/1 (EB IIA)

This sample is a fragment of carinated bowl including a very thin rim, part of the rounded base, and a lug handle applied at the girth, with a reddish-brown colour both in fracture and in the surface.

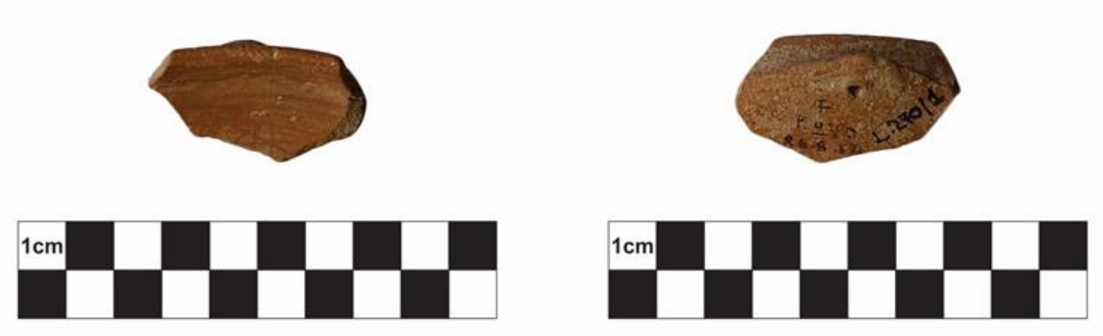

Figure 7: Sample TFN.1954.L.270/1 (EB IIA-B).
(Image, 2020)

Sample TFN.1958.L.614/2 (EB IIA-B)

This sample is a fragment of carinated bowl including a very thin rim and rounded base, with a reddish-brown colour both in fracture and in the surface

Figure 8: Sample TFN.1958.L.614/2 (EB IIA-B).
(Image, 2020)

Sample TFN.1954.L.247/1 (EB IIB)

This sample is a fragment of carinated bowl including a thinned rim and part of the base, with a reddish-brown colour both in fracture and in surface

Figure 9: Sample TFN.1954.L.247/1 (EB IIB).
(Image, 2020)

Sample TFN.1954.B.264/1 (EB IIB)

This sample is a fragment of carinated bowl including a very thin rim and rounded base, with a reddish-brown colour both in fracture and in the surface

Figure 10: Sample TFN.1954.B.264/1 (EB IIB).
(Image, 2020)

Sample TFN.1960.L.760/2 (EB IIB)

This sample is a fragment of carinated bowl including a very thin rim and part of the rounded base, with a reddish-brown colour both in fracture and in surface.

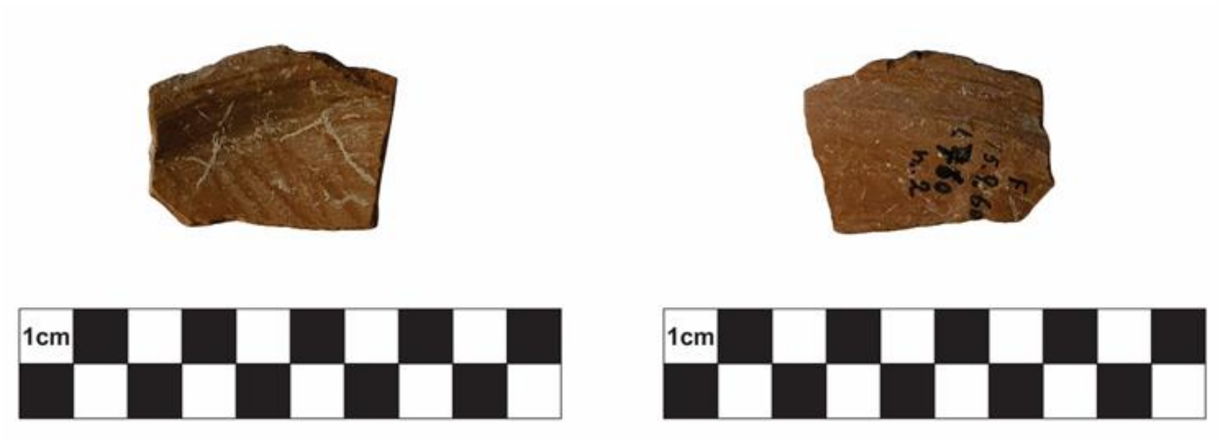

Figure 11: Sample TFN.1960.L.760/2 (EB IIB).
(Image, 2020)

Sample TFN.1960.L.801/24 (EB IIB)

This sample is a fragment of carinated bowl including a very thin rim and part of the base, with a reddish-brown colour both in fracture and in the surface

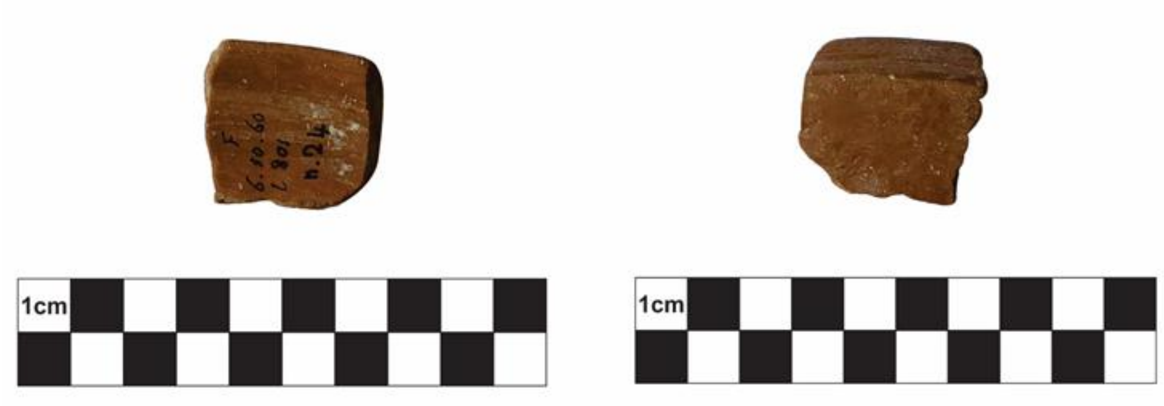

Figure 12: Sample TFN.1960.L.801/24 (EB IIB).
(Image, 2020)

Sample TFN.1947.L.84/2=F.718 (EB IIB)

This sample is a fragment of carinated bowl including a very thin rim and part of the base, with a reddish-brown colour both in fracture and in the surface.

Figure 13: Sample TFN.1947.L.84/2=F.718 (EB IIB).
(Image, 2020)

5.2 Analytical Techniques

No technique alone can give a complete picture of a heterogeneous material as ceramics. Thus, it is necessary to combine techniques and to compare the results obtained with different techniques. Therefore, the chosen techniques that best fit the questions raised in this thesis, as mentioned before, are Optical Microscopy and X-Ray Powder Diffraction, which are used for mineralogical and petrographic analysis.

5.2.1 Optical microscopy

Optical microscopy allows to study the mineralogical and petrographic composition of samples, not clearly visible to the naked eye. Indeed, it helps to identify minerals and rock fragments (Braekmans & Degryse, 2019) composing the ceramic material; in addition, it provides information about technological production, as well as to identify the origin of the raw materials.

For sample preparation, sherds were firstly photographed, then they were taken to the Thin Sections Laboratory at the Department of Earth Sciences – Sapienza University of Rome. At the Laboratory, samples were handed over to responsible Dr. Domenico Mannetta, who first cut the samples (figure 14). Fragments were then embedded in resin, moulded, and polished to reach a thickness of about 30 microns (figure 15).

Figure 14: Ceramic samples after the cut for thin section preparation.
(Images Gondim, 2020)

Samples were then analysed by a polarized Optical Microscope Leica DM750 P camera Leica MC190 HD (Department of Earth Sciences, Sapienza University of Rome, Italy) with the software LAS V4 4.12 and described basing on Whitbread's criteria (I. K. Whitbread, 1986; Ian K. Whitbread, 1995). This consists in the analysis of inclusions, matrix, and pores.

Among the inclusions we can distinguish minerals, rock fragments, or organic inclusions naturally present in the soil or added in the manufacture of the artefact.

Inclusions were identified and described according to the criteria of percentage, size, shape, rounding, spacing, distribution and alignments. Inclusions above 10 μm are considered inclusions whereas, inclusion smaller than 10 μm are considered part of the matrix. Inclusions can be defined as plastic (clay pellets, grog, organic material) and aplastic (minerals, rock fragments, shells, bones, and microfossils).

Concerning the pores, we need to describe the percentage, the shape as planar voids, canals, voids and vesicles and the alignment. The pores may occur as a result of the pottery manufacturing process or can be related to the preparation of the thin section.

Finally, the matrix is the most abundant component of the ceramic and this is composed mainly of clay minerals (< 2 μm) which cannot be identified in thin section. The calcareous nature, the colour in plane polarized light (PPL) and crossed polarizers (XPL), and the optical activity of the matrix were considered.

In addition, this analysis adopts the terminology of soil micromorphology to describe and classify argillaceous inclusions identified in ceramic thin section (Whitbread, 1986).

Figure 15: Thin sections of the samples.
(Images Gondim, 2020)

5.2.2 X-Ray Powder Diffraction (XRPD)

X-Ray Powder Diffraction (XRPD) was also performed for the semi-quantification of the mineralogical composition, in order to estimate firing temperatures. Indeed, this technique can identify both the mineral phases belonging to the raw material that survived and those that were formed during the burning process.

For XRPD sample preparation, a small part of the sample was ground. For that, an agate mortar was used to grind the collected sample. For each sample, the tools used for the collection (figure 16) were sanitized with water and denatured ethyl alcohol, in order to avoid contamination of the samples.

Ceramic powder was analysed by a Bruker D8 focus diffractometer (Department of Earth Sciences, Sapienza University of Rome, Italy) with CuKα radiation, operating at 40 kV and 30 mA. The following instrumental set-up was chosen: 3–60° 2θ range, scan step of 0.02° 2θ/ 2s. Data processing, including semi-quantitative analysis based on the "Reference Intensity Ration Method", was performed using X Powder X software.

Figure 16: tools used for preparation of the XRPD samples.
(Images Gondim, 2020)

6. Results

6.1 OM in thin section

Through the analysis of the thin sections it was possible to identify the nature, percentage, and grain size of the inclusions. The samples analysed can be divided in two different groups: the first includes most samples (TFN.1954.L.247/1, TFN.1954.B. 264/1, TFN.1958.L.614/2, TFN.1958.L.652/1, TFN.1960.L.760/2, TFN.1960.L.801/24, TFN.1954.L.270/1, TFN.1947.L.84/2=F.718) showing mainly quartz as inclusion, whereas samples TFN.1958.L.656/15 and TFN.1959.B.658/2 are mainly characterized by calcareous inclusions.

Below, a detailed description of each sample and a summary of its petrographic description is provided (Table 1).

Sample TFN.1958.L.652/1

Sample TFN.1958.L.652/1 (EB IIA) (Figure 17) has mainly elongated and equant inclusions (40%), distributed from single-spaced to double-spaced, from sub-rounded to angular in a black core from orange to brown at PPL, while the matrix is calcareous and has optical activity. The predominance of inclusions is quartz (elongated and equant, angular to rounded, 0.04 - 0.32 mm) from sedimentary rocks, (equant to elongated, sub-rounded to rounded, 0.06 - 0.89 mm), common iron oxide nodules, (equant, rounded to well rounded, 0.02 - 0.22 mm), few fragments of siliceous rocks, (equant and elongated, sub-round to subangular, 0.06 - 0.45 mm) along with some feldspars (elongated and equant, angular to rounded, 0.07 - 0.1 mm). The inclusions present unimodal grain size distribution. Regarding porosity (3%), it is composed mainly of meso- to rare micro-vesicles and of macro- to mega-*vughs*, not aligned with the margin of the sample.

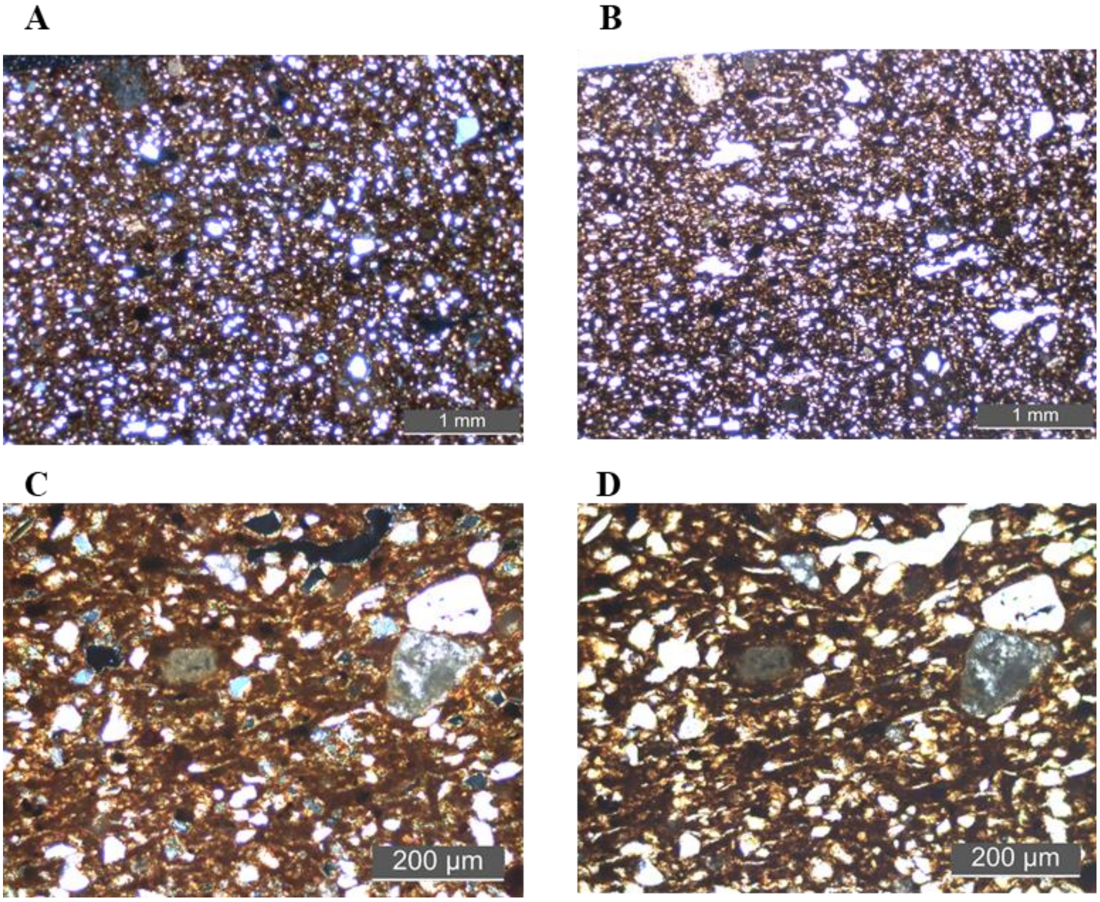

Figure 17: Microscope images of sample TFN.1958.L.652/1;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1958.L.656/15

Sample TFN.1958.L.656/15 (EB IIA) (Figure 18) is composed mostly by elongated and equant inclusions (30%) distributed from single-spaced to double-spaced, from sub-rounded to angular, orange to light brown at PPL, the matrix is calcareous and presents optical activity. The inclusions are characterized by frequent quartz (elongated and equant, angular to rounded, 0.02 - 0.1 mm), predominant nodules of iron oxides, (equant, rounded to well-rounded, 0.01 - 1.5 mm), along with very few feldspars (elongated and equant, angular to rounded, 0.01 mm). The inclusions present unimodal grain size distribution. With respect to porosity (3%), it is composed mainly of meso- to rare micro-vesicles and meso-*vughs* slightly aligned to the margin of the sample.

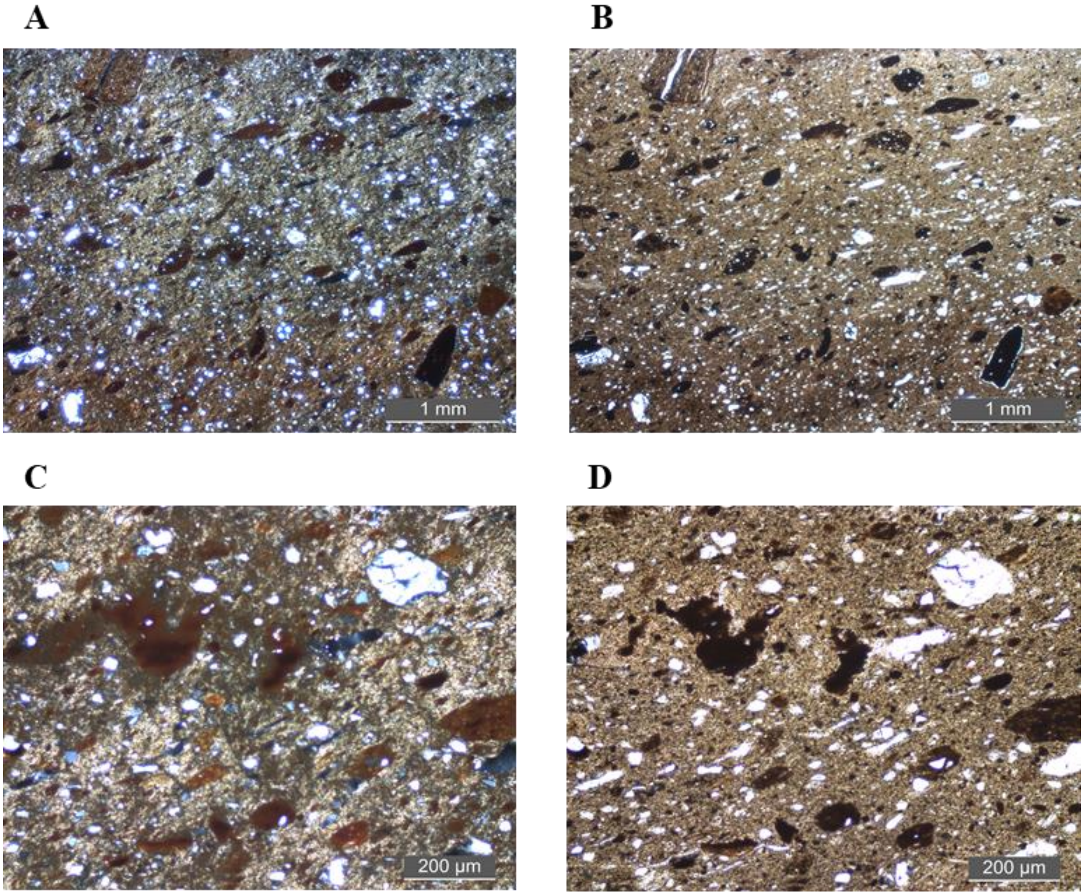

Figure 18: Microscope images of sample TFN.1958.L.656/15;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1959.B.658/2

Sample TFN.1959.B.658/2 (EB IIA) (Figure 19) presents inclusions mostly elongated and equant (30%) which are distributed from single-spaced to double-spaced, from sub-rounded to angular, yellow to light brown at PPL, the matrix is calcareous and has optical activity. Regarding inclusions, these are mainly represented by frequent quartz (elongated and equant, angular to rounded, 0.03 - 0.49 mm), predominant nodules of iron oxides (equant, rounded to well-rounded, 0.03 - 0.63 mm), very few feldspars (elongated and equant, angular to rounded, 0.02 - 0.1 mm), common sedimentary calcareous rocks (equant to elongated, sub-rounded to rounded, 0.04 - 1.3 mm) and very rare siliceous rocks (equant and elongated, sub-rounded to sub-angular, 0.04 - 0.66 mm). The inclusions present unimodal grain size distribution. The porosity (3%) is composed mainly of meso to rare micro-vesicles and meso-*vughs* a bit aligned to the margin of the sample.

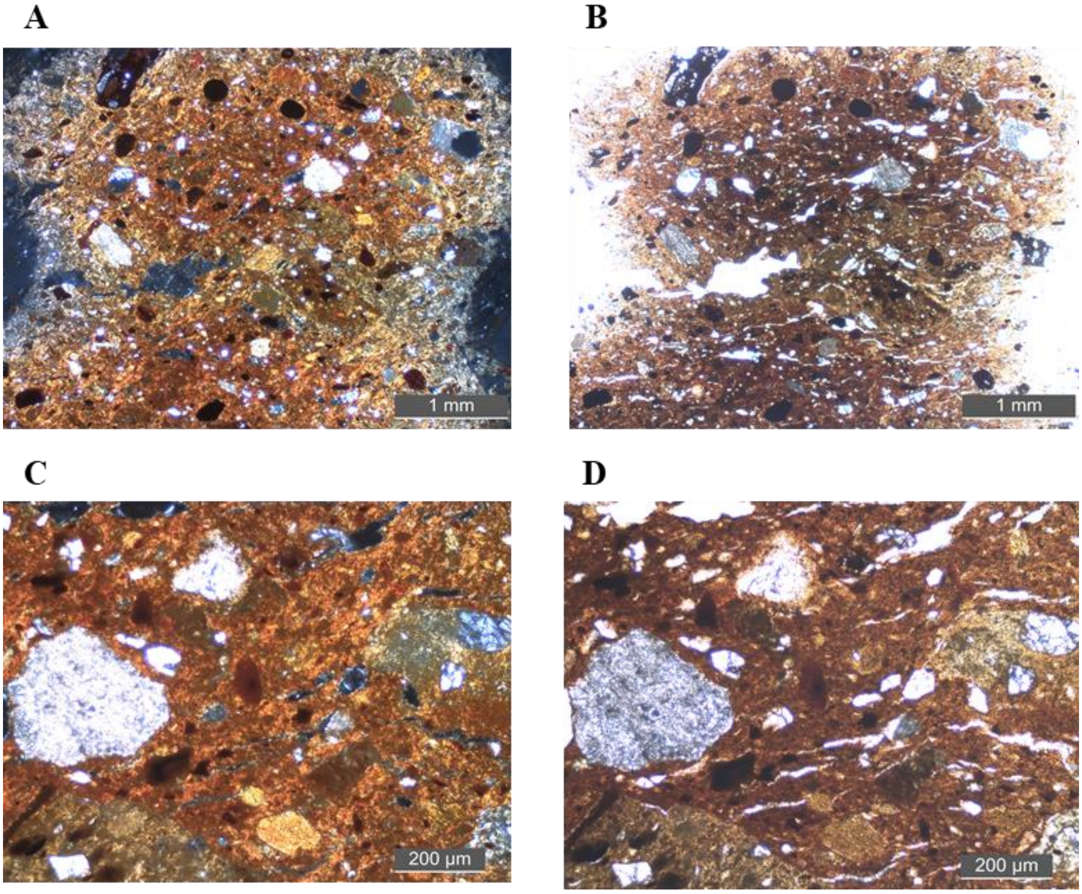

Figure 19: Microscope images of sample TFN.1959.B.658/2;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1954.L.270/1

Sample TFN.1954.L.270/1 (EB IIA-B) (Figure 20) has inclusions mostly elongated and equant (40%), distributed from single- to double-spaced, from sub-round to angular in black core from orange to brown in PPL, in a calcareous matrix with optical activity. The inclusions are represented especially by predominant quartz (elongated and equant, angular to rounded, 0.02 - 0.35 mm), sedimentary rocks (equant to elongated, sub-round to rounded, 0.05 - 1 mm) along with some feldspars (elongated and equant, angular to rounded, 0.04 - 0.1 mm), rare fragments of siliceous rock, (equant and elongated, sub-round to subangular, 0.1 - 0.4 mm) and few nodules of iron oxides, (equant, rounded to well-rounded, 0.01 - 0.17 mm). The inclusions present unimodal grain size distribution. The porosity (5%) is constituted mainly by rare meso- to micro-vesicles and mega- to meso-*vughs* aligned with the margin of the sample.

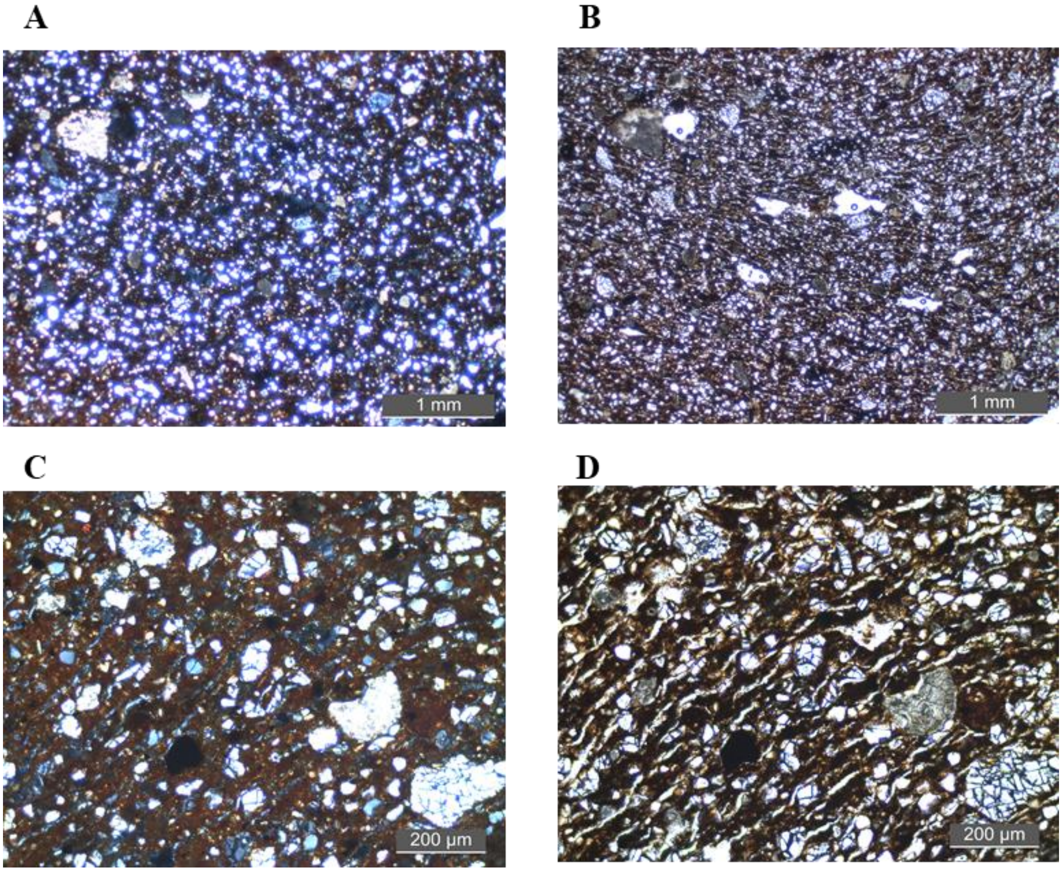

Figure 20: Microscope images of sample TFN.1954.L.270/1;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1958.L.614/2

Sample TFN.1958.L.614/2 (EB IIA-B) (Figure 21) displays mainly elongated and equant inclusions (40%), distributed from single-spaced to double-spaced, from sub-rounded to angular in a black core from orange to brown at PPL, in a calcareous matrix with weak optical activity. The inclusions are mainly represented by predominant quartz (elongated and equant, angular to rounded, 0.02 - 0.21 mm), common fragments of sedimentary rocks (equant to elongated, sub-rounded to rounded, 0.08 – 1 mm) together with few feldspars (elongated and equant, angular to rounded, 0.06 -0.14 mm), and few nodules of iron oxides, (equant, rounded to well rounded, 0.01 - 0.39 mm). The inclusions present a unimodal grain size distribution. The porosity (5%) is mainly composed of micro- to meso-vesicles and meso-*vughs* aligned to the margin of the sample.

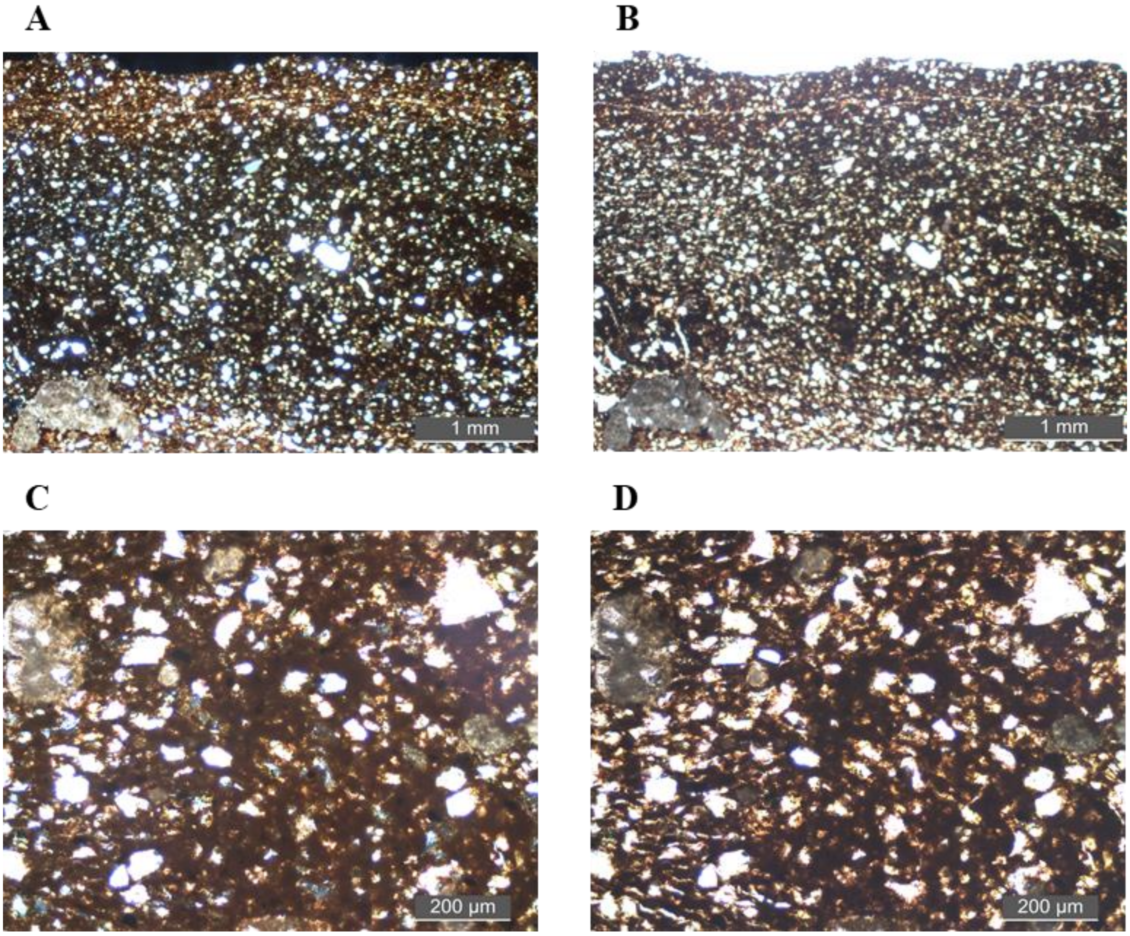

Figure 21: Microscope images of sample TFN.1958.L.614/2;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

TFN.1954.L.247/1

Sample TFN.1954.L.247/1 (EB IIB) (Figure 22) displays mainly elongated and equant inclusions (40%), distributed from single-spaced to double-spaced, from sub-rounded to angular in an orange to brown (colour at PPL), calcareous matrix, optically active. The inclusions are mainly represented by predominant quartz (elongated and equant, angular to rounded, 0.02 -0.4 mm) together with common feldspars (elongated and equant, angular to rounded, 0.02 - 0.4 mm) and fragments of sedimentary rocks (equant to elongated, sub-rounded to rounded, 0.06 – 0.2 mm), few fragments of siliceous rocks, (equant and elongated, sub-rounded to sub-angular, 0.05 - 0.6 mm) and few nodules of iron oxides (equant, rounded to well rounded, 0.03 – 0.21 mm). The inclusions show a unimodal grain size distribution. The porosity (5%) is mainly composed of micro- to macro-*vughs* and from micro- to meso-vesicles aligned to the margin of the sample.

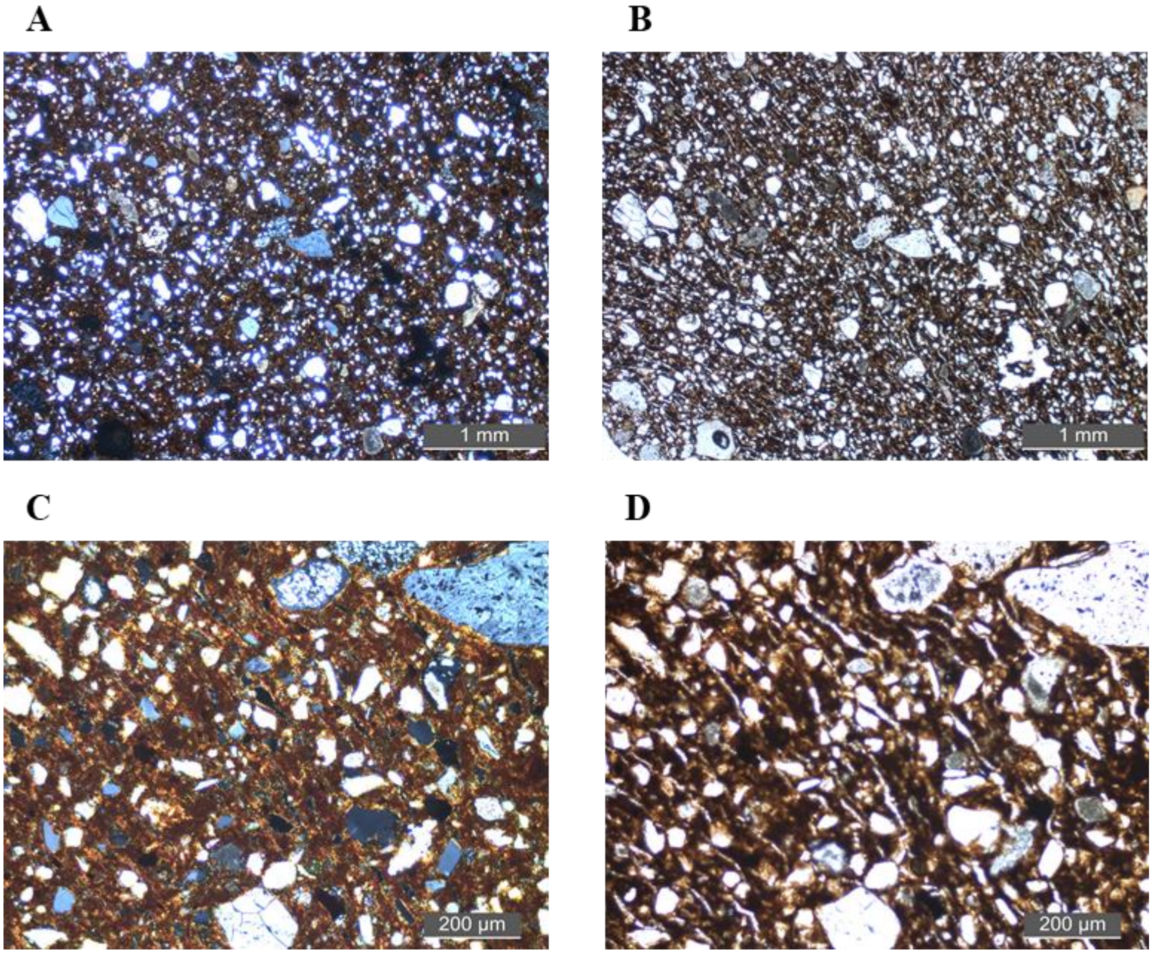

Figure 22: Microscope images of sample TFN.1954.L.247/1;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

TFN.1954.B.264/1

Sample TFN.1954.B.264/1 (EB IIB) (Figure 23) presents inclusions mostly elongated and equant (40%), distributed from single- to double-spaced, from sub-round to angular in a black nucleus from orange to brown in PPL, the matrix is of limestone origin and presents optical activity. The inclusions are represented mainly by predominant quartz (elongated and equant, angular to rounded, 0.02 - 0.21 mm), sedimentary rocks (equant to elongated, sub-round to rounded, 0.06 - 1.5 mm) and few feldspars (elongated and equant, angular to rounded, 0.05 - 0.1 mm), few fragments of siliceous rocks (equant and elongated, sub-round to subangular, 0.05 - 0.45 mm) and few nodules of iron oxides, (equant, rounded to rounded well, 0.01 - 0.15 mm). The inclusions show a unimodal grain size distribution. Composed predominantly of micro- to meso-vesicles and rare micro- to macro-*vughs* aligned with the margin of the sample, the porosity is 3%.

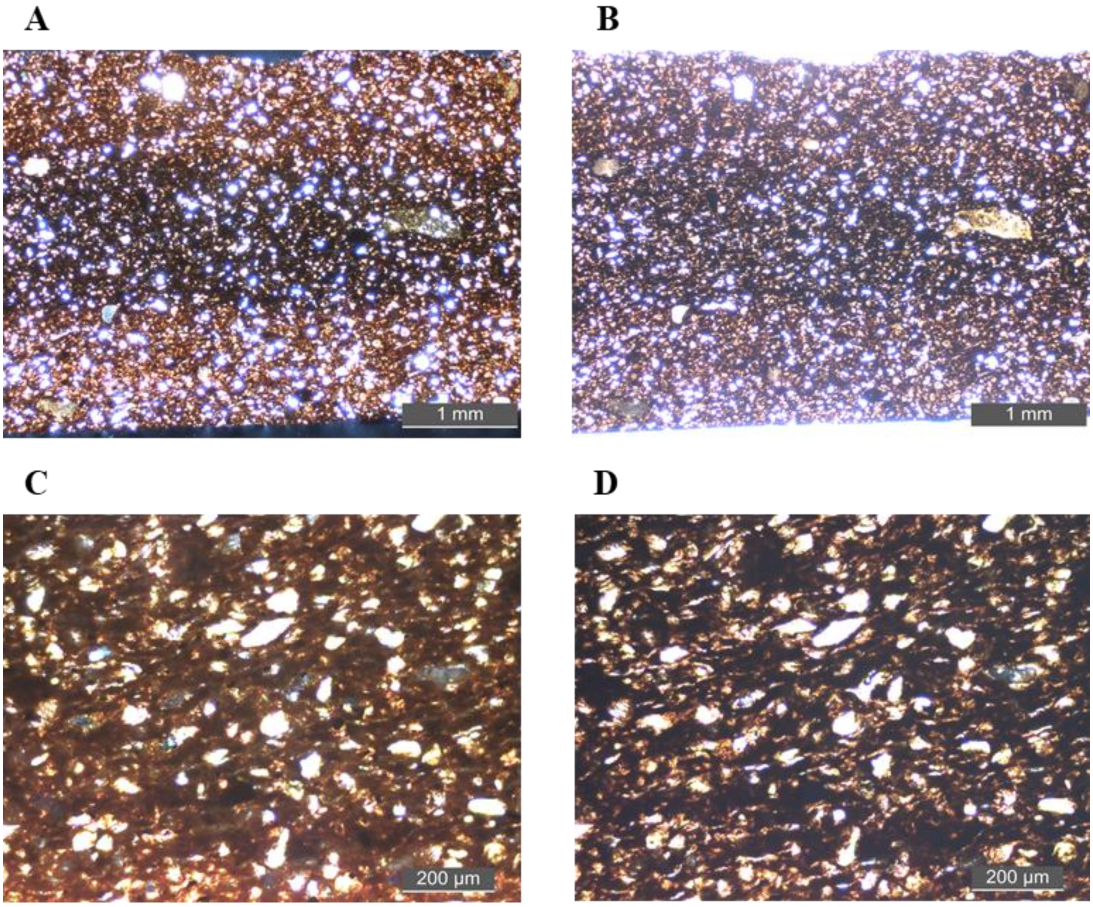

Figure 23: Microscope images of sample TFN.1954.B.264/1;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1960.L.760/2

Sample TFN.1960.L.760/2 (EB IIB) (Figure 24) has inclusions in its majority elongated and equant (40%), distributed from single- to double-spaced, from sub-rounded to angular in orange to brown in PPL, the nature of the matrix is calcareous and has optical activity. The inclusions are represented by predominant quartz (elongated and equant, angular to rounded, 0.03 - 0.26 mm), fragments of sedimentary rocks (equant to elongated, sub-round to rounded, 0.03 - 0.6 mm) along with some feldspars (elongated and equant, angular to rounded, 0.06 - 0.1 mm), rare fragments of siliceous rocks (equant and elongated, sub-round to subangular, 0.2 - 0.3 mm) and common nodules of iron oxides (equant, rounded to well rounded, 0.04 - 0.22 mm). The inclusions present unimodal grain size distribution. The porosity (5%) is composed mainly of rare meso- to micro-vesicles and meso- to mega-*vughs* not aligned with the margin of the sample.

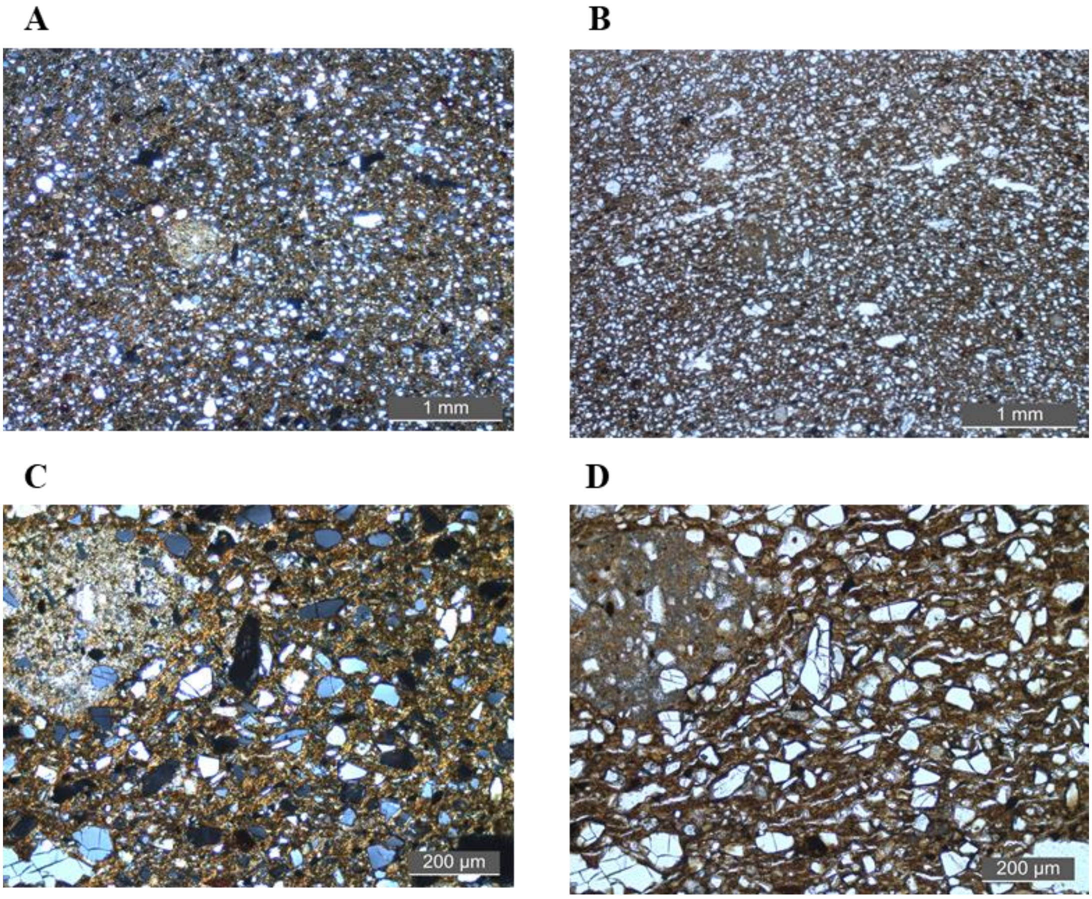

Figure 24: Microscope images of sample TFN.1960.L.760/2;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1960.L.801/24

Sample TFN.1960.L.801/24 (EB IIB) (Figure 25) presents inclusions mainly elongated and equant (40%), distributed from single- to double-spaced, from sub-rounded to angular in an orange to brown in PPL, calcareous matrix with optical activity. The inclusions present predominant quartz (elongated and equant, angular to rounded, 0.05 - 0.36 mm), sedimentary rocks, (equant to elongated, sub-round to rounded, 0.05 - 1 mm) together with very few feldspars (elongated and equant, angular to rounded, 0.04 - 0.1 mm), rare fragments of siliceous rocks (equant and elongated, sub-round to sub-angular 0.05 - 0.3 mm) and few nodules of iron oxides (equant, rounded to well rounded, 0.02 - 0.23 mm). The inclusions present unimodal grain size distribution. With respect to porosity (5%), it is composed principally of rare micro- to meso-vesicles and meso- to mega-*vughs* aligned with the margin of the sample.

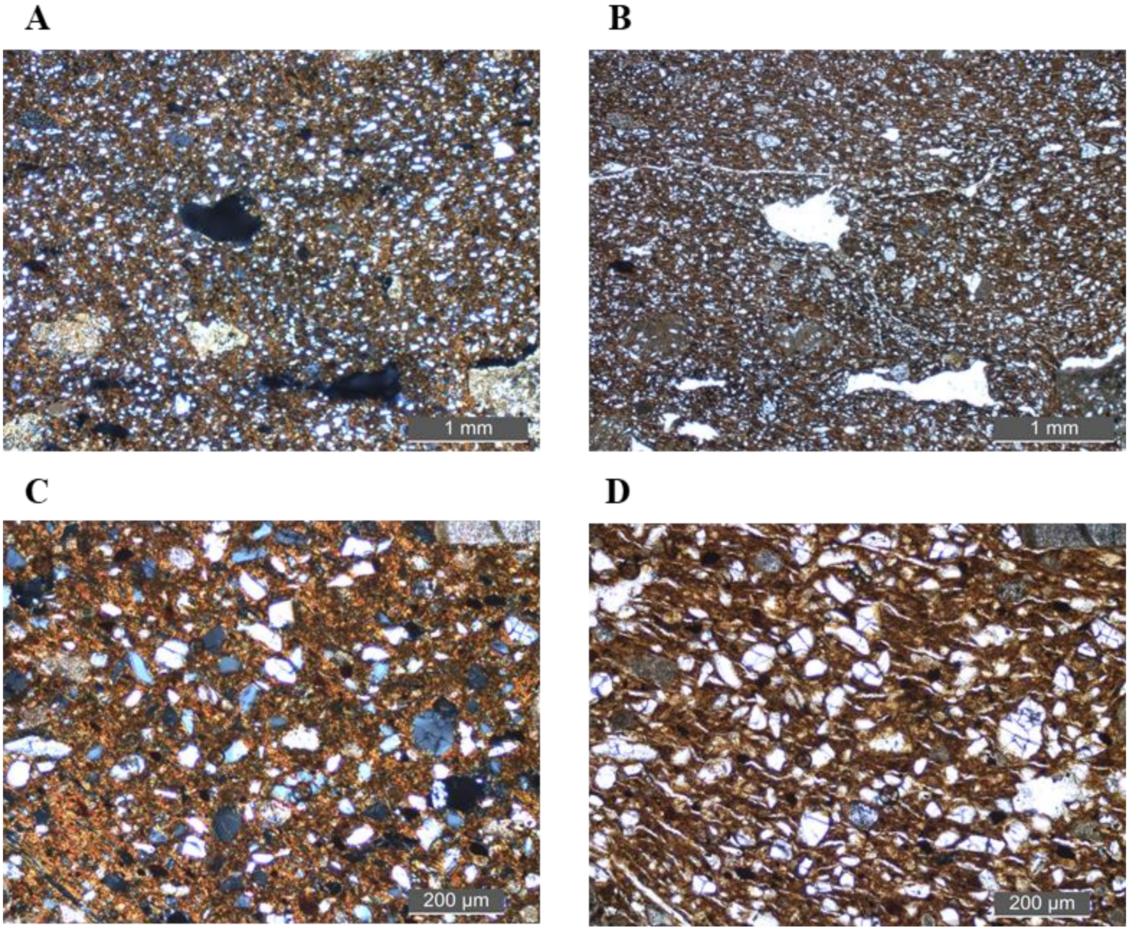

Figure 25: Microscope images of sample TFN.1960.L.801/24;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Sample TFN.1947.L.84/2 = F.718

Sample TFN.1947.L.84/2 = F.718 (EB IIB) (Figure 26) shows equant and elongated inclusions (30%) distributed from double- to open-spaced, from sub-angular to sub-rounded, in a brown to red matrix, which is calcareous, with weak optical activity. The inclusions are mostly represented by quartz and predominant feldspars (equant and elongated, sub round/subangular, 0.1 mm), together with rare fragments of sedimentary rocks (equant and elongated, sub-rounded/ sub-angular, 0.3-0.6 mm), very rare fragments of siliceous rocks (equant and angular, 0.3 mm). The inclusions present unimodal particle size distribution. The porosity is scarce (10%) and composed of meso- to micro-vesicles and macro-*vughs*, aligned with the margin of the sample.

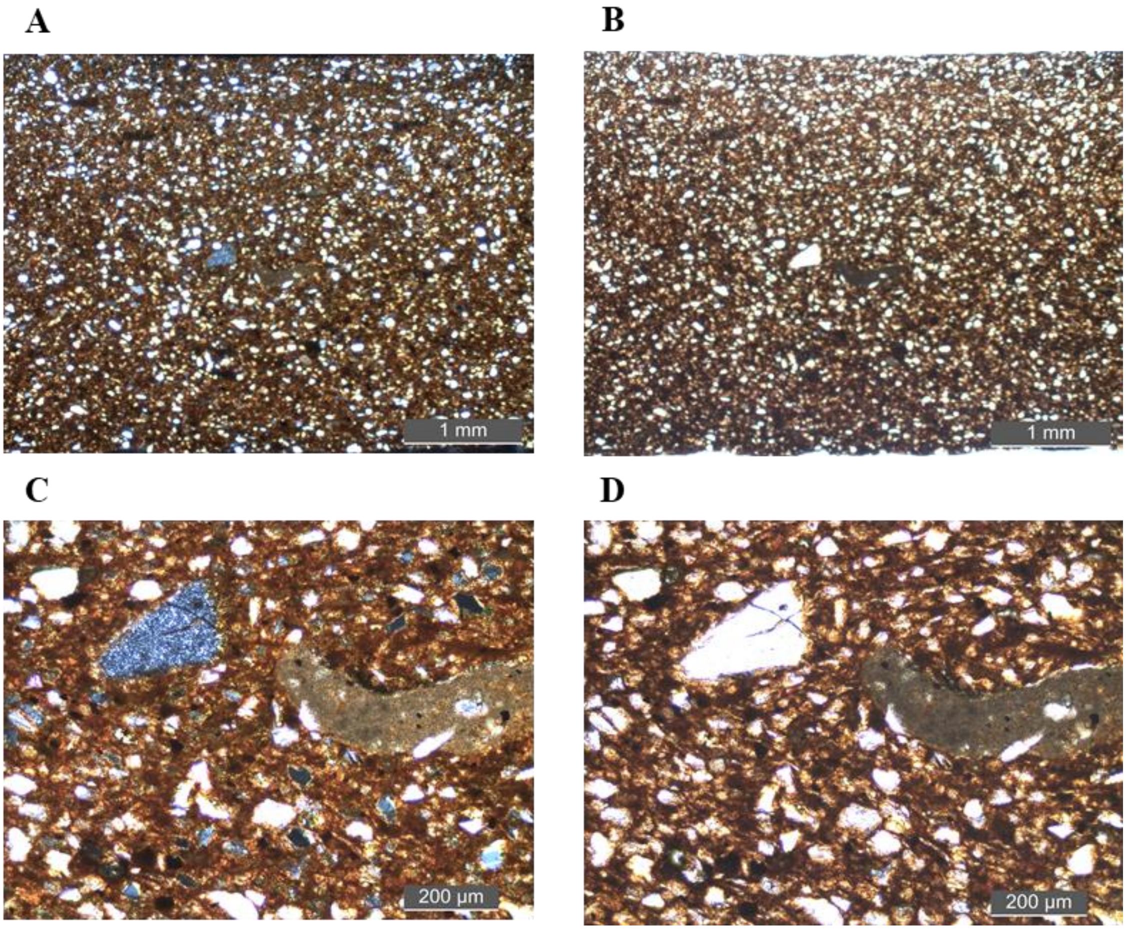

Figure 26: Microscope images of sample TFN.1947.L.84/2=F.718;
A: mag. 2.5x, XPL, B: mag. 2.5x, PPL, C: mag. 10x, XPL, D: mag. 10x, PPL.

Table 1

Samples	**Period**	**Voids**	**Matrix**	**Inclusions**
TFN.1958. L.652/1	(EB IIA)	3% Macro-mega *vughs* Meso-micro rare vesicles not aligned	57% calcareous, heterogeneous orange-brown at PPL optical activity	40% - <u>Dominant:</u> quartz, elongated and equant, from angular to rounded (0.04 - 0.32 mm) - <u>Common:</u> nodules of iron oxides, equant, from rounded to well rounded (0.02 - 0.22 mm) - <u>Common:</u> fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.06 – 0.89 mm) - <u>Few:</u> fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.06 - 0.45 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.07 -0.1 mm)
TFN.1958. L.656/15	(EB IIA)	3% meso *vughs* meso-micro rare vesicles slightly aligned	67% calcareous, heterogeneous orange-light brown at PPL optical activity	30% - <u>Predominant:</u> nodules of iron oxides, equant, from rounded to well rounded (0.01 – 1.5 mm) - <u>Frequent:</u> quartz, elongated and equant, from angular to sub-rounded (0.02 – 0.1 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.01 mm)
TFN.1959. B.658/2	(EB IIA)	3% meso *vughs* meso-micro rare vesicles slightly aligned	67% calcareous, heterogeneous yellow-light brown at PPL optical activity	30% - <u>Predominant:</u> nodules of iron oxides, equant, from sub-rounded to well-rounded (0.03 - 0.63 mm) - <u>Frequent:</u> quartz, elongated and equant, from angular to rounded (0.03 - 0.49 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.02 -0.1 mm) - <u>Very rare:</u> fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.04 - 0.66 mm)
TFN.1954. L.270/1	(EB IIA)	5% Mega-meso *vughs* Meso- micro rare vesicles aligned	55% calcareous, heterogeneous black core orange-brown at PPL optical activity	40% - <u>Dominant:</u> quartz, mainly elongated but also equant, from angular to rounded (0.02 - 0.35 mm) - <u>Common:</u> fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.02 – 0.5 mm) - <u>Few:</u> fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.1 - 0.4 mm)

				- <u>Few:</u> nodules of iron oxides, equant, from rounded to well-rounded (0.01 - 0.17 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.04 -0.1 mm)
TFN.1958. L.614/2	(EB IIA-B)	5% Meso-*vughs* micro-meso vesicles aligned	55% calcareous, heterogeneous black core orange-brown at PPL optical activity	40% - <u>Dominant:</u> quartz, elongated and equant, from angular to rounded (0.02 - 0.21 mm) - <u>Common:</u> nodules of iron oxides, equant, from rounded to well-rounded (0.01 - 0.39 mm) - <u>Common:</u> fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.08 – 1mm) - <u>Few:</u> feldspars, elongated and equant, from angular to rounded (0.06 -0.14 mm)
TFN.1954. L.247/1	(EB IIB)	5% micro-macro *vughs* micro-meso vesicles aligned	55% calcareous heterogeneous orange-brown at PPL optical activity	40% - <u>Dominant</u>: quartz, elongated and equant, from angular to rounded (0.02 -0.4 mm) - <u>Common</u>: feldspars, elongated and equant, from angular to rounded (0.02 - 0.4 mm) - <u>Common</u>: fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.06 – 0.2 mm) - <u>Few</u>: fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.05 - 0.6 mm) - <u>Few</u>: nodules of iron oxides, equant, from rounded to well rounded (0.03 – 0.21 mm)
TFN.1954. B.264/1	(EB IIB)	3% micro- macro *vughs* micro-meso vesicles aligned	57% calcareous heterogeneous black core orange-brown at PPL optical activity	40% - <u>Dominant:</u> quartz, elongated and equant, from angular to rounded (0.02 - 0.21 mm) - <u>Common</u>: Fragments of sedimentary rocks mainly equant to elongated, from sub-rounded to rounded (0.06 - 1.5 mm) - <u>Few:</u> feldspars, elongated and equant, from angular to rounded (0.05 -0.1 mm) - <u>Few:</u> fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.05 - 0.45 mm) - <u>Few:</u> Nodules of iron oxides, equant, from rounded to well rounded (0.01 - 0.15 mm)
TFN.1960. L.760/2	(EB IIB)	5% Meso-mega *vughs* Meso-micro rare vesicles not aligned	55% calcareous, heterogeneous	40% - <u>Dominant:</u> quartz, elongated and equant, from angular to rounded (0.03 - 0.26 mm)

			orange-brown at PPL optical activity	- <u>Common:</u> nodules of iron oxide, equant, from rounded to well-rounded (0.04 - 0.22 mm) - <u>Common:</u> fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.03 – 0.6 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.06 -0.1 mm) - <u>Rare:</u> fragments of siliceous rocks, equant and elongated, from sub-rounded to sub-angular (0.2 - 0.3 mm)
TFN.1960. L.801/24	(EB IIB)	5% Meso-mega *vughs* Micro-meso rare vesicles aligned	55% calcareous, heterogeneous orange-brown at PPL optical activity	40% - <u>Dominant:</u> quartz, mainly elongated but also equant, from angular to rounded (0.05 - 0.36 mm) - <u>Common:</u> fragments of sedimentary rocks, mainly equant to elongated, from sub-rounded to rounded (0.05 – 1 mm) - <u>Few:</u> nodules of iron oxides, equant, from rounded to well rounded (0.02 - 0.23 mm) - <u>Very few:</u> feldspars, elongated and equant, from angular to rounded (0.04 -0.1 mm) - <u>Rare:</u> fragments of siliceous, equant and elongated, from sub-rounded to sub-angular (0.05 - 0.3 mm)
TFN.1947. L. 84/2 = F.718	(EB IIB)	10% Macro-*vughs* meso- micro-vesicles aligned	60% calcareous, homogeneous brown to red at PPL optically active	30% - <u>Predominant:</u> quartz and felspars, equant-elongated, sub-rounded/sub-angular (0.1 mm) - <u>Present:</u> nodules of iron oxides, equant, rounded (0.3-0.4 mm) - <u>Rare:</u> fragments of sedimentary calcareous rocks, equant-elongated, sub-rounded/sub-angular (0.3-0.6 mm) - <u>Very rare:</u> fragments of siliceous rocks, equant, angular (0.3 mm)

6.2 X-Ray Powder Diffraction analysis

XRPD results (see table 2 for summary results and for complete result see Appendix I) show that the sherds are mainly composed of quartz, calcite, K-feldspars and plagioclase.

Quartz is the predominant phase as observed by optical microscopy analysis. The high amount is observed in all the analysed samples, less abundant in samples TFN.1954.L.270/1, TFN.1959.B.658/2 and TFN.1958.L.652/1.

Calcite is scarce in samples TFN.1958.L.652/1, TFN.1959.B.658/2, TFN.1960.L.801/24, TFN.1954.L.270/1, absent in sample TFN.1959.L.656/15 and in trace in the other samples.

K-feldspars are present in samples TFN.1954.L.247/1, TFN.1958.L.614/2, TFN.1958.L.652/1, TFN.1954.L.270/1, scarce in samples TFN.1954.B.264/1, TFN.1959.B.658/2, TFN.1960.L.760/2, and TFN.1960.L.801/24 and it was not identified in sample TFN.1958.L.656/15.

Plagioclase is identified as scarce in samples TFN.1954.B.264/1, TFN.1958.L.652/1, TFN.1958.L.656/15, TFN.1960.L.760/2 and TFN.1960.L.801/24; it was found in trace in samples TFN.1954.L.247/1 and TFN.1958.L.614/2. Indeed, it was absent in samples TFN.1959.B.658/2 and TFN.1954.L.270/1.

Hematite was only identified in samples TFN.1958.L.656/15 and TFN.1959.B.658/2. Clino-pyroxene was only found in the sample TFN.1960. L.801/24. Muscovite is present in sample TFN.1959.B.658/2, scarce in samples TFN.1958.L.652/1 and TFN.1960.L.760/2 and in trace in TFN.1960.L.801/24. Gehlenite was identified in trace only in sample TFN.1959.B.658/2. Aragonite is identified as scarce in sample TFN.1958.L.656/15 and in traces in sample TFN.1959.B.658/2. Wollastonite was identified as scarce only in TFN.1958.L.656/15 while it was found in trace in samples TFN.1954.L.247/1 and TFN.1958.L.614/2. Amphiboles are scarcely present in samples TFN.1954.B.264/1 and TFN.1958.L.652/1 and in trace in sample TFN.1958.L.614/2.

Table 2

Mineral assemblages of sherd samples and their relative abundance (++++ very abundant, 70-50%; +++ abundant, 50-30%; ++ present, 30-15%; + scarce, 15-5%; tr. traces, <5%). Mineral abbreviations are as follows: Qtz = Quartz, Cal = Calcite, K-fds = K-feldspar, Pl= Plagioclase, Clays = clay minerals, Hem = Hematite, Cl-Py = Clino-Pyroxene, Ms = Muscovite, Gh = Gehlenite, Arg = Aragonite, Wo = Wollastonite, Amp = Amphibole

Samples	**Qtz**	**Cal**	**K-fds**	**Pl**	**Clays**	**Hem**	**Cl-Py**	**Ms**	**Gh**	**Arg**	**Wo**	**Amp**
TFN.1958.L.652/1	+++	+	++	+	-	-	-	+	-	-	-	+
TFN.1958.L.656/15	++++	-	-	+	-	tr	-	-	-	+	+	-
TFN.1959.B.658/2	+++	+	+	-	-	tr	-	++	tr	tr	-	-
TFN.1954.L.270/1	+++	+	++	-	++	-	-	-	-	-	-	-
TFN.1958.L.614/2	++++	tr	++	tr	-	-	-	-	-	-	tr	tr
TFN.1954.L.247/1	++++	tr	++	tr	-	-	-	-	-	-	tr	-
TFN.1954.B.264/1	++++	tr	+	+	-	-	-	-	-	-	-	+
TFN.1960.L.760/2	++++	tr	+	+	-	-	-	+	-	-	-	-
TFN.1960.L.801/24	++++	+	+	+	-	-	+	tr	-	-	-	-

7. Discussions

In this chapter the results of the optical microscope and the XRPD will be discussed, to identify the raw materials used in the production of ceramics and consequently speculate whether or not Tell el-Far'ah North was the centre production of this specialized ware.

7.1 Raw materials

Mineralogical and petrographic analyses showed that all samples can be defined as Ca-rich because of their calcareous matrix and the presence of calcareous inclusions (Fabbri et al., 2014).

The samples show similar minero-petrographic features, mainly characterized by predominant quartz. In addition, K-feldspars and plagioclase, siliceous and calcareous sedimentary rock fragments are also present in the fragments. Traces of hematite, clinopyroxene, muscovite, aragonite, amphiboles, gehlenite, and wollastonite were also identified.

A detailed mineralogical analysis and petrographic characterization of ceramic materials from EB I-II (3300–2700 BC) belonging to the Tell el-Far'ah North site was performed and published by Medeghini et al. (2019), in which the samples were characterized by the presence of limestone fragments, quartz, calcite crystals and nodules of iron oxides. The predominance of coarse angular crystals of calcite defined *fabric A-calcite* whereas *fabric B-calcareous* was characterized by the predominance of calcareous inclusions. In addition, a *loner* was separated, with fine grain size mainly represented by quartz and feldspars and minor amounts of nodules of iron oxides and fragments of calcareous and siliceous sedimentary rocks.

Therefore, based on this classification it was possible to identify the samples TFN.1958.L.656/15 and TFN.1959.B.658/2 as belonging to *Fabric B-calcareous* due to the predominance of calcareous inclusions. In addition, a new petrographic group could be classified as *Fabric C-quartz* showing quartz as main inclusions and including the *loner* sample (TFN.1947.L.84/2=F.718) analysed by Medeghini et al. (2019) and samples TFN.1954.L.247/1, TFN.1954.B.264/1, TFN.1958.L.614/2, TFN.1958.L.652/1, TFN.1960.L.760/2, TFN.1960.L.801/24, TFN.1954. L.270/1 analysed in this dissertation (Figure 27).

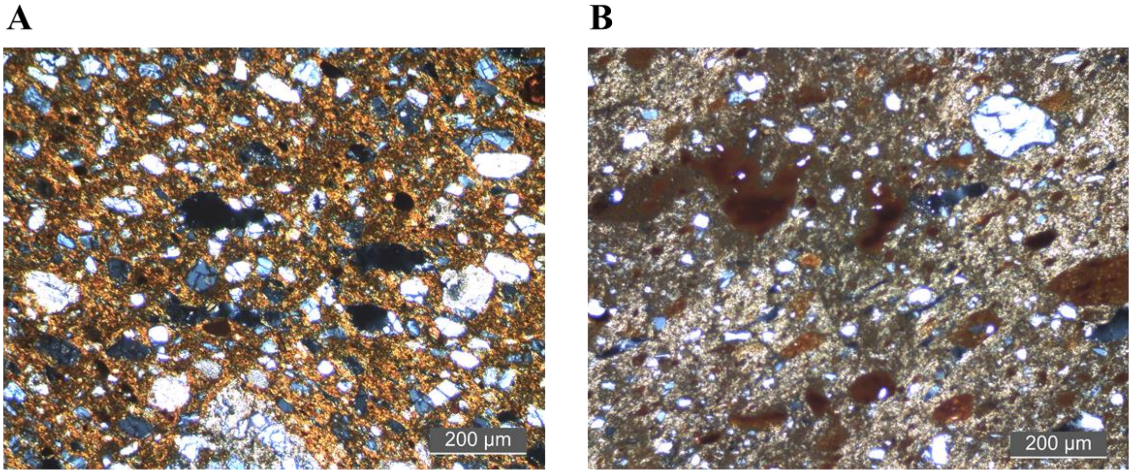

Figure 27: Microscopic images of representative samples
A: TFN.1960.L.801/24. mag. 10x XPL identified as *fabric C-quartz*, and
B: TFN.1958.L.656/15. mag. 10x, XPL identified as *fabric B-calcareous*.

Fabric B-calcareous was associated to a macro-functional class including vessels of tableware (bowls, carinated bowls, jars, medium-sized jars) and red-burnished ware (bowls, carinated bowls, jars and small globular jars). The samples identified as *fabric C-quartz* are only carinated bowls of Metallic Ware. Despite the differences, both fabrics correspond to the same Tell el Far'ah North macro-functional ceramic class, related to the domestic need, tableware, as they are characterized by thinner and less abundant inclusions (Braekmans & Degryse, 2019).

The petrographic composition of Metallic Ware samples from Tell el-Far'ah is different from the North Canaanite one. Indeed, the samples of North Canaanite Metallic Ware described by Greenberg & Porat (1996) are mainly characterized by shale fragments, probably intentionally added to the clay or part of the original clay, quartz, milky colour carbonates, siltstones, basalt, volcanic fragments and oolites. Moreover, the North Canaanite Metallic Ware raw material source is comprised of non-calcareous siltstones clay, and mature sandstone, all rich in iron oxides and associated with highly weathered basalts. As far as the matrix is concerned, due to the high firing temperature, it was sometimes found by these authors as vitrified, with the silty components corresponding to quartz, iron oxides, carbonates, and mica laths.

7.2 Technological level

The starting raw material was composed by a calcareous clay with K-feldspars, plagioclase and scarce calcareous rock fragments. The two samples (TFN.1958. L.656/15 and TFN.1959. B.658/2) identified as *fabric B-calcareous* and samples belonging to *fabric C-quartz* show a similar starting clay.

These ceramics produced from calcareous clay were used with the intention of obtaining sintering for lower firing temperatures procedure as commonly used in Neolithic, Chalcolithic, Bronze Age, Iron Age, Hellenistic and Roman period ceramics (Fabbri et al., 2014).

The *fabric B-calcareous* is characterised by the predominance of calcareous inclusions, quartz crystals and nodules of iron oxide. When the original structure of the calcareous inclusions is preserved and can be identified, it shows that the clay has been poorly worked and has not been purified before being prepared for the moulding of the artefact (Fabbri et al., 2014).

Quartz has been identified as predominant in *fabric C-quartz*, from angular to rounded. The variability in shape could suggest the addition of sand in the ceramic preparation paste to modify the plasticity of the paste and the thermal properties of the produced vessel and to create the structure (Henderson, 2000).

The lack of calcareous granules and coarse inclusions in general in samples from *fabric C-quartz* suggests that the raw material used for the manufacture of Metallic Ware was modified by levigation, a common procedure for large-scale, specialised ceramic production (Rice, 2015).

The absence of clay pallets in the samples characterized as *fabric B-calcareous* suggests that the production was accurate, and a homogenous paste was obtained during the mixing phase.

The size and shape of the voids can help to understand the paste improvement treatments during the production of the vessel. The analysed samples show both rounded, mainly meso-vesicles and elongated micro- to mega-*vughs*. The diffuse presence of vesicles suggests an initial hand-processed manufacture (De Vito et al., 2014), whereas the aligned *vughs* could suggest the use of a potter’s wheel. The lack of alignment of inclusions could be probably associated to the manufacture of vessels by manual potter's wheel (i.e. slow wheel or *tournette*), that due to kinetic energy did not allow the alignment of inclusions (Botticelli et al., 2020).

The quality of North Canaanite Metallic Ware raw material allowed a great variety of shapes and forming methods from the same clay, so modular techniques were used to produce vessels characterized by thin walls and impermeable, the bowls and platters were made in a mould or by the upside-down method, in finishing all vessels or at least their rims rotary motion was used. These details are most evident on the rims of platters and jars, as well as on some jug rims. (Greenberg & Porat, 1996). On the other hand, the sherds analysed in this dissertation are all carinated bowls provided with a small horizontal lug handle, produced in a highly-sieved brown-reddish ware, the clay was pressed against a mould, always after being taken to the potter's wheel to be finished and the finishing to leave the wall thinner and carinated was given from the use of an object for scraping. This thinning of the outer surface gives the bowl its particular shape with rounded bottom and thin walls (Beck, 1985).

The firing conditions of ceramics is a key and fairly important point to characterize their manufacture because it is possible to access information on raw materials used, technology, firing techniques (open pits or enclosed ovens or kilns) (Sinopoli, 1991).

The matrix colour gives information about the firing atmosphere, since a redder hue is due to an oxidizing atmosphere, while the black one means that the burning was carried out under reducing conditions. Most of the samples analysed show variability in the matrix colour in a redder tone, which suggests the firing in an oxidising environment in which oxygen availability was not totally controlled (Botticelli et al., 2020). In addition, in samples TFN.1958.L.656/15 and TFN.1959.B.658/2 iron oxide, identified in the optical microscope analysis, were confirmed by XRPD as hematite, which was probably already present in the clay and was transformed into hematite due to oxidizing firing atmosphere developed during firing (Medeghini et al., 2016)

On the other hand, samples TFN.1954.B.264/1, TFN.1958.L.614/2 and TFN.1954.L.270/1 have a black core, this black core is the result of firing in reducing atmosphere with oxidizing cooling stage (Nodari et al., 2004).

All samples showed optical activity, which gives a preliminary indication about a firing temperature lower than 850° C, the temperature at which clay minerals and carbonates completely lose their optical properties (Memmi, 2004).

Quartz, identified as predominant in all the samples, is resistant to chemical transformation and mechanical friction (Iordanidis et al., 2009) and presents no morphological or chemical change influencing up to the temperature of 1050 ºC (Riccardi et al., 1999).

The presence of primary calcite suggest a low firing temperature (< 750-800 ºC), however the size of the grains and the firing atmosphere also has a great influence on the stability of calcite, so that it can be found when firing temperatures reach up to 800 ºC. (Fabbri et al., 2014).

Indeed, during a firing process above 800 ºC, the free-lime from the de-carbonated calcareous inclusions generates new Ca-silicates by reaction with the fired clay. These newly formed minerals include gehlenite, wollastonite and clinopyroxene (Fabbri et al., 2014). The temperature and composition of the Ca-rich clay bulk is a driving force in the formation of phases such as gehlenite and wollastonite (Duminuco et al., 1998).

The presence of scarce gehlenite in the sample TFN.1959.B.658/2 *fabric B-calcareous* suggests that the firing temperature was in the range 850 °C-900 °C (De Vito et al., 2014). The samples *fabric B-calcareous* TFN.1958.L.656/15 and *fabric C-quartz* TFN.1954.L.247/1 showed traces of wollastonite that begins to form between 800-900°C (Medeghini et al., 2016).

The maximum firing temperature of the analysed samples was estimated based on the nature and state of inclusions identified in thin section and the XRPD complemented with a more complete and accurate mineralogical analysis. Therefore, it is estimated that the firing temperature was below 850ºC as it was still possible to identify calcareous inclusions without any reaction rims. However, some samples (TFN.1959.B.658/2, TFN.1958.L.656/15, TFN.1954.L.247/1, TFN.1960.L.801/24) showed new-formed minerals appearing at slightly higher temperatures, thus inferring a temperature in the range 850 - 900 ºC.

Regarding the manufacturing process described by Greenberg & Porat (1996), it involved a different technology. The raw material was a non-calcareous clay, rich in shales, quartz and iron oxides in various forms that acted as a flux, lowering the temperature at which the clay sintered to a hard body, which made the final product neither swell nor shrink. On the contrary, Metallic Ware from Tell el-Far'ah consists of calcareous clay, quartz, siliceous and sedimentary rocks and less iron oxides. Although there is this difference in raw materials, both North Canaanite Metallic Ware and Tell el-Far'ah Metallic Ware produced ceramics for household use, more specifically tableware and non-cooking pots. North Canaanite Metallic Ware had high kiln technology that allowed potters to keep a controlled firing above 900 ºC (Greenberg & Porat, 1996). The similarity of firing of Metallic Ware from Tell el-Far'ah is that it was also performed in kilns so that the temperature could be kept under control, but the maximum firing temperatures reached vary between 850-900 ºC.

The flourishing period of the North Canaanite Metallic Ware was during the EB II (Greenberg & Porat, 1996), in agreement with the results of this dissertation that show a specialized production gradually increasing during the Early Bronze II, with four samples from the EB IIA period, one sample from the EB IIAB and five samples from the EB IIB.

The sherds analysed in this thesis come much closer to the Metallic Ware petrographically described by Beck (1985) as brownish-red and produced with a well-levigated clay rich in silty quartz and carbonates fragments then fired at high temperature. It is possible that the sherds analysed by Beck in Tel Aphek could be related to those of Tell el-Far'ah North site.

This research contributes to the differentiation of the ceramics produced at Tell el-Far'ah North from the Canaanite Metallic Ware. Although Beck (1995) recognised that Tell el-Far'ah ceramics were similar to the ceramics analysed in Tel Aphek, further analysis of Metallic Ware in Tel Aphek could contribute to the reconstruction of the relation among the production centres.

7.3 Provenance

The Metallic Ware samples analysed are distinguished into two petrographic groups that reflect the use of two different recipes: *fabric B* and *fabric C*.

However, the petrographic composition suggests a similar geological provenance of the raw materials. In particular, quartz, identified as predominant inclusions in the samples, and the calcareous nature of the clay could suggest the use of the *alluvium* (unconsolidated marls with siliceous sand) as probable raw material used in the production of the ceramics. Further analysis could be useful to identify microfossils important to define the age of the deposit.

8. Conclusions

Archaeometric studies have gained much prominence for their contribution to the interpretation of archaeological ceramic remains, since they provide greater and diversified access to the technologies of ancient populations.

Metallic Ware was a common and widespread ceramic production during the Early Bronze Age II in the Middle East. The analysis of some representative samples of MW from Tell el-Far’ah North, through thin section by optical microscope, allowed the identification and classification of the analysed sherds in two different fabrics, *fabric B-calcareous*, characterized by the predominance of calcareous inclusions and *fabric C-quartz,* with predominant quartz as inclusion. *Fabric B-calcareous* had been already related to the Tell el-Far'ah North ceramics analysed by Medeghini et al. (2019), corresponding to a macro-functional class including vessels of tableware (bowls, carinated bowls, jars, medium-sized jars) and red-burnished ware (bowls, carinated bowls, jars and small globular jars). On the contrary, *fabric C-quartz* is represented by carinated bowls of Metallic Ware.

Tell el-Far'ah Metallic Ware differs greatly from the Metallic Ware found in northern Canaan and analysed by Greenberg & Porat (1996), in terms of raw materials, inclusions, shaping and firing temperature. The fragile and distinctive ring when struck characteristic of Tell el-Far'ah Metallic Ware, has been possibly achieved by firing temperatures ranging from 850 to 900 ºC, lower than those used in the Canaanite production. Analysis of Metallic Ware from Canaanite North and Tell el-Far'ah shows that this ceramic was a characteristic and widespread product in Bronze Age II. Both ceramics, from North Canaan and Southern Levant, were produced to suit domestic needs and uses, were tableware, did not bring so many innovations but completely duplicated the Early Bronze Age repertoire of non-metallic ceramics.

The petrographic and mineral features highlighted in this study for the Metallic Ware production at Tell el-Far’ah are more comparable with the Tel Aphek ceramics identified by Beck (1995) as Metallic Ware. A deeper investigation and comparison with the ceramics produced in Tell el-Far'ah would help to better understand and reconstruct the relation between these production centres. A more comprehensive and detailed study is still needed to compare fabrics, identify differences, techniques and understand the origins of raw materials and local specialised centres.

Tell el-Far'ah is an important archaeological site where a gradual transition from EB I to EB II can be observed, the material culture, in this case ceramics, reflects such transformations. The presence of kilns at Tell el Far'ah suggests the existence of professional potters; another important factor is the existence of slow wheels of potters, such as the *tournette*, which implies as an indicator of specialised local ceramic production (de Vaux, 1955; Medeghini et al., 2019).

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Appendix I: XRPD results

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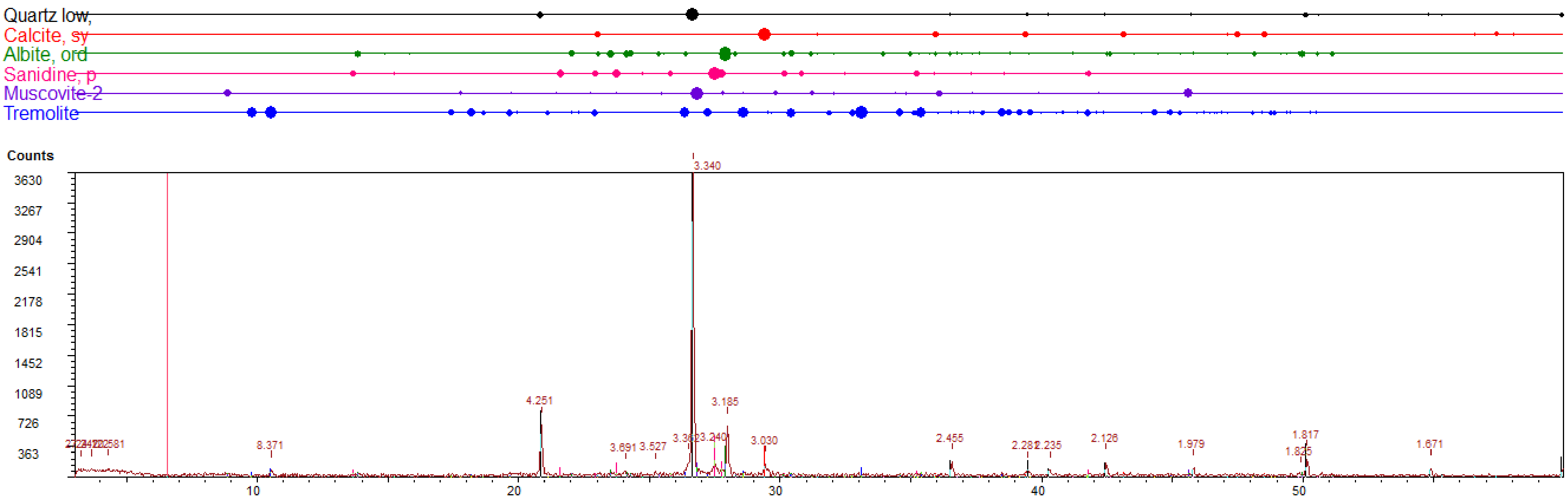

2 Theta (º)

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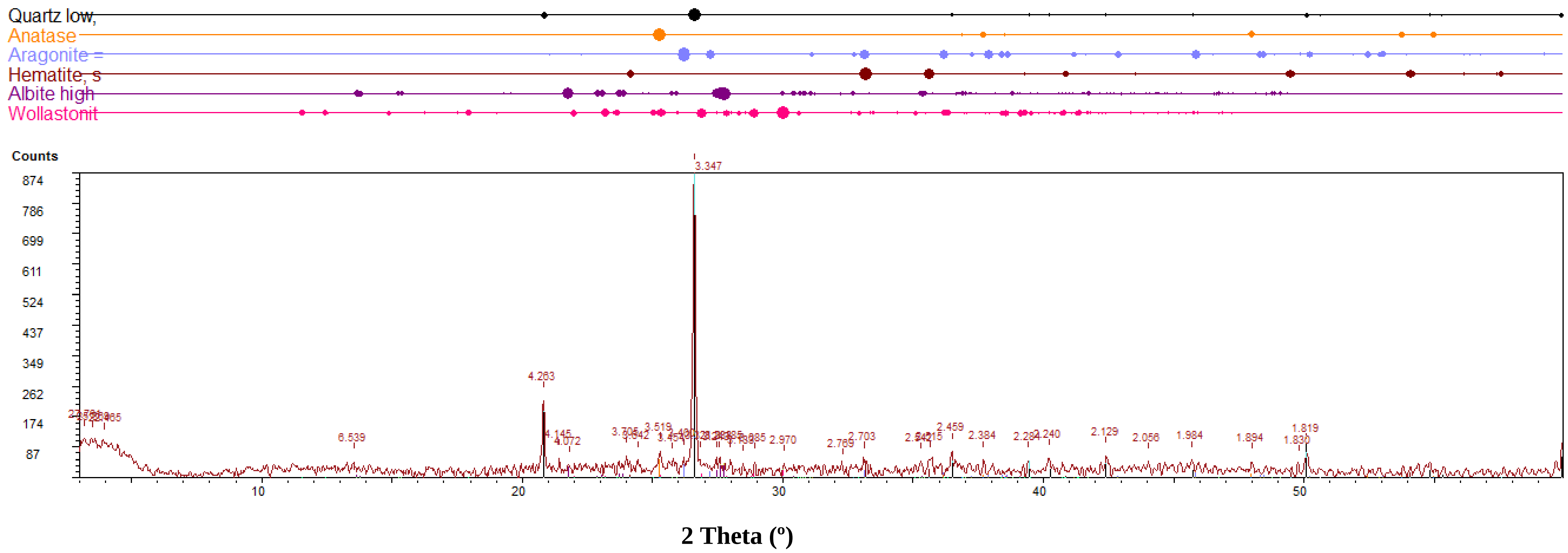

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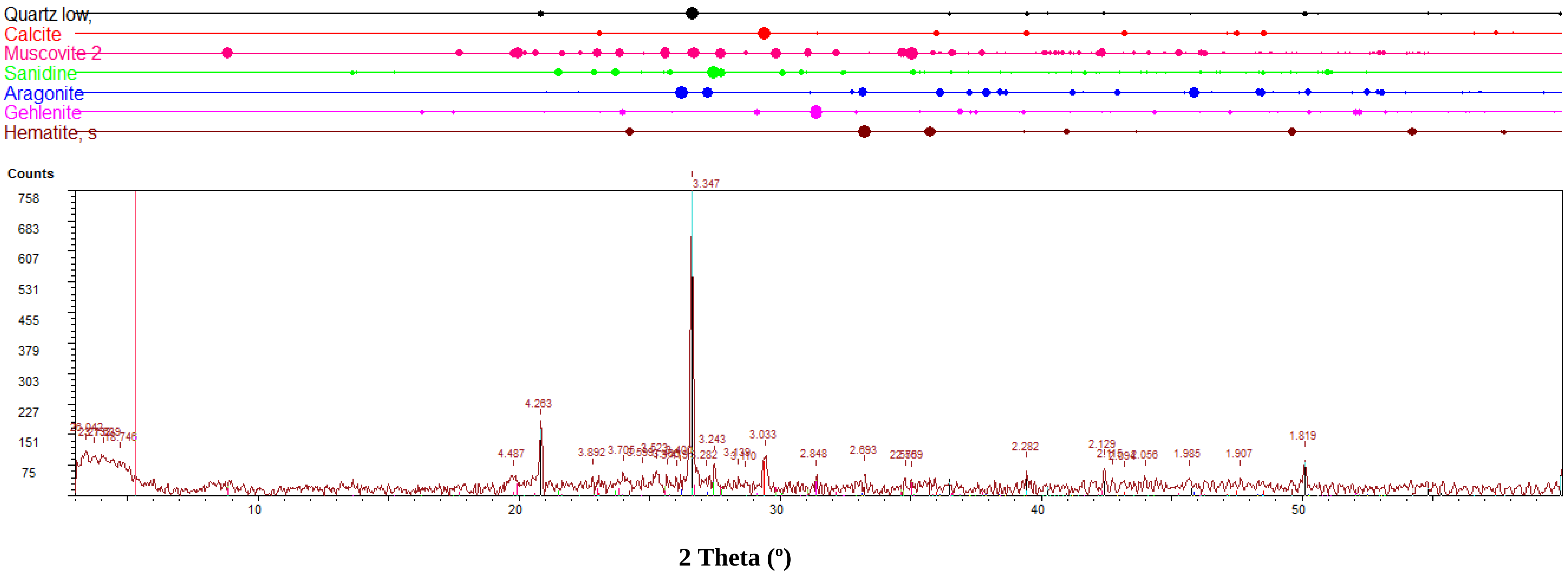

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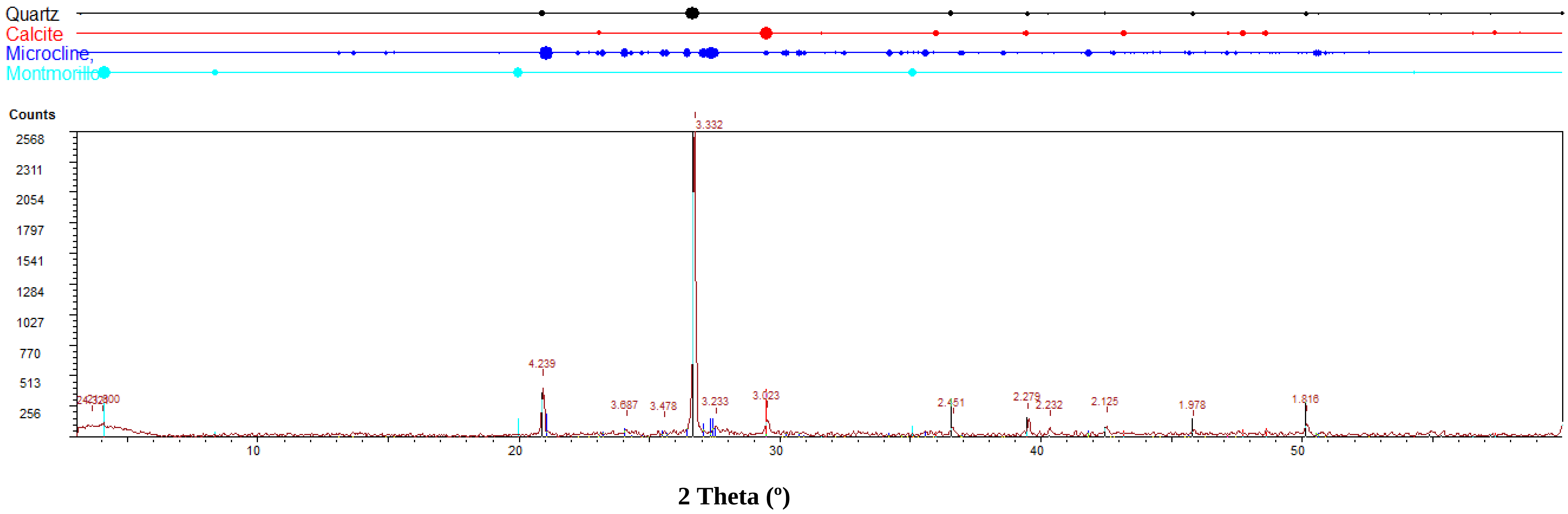

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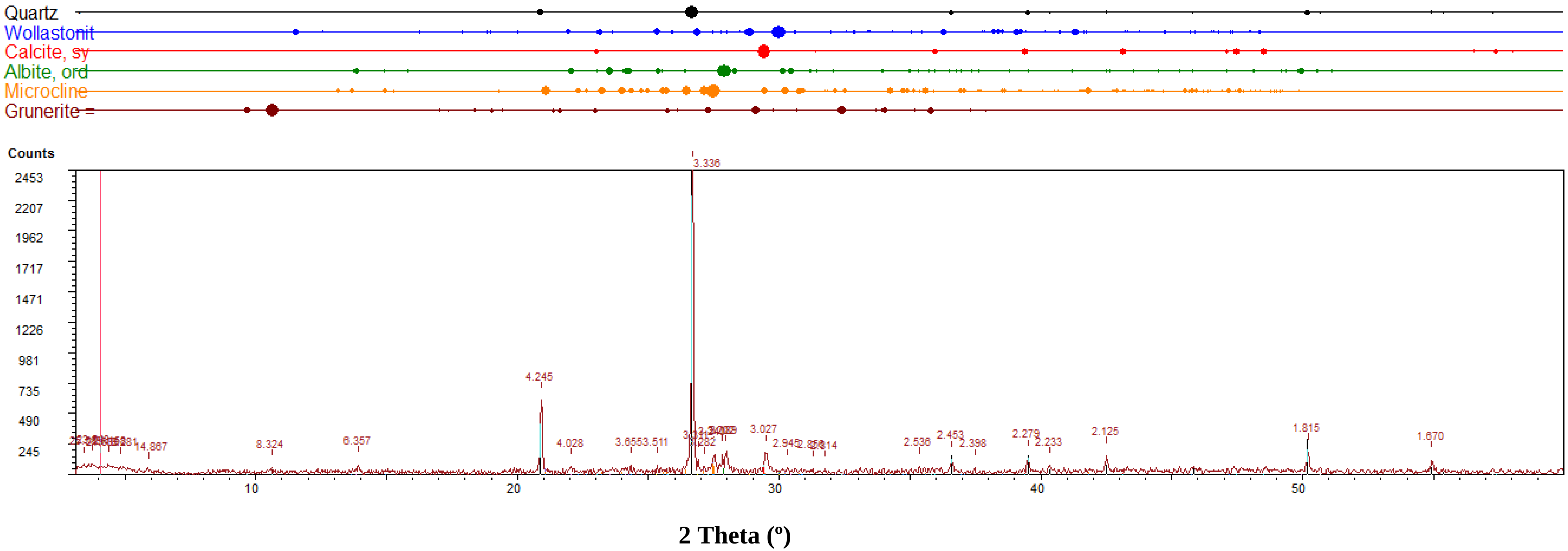

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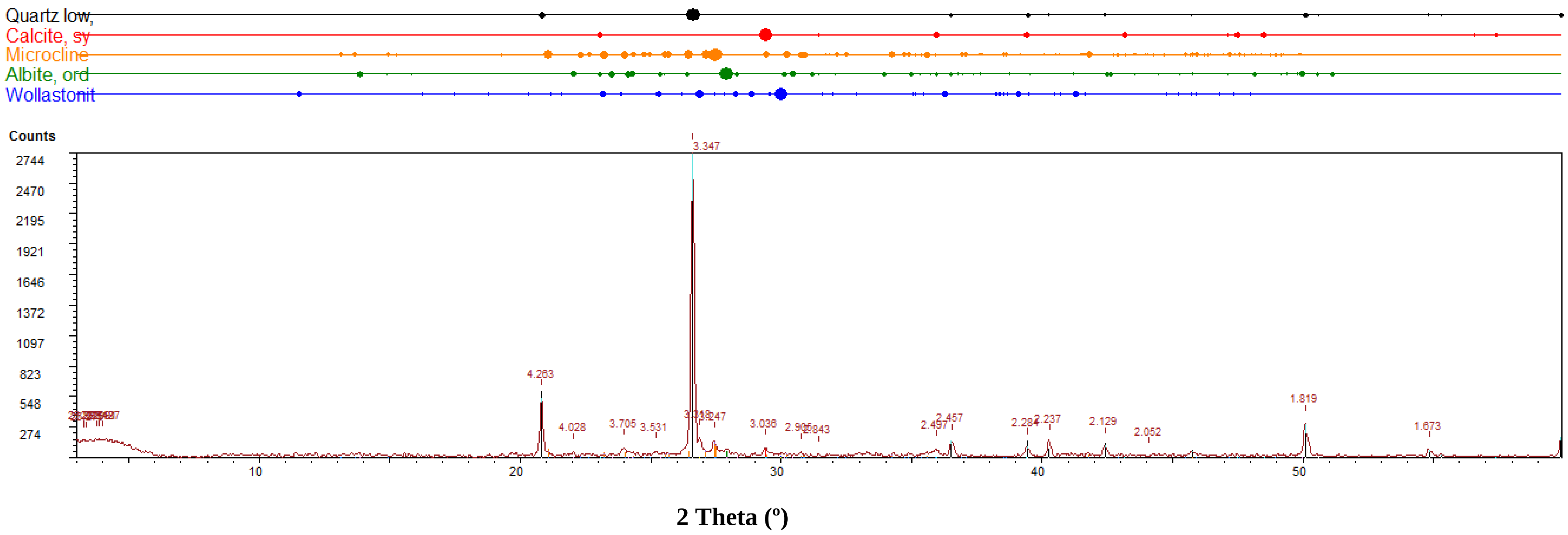

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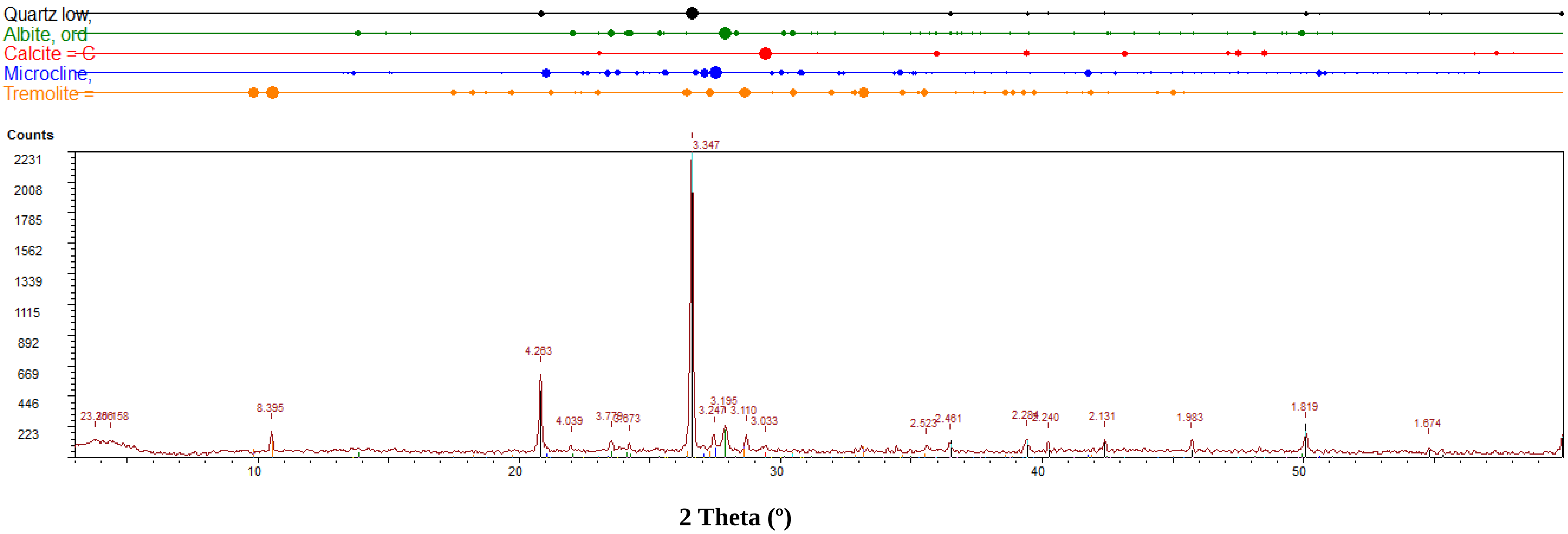

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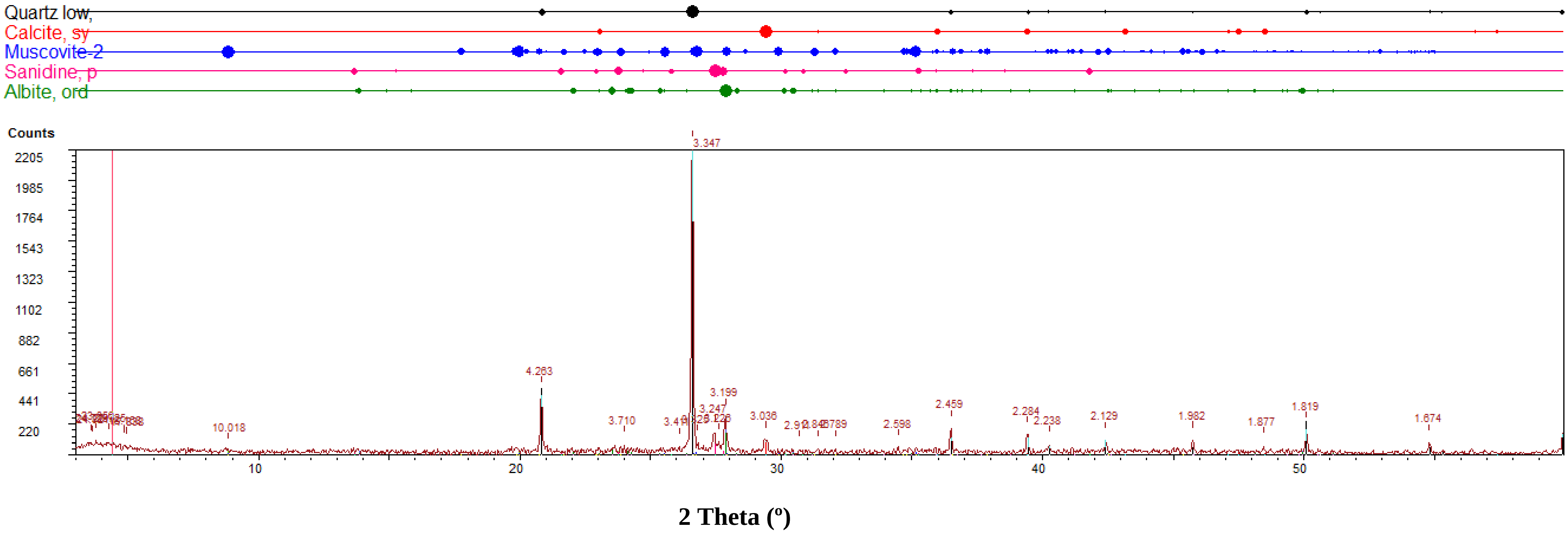

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