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The ‘metallic ware’ from Tell el Far’ah North (West Bank): Petrography, technology, and provenance of a hidden ceramic industry

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ABSTRACT

The present work illustrates a multi-analytical study of ceramic fragments that represent a distinctive class of pottery dating to the Early Bronze II (3050–2850 BC) from the archaeological site of Tell el-Far'ah North (West Bank). Optical Microscopy, coupled with SEM-EDS and XRPD, allowed to identify it as a ‘metallic ware’ industry produced with a low calcareous clay where quartz is dominant, along with feldspars, fragments of sedimentary and siliceous rocks, and nodules of iron oxides. This mineralogical assemblage is consistent with the geological formations in proximity to the site. The high quality of this ceramic industry was contemporarily achieved by a judicious selection of supplies and a firing temperature in a range between 800 and 900 °C. The metallic ware identified at the Tell el-Far'ah North most likely represents a ceramic industry of the central hill country. Tell el-Far'ah North, or another site in the area, may have been the production location of this pottery, according to the pattern of regional production centres, and regional specialised industries, which characterizes the Southern Levant in the Early Bronze II.

1. Introduction

Archaeometry is a discipline which applies scientific techniques from physics, chemistry, biology, Earth sciences, and engineering to address archaeological issues and problems [1]. The objects of investigation cover a wide array, including organic and inorganic materials, only modified, or entirely produced by humans [2–8]. Aims of archaeometric studies are the reconstruction of the nature and the constituents of ancient materials, their dating, provenance, way of production, functional use, and conservation state [9–12]. In particular, archaeometric analyses of ancient ceramics are widely applied to support archaeology. Ceramics are a ubiquitous component of material culture and may offer insights into the technical evolutions and socio-economic traits of the context in which they were produced.

In this perspective, the study of ceramics from the Early Bronze (henceforth EB) II (3050–2850 BC) in Southern Levant enhances our knowledge of this phase, during which the earliest urban society was established in the region. EB II urbanism was marked by a process of aggregation in fortified centres, new settlement and household layouts, new social behaviours, and a simplification of material culture, resulting among other things from the reorganization of ceramic production [13]. Some specific classes of pottery were manufactured in regional specialist workshops [13] and distributed as commodities over a considerable distance [14]. Among these, ‘metallic ware’ has been long recognized as a distinctive ware tradition of the EB II Southern Levant.

Greenberg & Porat [15] first defined metallic ware as a specific industry, including a consistent range of household forms (except for cooking pots). These vessels are generally thinner walled than similar forms in non-metallic ware and give off a characteristic metallic clink when struck; they were relatively lighter and thus easier to be transported. Scientific analyses outlined the two main features of this industry: the use of Lower Cretaceous shale-rich clays – whose supply has been localised in the outcrops at the southern end of the Anti-Lebanon massif – and the high firing temperature. When observed under optical microscope, it has a uniform appearance, with coarse grain-size shale fragments (ca. 15% of the volume of the sherd, up to 2 mm), quartz (ca. 5% coarse and 10–15% fine) and carbonates, common iron oxides, siltstones, less prevalent volcanic fragments with trachytic texture and

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oolites [15]. Such an industry, called North Canaanite/South Levantine Metallic Ware, probably originated in the Mount Hermon foothills and served several areas, up to 100 km away: the Hula and upper Jordan Valleys, the Galilee and the Jezreel Valley, the Golan plateau, northern Transjordan, and the southern Lebanese Beqaa. The production of the full range of South Levantine Metallic Ware ceased at end of the EB II, with a few vessels, mainly *pithoi*, still produced throughout the EB III (2850–2500/2450 BC).

Greenberg & Porat [15] identified a minor quantity of metallic ware sherds among the EB II ceramic material of Tell el-Far'ah North, but they did not carry out petrographic analyses.

Since this pioneering study, metallic ware regional industries have been differentiated across the Levant, characterized by different fabrics, and associated to diversified production centres [16].

Already in the 1980s, Beck [17] described 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, including Tell el-Far'ah North. These vessels were produced in a very fine brownish-red clay, well-levigated, with minute grits. No petrographic analysis was performed at that time, but later Greenberg & Porat [15] described the Aphek bowls as made of a clay rich in silty quartz and carbonate fragments, probably related to loess and loessy soils, pointing out the different petrographic composition from the South Levantine Metallic Ware.

Despite the importance of this Early Bronze Age Levantine ceramic industry, associated with the flourishing of early urbanism, metallic ware at Tell el-Far'ah North, though possibly recognized [15,17], has not yet been thoroughly studied.

During the current examination of the pottery from the EB I–II settlement of Tell el-Far'ah North [18] – unearthed during the excavations carried out by Roland de Vaux between 1946 and 1960 on behalf of the École Biblique et Archéologique Française de Jérusalem –, a few 'metallic ware' fragments were distinguished. They represent a group of small carinated bowls, and one specimen of hemispherical bowl so far, belonging to the EB II repertoire. The present study aims at giving a mineralogical, petrographic, and chemical characterization of these bowls, identified as representative of metallic ware industry during the macroscopic analysis. Optical Microscopy (OM), Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS), and X-Ray Powder Diffraction (XRPD), were used to investigate the nature of raw materials and the preparation conditions involved in the production of this ware, and to thoroughly define its distinctive features, compared to other metallic ware industries identified at other sites of the Southern Levant.

2. Archaeological context

The site of Tell el-Far'ah North, located in the West Bank, 11 km northeast of the modern city of Nablus (32°17′14″ N 35°20′16″ E), was situated in a strategic position on a rocky ridge in the western part of the fertile Wadi Far'ah Valley (Fig. 1). Tell el-Far'ah North has long been recognized as a key site in studying the Early Bronze Age in the Southern Levant, since it documents the passage from the EB I rural village to the EB II urban-centred society [19]. The EB IB–II transition was a crucial period, marked by political and socio-economic changes, together with the dissemination of ideological and technological innovations. Such changes are reflected in the material culture, namely in the ceramic production and related technological developments. At Tell el-Far'ah North, in particular, the presence of a two-story pottery kiln in the EB II town [20] suggests an increasing level of expertise and craft specialization, as well as the emergence of professional potters at the site [18]. The appearance of metallic ware vessels during the EB II may, therefore, be connected with the technical achievements accomplished in the ceramic industry, such as improved sieving procedures in the preparation of clays and the introduction of close kilns in the firing process.

3. Geological setting

Tell el-Far'ah North belongs to the geological area of the so-called Nablus district, which is formed by Cretaceous and Tertiary marine carbonate sedimentary rocks (limestones, dolostones, chalks, and marls), along with rare Jurassic limestones. The site is located on a hill at 198 m asl, its extension being around 600 m length by 300 m width, with the natural springs of Ain ad-Dlaib and Ain al-Far'ah nearby [19]. The settlement arose on the route that connected the Jordan Valley (27 km west) with the region of the ancient city of Shechem (currently Tell Balata, in Nablus). The archaeological site develops, to the north and north-west, close to the prominent Timrat Formation (Middle Eocene), where chalks and limestones can be found [21]. To the east, it is surrounded alternatively by the clayey Hordos Formation, which is overlaid by the Umm Sabune Conglomerates with its sand and gravel, and the chalky Menuha Formation (Senonian). This latter is characterized by the presence of fossils, which rarely appear in this area, except for the Bina Formation (Turonian), where the marly layer is overlaid by limestone, further to the east [22]. Finally, some dolostone can be found in the Weradim and Aminadav Formations (Cenomanian), to the far south-east (Fig. S1).

4. Materials and methods

Ten ceramic fragments identified during the macroscopic examination as metallic ware were selected (TFN.1947.L.84/2 = F.718, TFN.1954.L.247/1, TFN.1954.B.264/1, TFN.1954.L.270/1, TFN.1958.L.614/2, TFN.1958.L.652/1, TFN.1958.L.656/15, TFN.1959.B.658/2, TFN.1960.L.760/2, TFN.1960.L.801/24). The sample TFN.1947.L.84/2 = F.718, previously analysed and published as a *loner* in Medeghini et al. [18], is reconsidered in this study. Among about 2000 fragments analysed macroscopically, only about ten ceramic fragments have been distinguished so far as metallic ware, pointing to a production of limited diffusion and high specialization. These samples have been selected for the present study to characterize this distinctive ware.

The samples all come from EB II contexts and mostly belong to small carinated bowls with flared rim and rounded base, at times provided with a horizontal pierced lug handle attached at the point of carination. Other bowl types are present in lesser quantities: small carinated bowls with vertical rim and rounded base, and one small hemispherical bowl with thinned rim and a horizontal pierced lug handle (Table S2). All bowls are self-slipped and show a hand-burnished decoration, both inside and outside. They usually exhibit a reddish-brown colour both in fracture and at surface.

Samples in thin section were analysed by a Leica DM750 P polarized optical microscope equipped with a Leica MC190 HD digital camera basing on Whitbread's criteria [23,24] (Department of Earth Sciences, Sapienza University of Rome, Italy). Microphotographs were taken by using the LAS V4 4.12 software. Common features and differences among the samples were highlighted through the characterization of the three main components (inclusions, matrix, voids).

X-Ray Powder Diffraction (XRPD) was also performed for the semi-quantification of the mineralogical composition, to estimate firing temperatures and to infer on the compatibility of raw materials with local supplies. A small part of the sample was ground with agate mortar and pestle. The ceramic powder was then analysed by a Bruker D8 focus diffractometer (Department of Earth Sciences, Sapienza University of Rome, Italy) with Cu K_α 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 XPowderX© software.

Scanning Electron Microscopy coupled with Energy Dispersive Spectrometry (SEM-EDS) was used to study the inclusions at level of chemical composition, abundance, distribution, but also alteration. Thin sections were carbon-coated and analysed by a FEI-Quanta 400

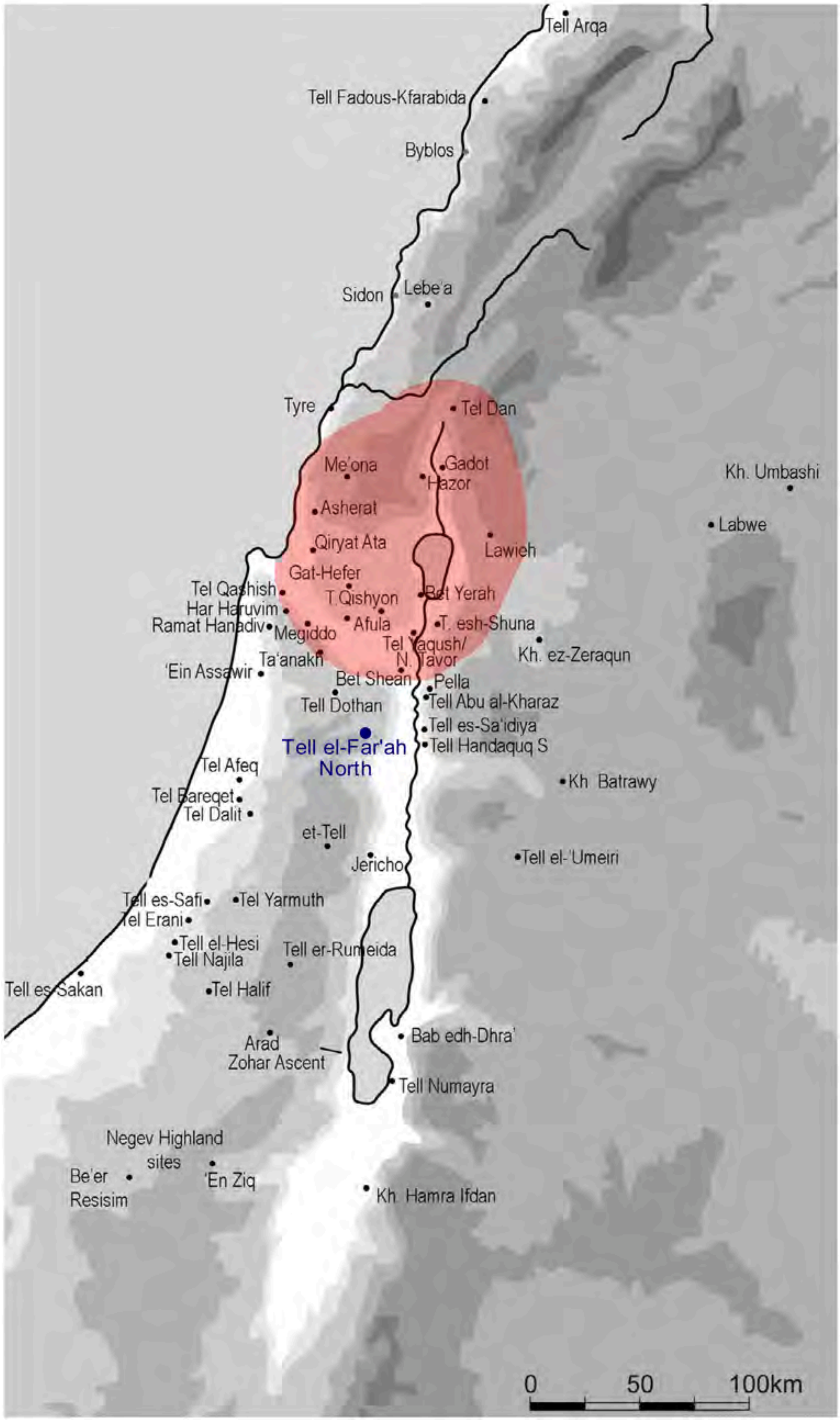

Fig. 1. Localisation of the archaeological site of Tell el-Far'ah North (in blue), where 'metallic ware' bowls are documented (modified after [13]). In red, the area of the most intensive distribution of North Canaanite/South Levantine Metallic Ware (modified after [15]). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

instrument, operating at 20 kV, equipped with an X-ray energy-dispersive spectrometer (Department of Earth Sciences, Sapienza University of Rome, Italy).

5. Results

5.1. Petrographic and SEM-EDS analysis

Basing chiefly on the nature, distribution, and morphology of the inclusions, petrographic analysis for the first time allowed to distinguish and describe in detail the fabric associated to the metallic ware bowls fragments identified at Tell el-Far'ah North (Table S2). Inclusions in the samples show an overall homogeneity in mineralogical composition: they are mainly represented by predominant quartz, variable occurrence of iron oxides (Fig. 2a and b), and calcareous sedimentary rocks (Fig. 2c, d, g and h), with a few fragments of siliceous rocks. This newly detected fabric (samples TFN.1947.L.84/2 = F.718, TFN.1954.L.247/1, TFN.1954.B.264/1, TFN.1954.L.270/1, TFN.1958.L.614/2, TFN.1958.L.652/1, TFN.1960.L.760/2, TFN.1960.L.801/24) has been defined as *fabric C-quartz*, being *fabric A-calcite* and *fabric B-calcareous* previously identified in Medeghini et al. [18].

All samples belonging to *fabric C-quartz* are characterized by the prevailing presence of quartz inclusions (Fig. 3), which appear from angular to sub-rounded, generally with unimodal distribution and fine

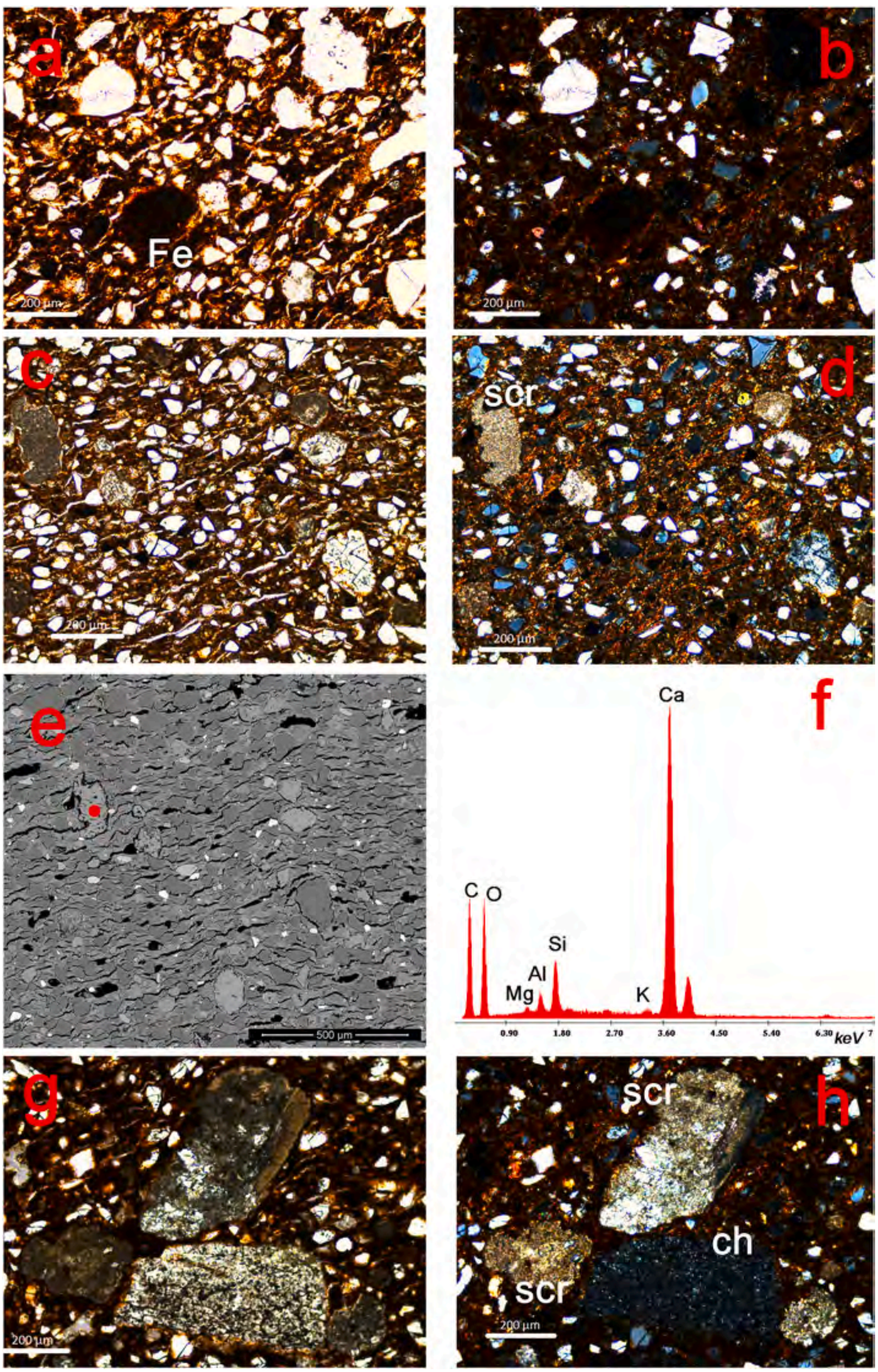

Fig. 2. OM (scale bar = 200 μm) and SEM-EDS images of samples showing typical features of *fabric C-quartz*: PPL (a) and XPL (b) images of iron oxides nodules in TFN.1954.L.247/1; PPL (c) and XPL (d) images of sedimentary calcareous rock (*scr*) fragments in TFN.1960.L.760/2, with corresponding BSE image (e, scale bar = 500 μm) and spectrum of the red dot (f); PPL (g) and XPL (h) images of TFN.1954.L.270/1 showing fragments of chert (*ch*) and *scr*. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

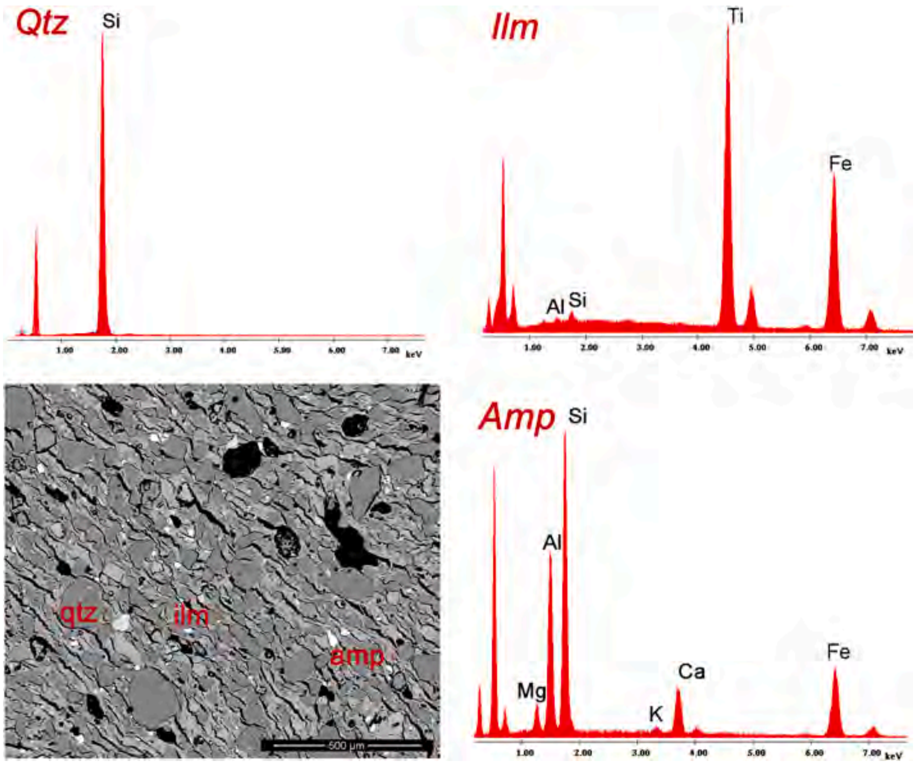

Fig. 3. SEM-BSE image of sample TFN.1954.L.247/1 and EDS spectra of typical inclusions: quartz (qtz), ilmenite (ilm) and amphiboles (amp).

grain size, slightly oriented along the vughs. Quartz inclusions seem to have a slightly higher variability in their dimensions in samples TFN.1947.L.84/2 = F.718 and TFN.1954.L.247/1. *Fabric C-quartz* also shows feldspars, fragments of sedimentary calcareous rocks (sometimes showing reaction rims) and a few fragments of siliceous rocks, nodules of iron oxides, whereas fossils are rare. Very rare calcite microcrystals were observed (Fig. 2c and d) and then confirmed by SEM-EDS in samples TFN.1960.L.760/2 (Fig. 2e and f) and TFN.1960.L.801/24.

Fossils, identified by SEM-EDS analysis, have dimensions lower than 50 µm, in samples TFN.1958.L.614/2 (along with rare zircon crystals,

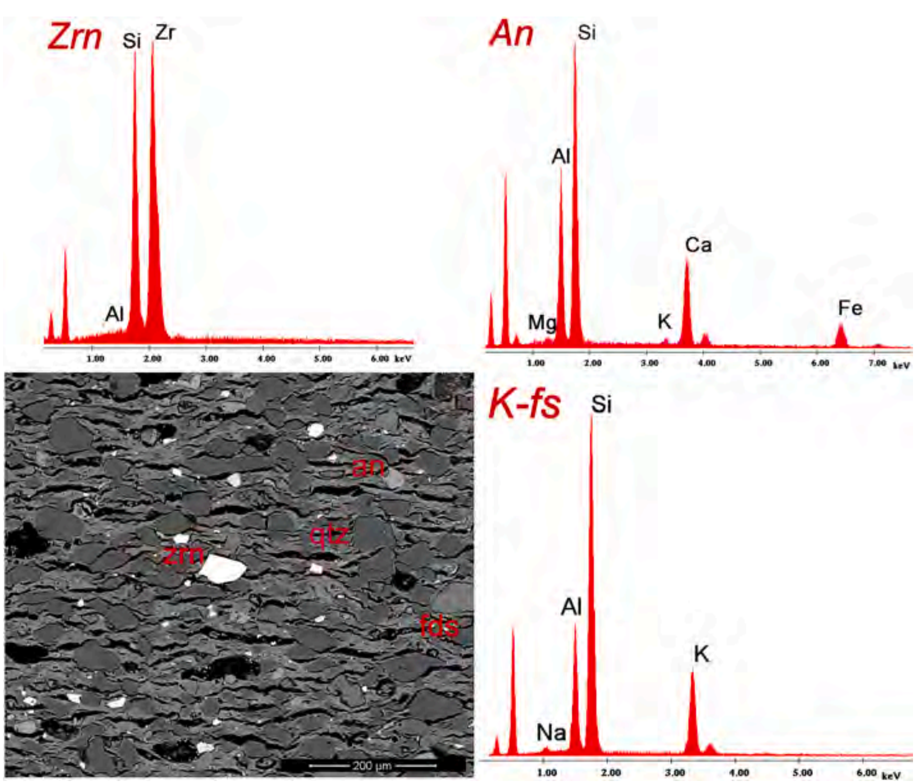

Fig. 4. SEM-BSE image of sample TFN.1958.L.614/2 and EDS spectra of typical inclusions: zircon (zrn), anorthite (an) and K-felspar (K-fs).

see Fig. 4) and TFN.1960.L.760/2. Some small ilmenite crystals (lower in size than 50 μm) have been also detected in several samples: TFN.1954.L.247/1 (together with rare amphiboles, see Fig. 3), TFN.1947.L.84/2 = F.718, and TFN.1958.L.614/2. Several samples included in this fabric (TFN.1954.L.247/1, TFN.1960.L.801/24, and TFN.1954.L.270/1) show chert fragments (Fig. 2g and h).

Inclusions are all scattered in a heterogeneous, optically active, and orange-brown coloured matrix, whereas samples TFN.1954.B.264/1, TFN.1958.L.614/2, and TFN.1954.L.270/1 show a black core.

Voids appear homogeneously diffused, often in the form of channels and aligned vughs. Some of the samples show secondary calcite at the surface of the sherds, but no recrystallization is indeed documented in the pores.

Samples belonging to *fabric C-quartz* are clearly distinguished from samples TFN.1958.L.656/15 and TFN.1959.B.658/2, both under OM and SEM-EDS (Fig. 5). Specifically, one of the analysed carinated bowls, sample TFN.1959.B.658/2 (Figs. S3c and d), turned out to belong to *fabric B-calcareous*, as already described by Medeghini et al. [18]. The sample is characterized by a general predominance of coarse grained, elongated iron oxide nodules and well-rounded calcareous aggregates, with relatively less quartz inclusions. Iron oxides often cement a silty component, made of predominant quartz and minor calcareous aggregates. Some altered, angular sand-sized crystals of calcite were also recognized (Fig. S4). The matrix appears heterogeneous, optically active, and orange-brown in colour, whereas it lacks the alignment of inclusions. On the contrary, TFN.1958.L.656/15 has to be considered a *loner*, because of its almost complete lack of calcareous aggregates (Figs. S3e and f). It is characterized by the common presence of quartz inclusions, though less abundant than in *fabric C-quartz*, generally sub-rounded and fine, and by the presence of coarse, sub-rounded, Fe-cemented inclusions with silty quartz. The matrix appears heterogeneous, optically active, and light-brown in colour when observed at plane polarized light (PPL). The sample also presents low porosity, weakly oriented and not aligned to the margins.

5.2. XRPD analysis

XRPD results (Table 1, Fig. S5) show that metallic ware sherds from Tell el-Far'ah North (*fabric C-quartz*) are mainly composed of quartz and feldspars, with scarce calcite and plagioclase. In addition, some amphiboles occur, scarce (TFN.1958.L.652/1 and TFN.1954.B.264/1) or in trace (TFN.1958.L.614/2). Micas are scarce (TFN.1958.L.652/1, TFN.1960.L.760/2, and TFN.1947.L.84/2 = F.718) or in trace (TFN.1960.L.801/24) as well. Clay minerals are present in sample TFN.1954.L.270/1; clino-pyroxene is scarce in sample TFN.1960.L.801/24; and hematite occurs in trace in sample TFN.1947.L.84/2 = F.718. The presence of neo-formed phases, *i.e.* gehlenite and wollastonite, was seldom observed (samples TFN.1954.L.247/1 and TFN.1958.L.614/2).

Differently, sample TFN.1959.B.658/2 (*fabric B-calcareous*) shows abundant quartz, with muscovite, scarce calcite and K-feldspars, and traces of hematite, gehlenite, and aragonite.

Finally, the *loner* is made of very abundant quartz, scarce plagioclase, aragonite, and wollastonite, with hematite in traces.

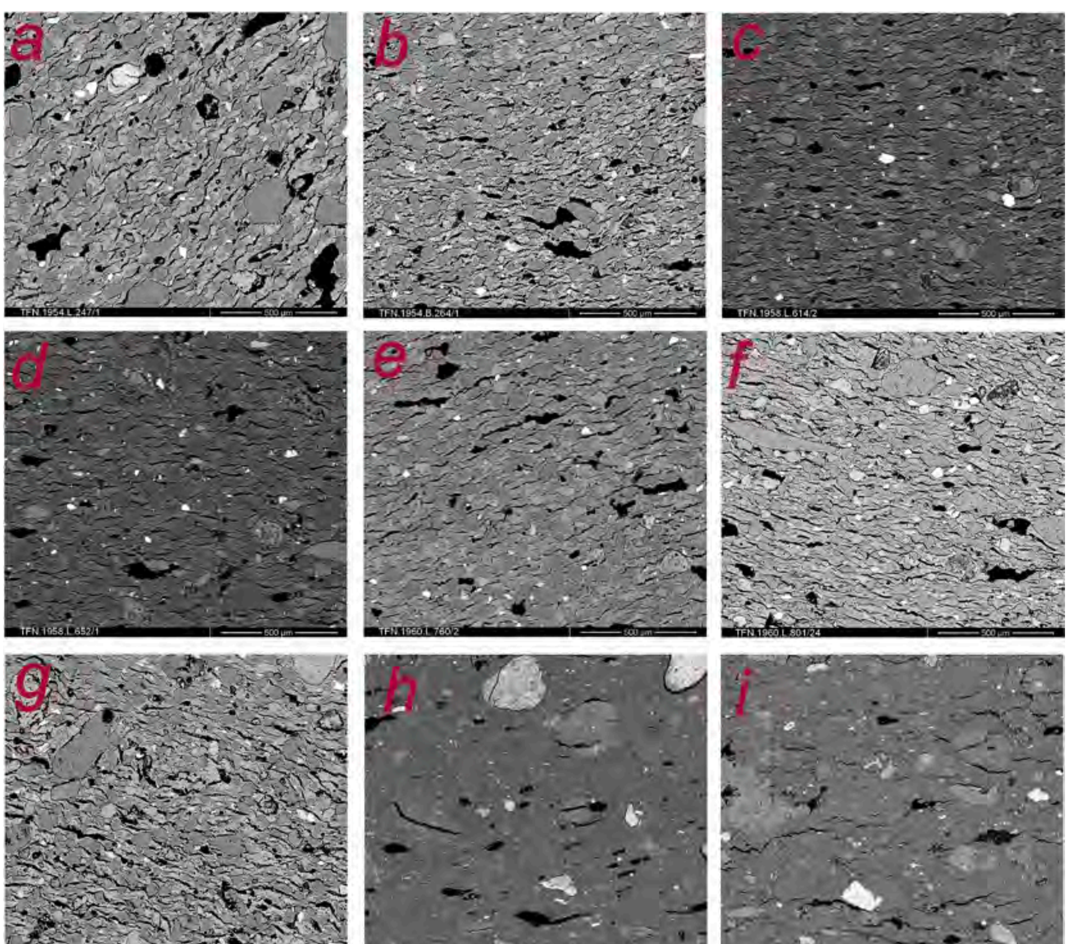

Fig. 5. Representative SEM-BSE images (scale bar = 500 μm) of the matrix in: (a–g) *fabric C-quartz*, (h) *fabric B-calcareous* and (i) *loner*. Specifically: (a) TFN.1954.L.247/1, (b) TFN.1954.B.264/1, (c) TFN.1958.L.614/2, (d) TFN.1958.L.652/1, (e) TFN.1960.L.760/2, (f) TFN.1960.L.801/24, (g) TFN.1954.L.270/1, (h) TFN.1959.B.658/2, (i) TFN.1958.L.656/15.

Table 1
Mineral assemblages of sherd samples and their relative abundance. 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 = Micas, Gh = Gehlenite, Arg = Aragonite, Wo = Wollastonite, Amp = Amphibole.

Fabric	Sample	Qtz	Cal	K-fds	Pl	Clays	Hem	Cl-Py	Ms	Gh	Arg	Wo	Amp
C-quartz	TFN.1954.L.247/1	++++	tr	++	tr							tr	
C-quartz	TFN.1954.B.264/1	++++	tr	+	+								+
C-quartz	TFN.1954.L.270/1	+++	+	++		++							
C-quartz	TFN.1958.L.614/2	++++	tr	++	tr							tr	tr
C-quartz	TFN.1958.L.652/1	+++	+	++	+				+				+
C-quartz	TFN.1960.L.760/2	++++	tr	+	+				+				
C-quartz	TFN.1960.L.801/24	++++	+	+	+			+	tr				
C-quartz	TFN.1947.L.84/2 = F.718	++++	tr	+	+		tr		+				
B-calcareous	TFN.1959.B.658/2	+++	+	+			tr		++	tr	tr		
loner	TFN.1958.L.656/15	++++			+		tr				+	+	

++++ very abundant.
+++ abundant.
++ present.
\+ scarce.
tr trace.

6. Discussion

6.1. Technological data

The multi-analytical approach here applied allowed to identify the distinctive petrofabric of the metallic ware bowls from Tell el-Far'ah North, giving an original contribution to the study of the broader phenomenon of metallic ware industries that characterize the Levant in the EB II.

The results by means of OM, XRPD, and SEM-EDS suggest that the starting raw material used in the production was a low calcareous clay with quartz and feldspars as main inclusions.

The predominant quartz crystals have been identified with a shape from angular to rounded. The variability in shape could suggest the addition of sand during the preparation of the ceramic paste, to modify its plasticity and the thermal properties of the produced vessel [25]. In addition, the lack of coarse inclusions suggests that the raw material used for the manufacture underwent levigation, a common procedure for a high-quality ceramic production, consisting in soaking clay in water to separate large minerals from the clay body [26]. The accurate selection of the original sand seems different in two samples, TFN.1947.L.84/2 = F.718 and TFN.1954.L.247/1, due to a slightly higher variability in the dimension of quartz inclusions. These samples come from the uppermost EB II layers of the fortified town and might indicate a different standard in the purification step throughout the period.

After the levigation process, the paste was properly mixed with water and worked for a long time, as suggested by the absence of clay pellets in the matrix, thus allowing the complete hydration of the clay.

As for the shaping, the analysed samples mainly show the predominance of micro-to mega-vughs and rare vesicles. The alignment of elongated voids and the absence of aligned inclusions indicate a low kinetic energy impressed during the modelling process. This suggests the use of a tournette (slow wheel) [18,27]; the regularity of the horizontal burnishing on the rim suggests as well that this part was turned on the wheel. In fact, some potter's wheels were found at Tell el-Far'ah North in EB II contexts (at least four items, still unpublished: two made of basalt, one made of limestone, and one made of clay). The use of tournettes in the ceramic production – attested in finishing operations, as well as in fashioning some vessel parts, also in other pottery classes –, required the acquisition of complex skills and likely points to the presence of specialist potters.

Most of the samples analysed in the present work showed slight variability in matrix colour, predominantly red when observed macroscopically, that suggests a firing in an oxidizing environment in which oxygen availability was not perfectly controlled [18]. 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, which may be linked to a firing in a reducing atmosphere with oxidizing cooling stage, or to a clay rich in organic matter fired under oxidizing conditions [28].

The maximum firing temperature of the analysed samples was estimated based on the nature and reaction rims of inclusions as documented in thin section by SEM-EDS, and on the newly-formed phases identified by XRPD. 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 [29]. However, carbonate-poor clayey materials have a higher sintering temperature than carbonate-rich clayey materials (~800 °C [30]), in which Ca and Mg act as fluxes [31].

The presence of primary calcareous inclusions could suggest a firing temperature lower than 800 °C, the upper limit of decarbonation process [32]. However, in a complex system as that of ceramic material, the grain size and the abundance of calcite inclusions, the chemical composition of the system, and the firing process parameters (atmosphere, speed of heating rate and cooling) also have a great influence on the stability of calcite, which can be still found up to 875–900 °C [33,34]. In the case of the metallic ware bowls from Tell el-Far'ah North, the identification of reaction rims around calcareous sedimentary rock fragments could indicate a firing temperature around 850 °C [35].

During a firing process above 800 °C, the free lime from decarbonated calcareous inclusions generates new Ca-silicates by reaction with the fired clay minerals [36]. Indeed, TFN.1954.L.247/1 and TFN.1958.L.614/2 showed traces of wollastonite, which usually co-occurs with calcite in the range 800–1100 °C [37]. In the other samples, no new-formed phases or matrix vitrification were observed, suggesting a lower firing temperature than the samples just mentioned. However, the co-occurrence of reaction rims identified by OM and the higher sintering temperature needed would indicate a firing temperature around 850 °C.

It has been proposed that North Canaanite/South Levantine Metallic Ware was produced at a high firing temperature, above 900 °C [15], and that high firing temperature would be the reason of metallic sound. However, Greenberg & Porat [15] did not report the XRPD data from which they inferred this high firing temperature, preventing us to compare and discuss the results.

6.2. Fabrics, forms, and function

Fabric-C quartz was employed in the manufacture of a single and distinctive class of small bowls. Fragments mostly belong to small carinated bowls with flared rim and rounded base, at times provided with a horizontal pierced lug handle applied at the girth. Other bowl types include small carinated bowls with vertical rim and rounded base, and one small hemispherical bowl with thinned rim and a horizontal pierced lug handle. No other forms were produced in this fabric, which therefore turns out to be carefully selected and highly specialised.

According to the results published in Medeghini et al. [18], during the EB II *fabric B-calcareous* was instead employed in the manufacture of a range of tableware vessels, mostly red burnished. Carinated bowls with flared rim were also present. This is the case of sample TFN.1959. B.658/2, and samples TFN.1947.Sq.4/1 and TFN.1946.Tr.V/15 = F.273, analysed and published in Medeghini et al. [18].

Fabric-C quartz and *fabric B-calcareous* were thus employed to produce similar vessels, resulting from the same manufacturing process, and appearing virtually interchangeable in functional terms. The use of a different fabric, and the resulting diverse appearance, could represent a different social meaning.

6.3. Provenance of raw materials

Fabric C-quartz here identified as the fabric of metallic ware bowls from Tell el-Far'ah North, consistently differs from the renown North Canaanite/South Levantine Metallic Ware, whose supplies have been identified in Lower Cretaceous clay deposits of the Hermon/Lebanon/Anti-Lebanon massif [15,38]. Shale and volcanic fragments are absent in the metallic ware samples from Tell el-Far'ah North. Such evidence indicates that different supplies, as well as a diverse production location, were involved.

The microscopic features described for *fabric C-quartz* are highly compatible with supplies in proximity to the site, such as the clayey Hordos Formation and the Umm Sabune Conglomerates. This compatibility is also marked by the undocumented presence of fossils, both in our samples and in the Hordos Formation. The presence of chert, which is typical of the Timrat Formation and can be found in the surroundings of Tell el Far'ah North, supports the hypothesis of local supplies. This let us infer about a local, specialised ceramic industry, or even a specialised workshop, with high expertise in the selection of raw materials.

On the other hand, *fabric C-quartz* is petrographically distant from the two types of clays used in the common ceramic repertoire at the site, which are linked to local sedimentary outcrops belonging to the Lisan or Alluvium Formation [18] (Fig. S1).

7. Conclusions

The multi-analytical approach applied in this study allowed to recognise a new fabric in the EB I–II ceramic ensemble from Tell el-Far'ah North. This fabric was used in the manufacture of a distinctive class of small (carinated) bowls retrieved in the EB II layers and belonging to a local metallic ware industry.

A low calcareous local clay, with quartz and feldspars as main inclusions, was used in the production. The accurate selection of the starting clay, the care in the mixing phase, the use of tournette, and the firing temperature range estimated between 800 and 900 °C, stand for a high-quality and highly specialised ceramic production, and are consistent with the presence of specialist potters.

This work has improved our overall knowledge on the EB II pottery assemblage from Tell el-Far'ah North, by proving the existence of a metallic ware industry that involved distinct supplies and technical choices – albeit in the framework of a homogeneous manufacturing tradition.

The archaeological relevance of this metallic ware industry is apparent. It differs from the contemporary, widespread North Canaanite/South Levantine Metallic Ware that characterizes EB II sites in the north. It most likely represents a ceramic industry of the central hill country, according to the pattern of regional production centres, and regional specialised industries, which characterizes the Southern Levant in the EB II.

The metallic ware bowls from Tell el-Far'ah North analysed in this study are likely to have been produced in a specialised workshop at Tell el-Far'ah North, or in its vicinity. The issue of production location remains to be fully clarified, whether it was Tell el-Far'ah North, as it is conceivable, or some other centre in the central hill country. Importation may account for the limited attestation of these metallic ware bowls at Tell el-Far'ah North; albeit the limited attestation might also indicate a very specialised production, i.e. an elite ware within a context of increasing social differentiation. Only further petrographic analyses on the ceramic ensembles from other sites in the area may contribute to assess the topic and to identify production centres.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ceramint.2021.09.222.

References

[1] I. Liritzis, N. Laskaris, A. Vafiadou, I. Karapanagiotis, P. Volonakis, C. Papageorgopoulou, M. Bratitsi, Archaeometry: an overview, Sci. Cult. 6 (2020) 49–99.

[2] A. Maras, M. Botticelli, P. Ballirano, Archaeometric investigations on cinnabar provenance and origin by X-ray powder diffraction: preliminary data, Int. J. Conserv. Sci. 4 (2013) 685–692.

[3] A. Doménech-Carbó, M. Mödlinger, M.T. Doménech-Carbó, Multiple-scan voltammetry and OCP: archaeometric tools for dating archaeological bronzes, J. Electroanal. Chem. 893 (2021) 115336, https://doi.org/10.1016/j.jelechem.2021.115336.

[4] N. Liu, Y. Yang, Y. Wang, W. Hu, X. Jiang, M. Ren, M. Yang, C. Wang, Nondestructive characterization of ancient faience beads unearthed from Ya'er cemetery in Xinjiang, Early Iron Age China, Ceram. Int. 43 (2017) 10460–10467, https://doi.org/10.1016/j.ceramint.2017.05.086.

[5] S. Amicone, V. Forte, B. Solard, C. Berthold, A. Memmesheimer, N. Mirković-Marić, Playing with fire: exploring ceramic pyrotechnology in the Late Neolithic Balkans through an archaeometric and experimental approach, J. Archaeol. Sci. Rep. 37 (2021) 102878, https://doi.org/10.1016/j.jasrep.2021.102878.

[6] A. Scala, F. Gabbrielli, M. Giamello, S. Mugnaini, Archaeometric analysis of building mortars used in the historic centre of Siena (Italy) between the 13th and 16th centuries, J. Archaeol. Sci. Rep. 35 (2021) 102790, https://doi.org/10.1016/j.jasrep.2021.102790.

[7] F. Alhaique, C. Moricca, L. Barelli, A. Masi, R. Pugliese, L. Sadori, G. Romagnoli, L. Piermartini, L. Brancazi, F. Gabbianelli, G. Chillemi, A. Valentini, Elite food between the late middle ages and renaissance: some case studies from Latium, Environ. Archaeol. (2021) 1–15, https://doi.org/10.1080/14614103.2020.1867038.

[8] C. Aurisicchio, A.M. Conte, L. Medeghini, L. Ottolini, C. De Vito, Major and trace element geochemistry of emerald from several deposits: implications for genetic models and classification schemes, Ore Geol. Rev. (2018), https://doi.org/10.1016/j.oregeorev.2018.02.001.

[9] M. Avramovska, C. Chmelik, A. Derkowski, A. Fantalkin, D. Freude, J. Haase, V. Hare, J. Kärger, A. Kuligiewicz, M. Moinester, Searching for the fundamentals of rehydroxylation dating of archaeological ceramics via NMR and IR microscopy, J. Am. Ceram. Soc. (2021) 17753, https://doi.org/10.1111/jace.17753, jace.

[10] W. Enyuan, X. Yinfei, Z. Yibing, W. Jinwei, Regional microstructural characteristics between the body and glaze of ancient Chinese ceramics, Ceram. Int. (2020), https://doi.org/10.1016/j.ceramint.2020.05.303.

[11] V. Forte, S. Nunziante Cesaro, L. Medeghini, Cooking traces on Copper Age pottery from central Italy: an integrated approach comprising use wear analysis, spectroscopic analysis and experimental archaeology, J. Archaeol. Sci. Rep. (2018), https://doi.org/10.1016/j.jasrep.2017.12.052.

[12] M.C. Caggiani, G. Barone, L. Ferri, R. Laviano, A. Mangone, P. Mazzoleni, Raman and SEM-EDS insights into technological aspects of Medieval and Renaissance ceramics from Southern Italy, J. Raman Spectrosc. 52 (2021) 186–198, https://doi.org/10.1002/jrs.5884.

[13] R. Greenberg, Urbanism and its demise in the early Bronze II and III, in: Archaeol. Bronze Age Levant, Cambridge University Press, 2019, pp. 70–135, https://doi.org/10.1017/9781316275993.004.

[14] R. Greenberg, Travelling in (world) time: transformation, commoditization, and the beginnings of urbanism in the Southern Levant, in: T.C. Wilkinson, S. Sherratt, J. Bennet (Eds.), Interweaving Worlds, Syst. Interact. Eurasia, 7th to 1st Millenn. BC, Oxbow Books, Oxford, 2011, pp. 79–86, https://doi.org/10.2307/j.ctvh1dr2k.

[15] R. Greenberg, N. Porat, A third millennium Levantine pottery production center: typology, petrography, and provenance of the Metallic Ware of northern Israel and adjacent regions, Bull. Am. Sch. Orient. Res. 301 (1996) 5–24, https://doi.org/10.2307/1357293.

[16] R. Greenberg, M. Iserlis, A note on first dynasty Egypt, Tel Bet Yerah, and the origins of commodity exchange on the Levantine seaboard, J. Anc. Egypt. Interconnect. 27 (2020) 38–50.

[17] P. Beck, An early Bronze Age "Family" of bowls from Tel Aphek, Tel. Aviv. 12 (1985) 17–28, https://doi.org/10.1179/tav.1985.1985.1.17.

[18] L. Medeghini, M. Sala, C. De Vito, S. Mignardi, A forgotten centre of ceramic production in southern levant: preliminary analytical study of the early Bronze Age pottery from Tell el-Far'ah North (West Bank), Ceram. Int. 45 (2019) 11457–11467, https://doi.org/10.1016/j.ceramint.2019.03.013.

[19] P. De Miroschedji, Far'ah, Tell el- (North). Neolithic Period to Middle Bronze Age, New Encycl. Archaeol. Excav. Holy Land, Jerusalem, 1993, pp. 433–438.

[20] R. de Vaux, La cinquième campagne de fouilles à Tell el-Far'ah, près Naplouse, Rev. Biblique 62 (1955) 541–589.

[21] P. Cook, The Geological Map of Israel, 1:50,000. Sheet 5-IV, Shekhem, Jerusalem, 2000.

[22] Y. Mimran, G. Shaliv, E. Sakal, A. Sneh, The Geological Map of Israel, 1:50,000. Sheet 6-III, IV: Beqaot (Partly Revised, 2020), 2020. Jerusalem.

[23] I.K. Whitbread, The characterisation of argillaceous inclusions in ceramic thin sections, Archaeometry 28 (1986) 79–88, https://doi.org/10.1111/j.1475-4754.1986.tb00376.x.

[24] I.K. Whitbread, Greek Transport Amphorae: A Petrological and Archaeological Study, British School at Athens, 1995.

[25] C. Grifa, G. Cultrone, A. Langella, M. Mercurio, A. De Bonis, E. Sebastián, V. Morra, Ceramic replicas of archaeological artefacts in Benevento area (Italy): petrophysical changes induced by different proportions of clays and temper, Appl. Clay Sci. 46 (2009) 231–240, https://doi.org/10.1016/j.clay.2009.08.007.

[26] M.L. Teoh, S.B. McClure, E. Podrug, Macroscopic, petrographic and XRD analysis of Middle Neolithic *figulina* pottery from central Dalmatia, J. Archaeol. Sci. 50 (2014) 350–358, https://doi.org/10.1016/j.jas.2014.07.007.

[27] V. Roux, P. De Miroschedji, Revisiting the history of the potter's wheel in the Southern Levant, Levant 41 (2009) 155–173, https://doi.org/10.1179/007589109X12484491671095.

[28] L. Nodari, E. Marcuz, L. Maritan, C. Mazzoli, U. Russo, Hematite nucleation and growth in the firing of carbonate-rich clay for pottery production, J. Eur. Ceram. Soc. 27 (2007) 4665–4673, https://doi.org/10.1016/j.jeurceramsoc.2007.03.031.

[29] I. Turbanti Memmi, Pottery production and distribution: the contribution of mineralogical and petrographical methodologies in Italy. State of the art and future developments, Period. Mineral. 73 (2004) 239–257.

[30] M.S. Tite, Y. Maniatis, Scanning electron microscopy of fired calcareous clays, Trans. J. Br. Ceram. Soc. 74 (1975) 19–22.

[31] E.R. Segnit, C.A. Anderson, Scanning electron microscopy of fired illite, Trans. J. Br. Ceram. Soc. 71 (1972) 85–88.

[32] S. Dash, M. Kamruddin, P.K. Ajikumar, A.K. Tyagi, B. Raj, Nanocrystalline and metastable phase formation in vacuum thermal decomposition of calcium carbonate, Thermochim. Acta 363 (2000) 129–135, https://doi.org/10.1016/S0040-6031(00)00604-3.

[33] M.J. Trindade, M.I. Dias, J. Coroado, F. Rocha, Mineralogical transformations of calcareous rich clays with firing: a comparative study between calcite and dolomite rich clays from Algarve, Portugal, Appl. Clay Sci. 42 (2009) 345–355, https://doi.org/10.1016/j.clay.2008.02.008.

[34] M. Bayazit, I. Işık, A. Issi, E. Genç, Spectroscopic and thermal techniques for the characterization of the first millennium AD potteries from Kuriki-Turkey, Ceram. Int. 40 (2014) 14769–14779, https://doi.org/10.1016/j.ceramint.2014.06.068.

[35] M. Riccardi, An approach to the dynamics of clay firing, Appl. Clay Sci. 15 (1999) 393–409, https://doi.org/10.1016/S0169-1317(99)00032-0.

[36] B. Fabbri, S. Gualtieri, S. Shoval, The presence of calcite in archeological ceramics, J. Eur. Ceram. Soc. 34 (2014) 1899–1911, https://doi.org/10.1016/j.jeurceramsoc.2014.01.007.

[37] M.J. Trindade, M.I. Dias, J. Coroado, F. Rocha, Firing tests on clay-rich raw materials from the Algarve basin (Southern Portugal): study of mineral transformations with temperature, Clay Clay Miner. (2010), https://doi.org/10.1346/CCMN.2010.0580205.

[38] M. Iserlis, D. Steiniger, R. Greenberg, Contact between first dynasty Egypt and specific sites in the Levant: new evidence from ceramic analysis, J. Archaeol. Sci. Rep. 24 (2019) 1023–1040, https://doi.org/10.1016/j.jasrep.2019.03.021.