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**Ceramic exchange in the northern UAE during the Late Bronze Age: preliminary results of macroscopic and petrographic analyses**

**Maria Paola Pellegrino, Sophie Méry, Anne Benoist, Sophie Costa & Julien Charbonnier**

**Summary**

In the case of Late Bronze Age pottery archaeometry is still rare in south-east Arabia. This article presents the results of a study undertaken on pottery assemblages from three Late Bronze Age sites located in the northern United Arab Emirates: Masafi-5, Kalba 4, and Shimal SX. Macroscopic and technological observations of a large set of potsherds were combined with a petrographic analysis of twenty-eight thin sections. Beyond providing a characterization of four petrographic groups, the study demonstrates a close trading connection between the east coast (Kalba 4), the internal region (Masafi-5), and the west coast (Shimal SX) and reveals the regional mobility of people during the Late Bronze Age and early Iron Age.

**Keywords:** pottery, Late Bronze Age, south-east Arabia, petrographic analysis, exchanges

**[A]Introduction**

The aim of this article is to report the first results of our work on the development of ceramic exchange in the north of the United Arab Emirates (UAE) during the Late Bronze Age (LBA). There has recently been a growing interest regarding the transition between the Bronze and Iron Ages in the UAE (Fig. 1). The excavation of sites such as Shimal SX (Franke-Vogt 1991; Velde 1992), Tell Abraq (Potts 1990; 1991; Magee et al. 2017), Kalba 4 (Carter 1997; Magee & Carter 1999; Eddisford & Phillips 2009), and most recently Masafi-5, provided significant data regarding this transition phase, which is known as ‘Late Bronze Age’ and ‘Iron Age I’. In Tell Abraq and Shimal, Velde and

Magee stressed the existence of a cultural ‘break’ and the replacement of Bronze Age traditions at the end of the second millennium BC by new pottery traditions, mainly of ‘coarse gritted ware’ (Magee 1996; 2011; Velde 1998; 2003). In Kalba, Magee and Carter outlined an assemblage with a wider diversity of fabrics but also different from Tell Abraç and Shimal (Magee & Carter 1999). Finally, as soon as the Masafi-5 ceramic assemblage was unearthed, it became clear to Benoist (Degli Esposti & Benoist 2015) that she was dealing with a unique pottery assemblage from a period which was dated between the sixteenth and eleventh centuries BC.

[insert Fig. 1 near here].



FIGURE 1. A map showing the sites mentioned in the text.

Based on these new discoveries at Masafi-5, we were able to design a research programme in order to better characterize the productions dated from the end of the Bronze Age and the beginning of the Iron Age. The main aim was firstly, to see if they represented a real break in the local pottery traditions and secondly, to study the possible contacts between different sites during this period. The question of the production and distribution of pottery in the north of the UAE during the LBA is

connected with the typo-chronological study of the pottery, and can be approached by studying the *chaîne opératoire* of these pottery assemblages.<sup>1</sup>

As part of our research programme, ceramics from different sites located in the north of the UAE (Masafi-5, Kalba 4, Tell Abraç, and Shimal SX) were sampled and analysed macroscopically by one of the authors (MPP). The analysis revealed the presence of four main fabric groups. The macroscopic study has been complemented with petrographic analysis for which twenty-eight sherds were selected for thin section. Petrographic analysis was conducted by SM, revealing the diversity of mineral composition in the ceramic material found on the different sites. Petrographic results were thus compared with local and regional geological data such as geological maps, studies or publications, and geological samples. Regional geological maps point to possible sources of raw materials used by the potters, based on the mineral composition observed in the ceramics. By determining whether pottery was locally produced or imported, it was possible to extrapolate and determine the degrees of connections between the studied sites and also the movement of products — in this case, pottery — between the east and west coasts of the northern UAE.

### **[A]The macroscopic and petrographic study**

Macroscopic observation of pottery is the basic method for processing large quantities of ceramics and provides archaeologists with essential information ahead of further petrographic sampling. The results gathered through thin-section analysis can sometimes be extrapolated for the entire assemblage. They should only be extrapolated when the results are consistent with the homogeneous groups that have been identified during the macroscopic phase. As the groups we are dealing with are not always homogeneous, we need to remain cautious at this stage of the study.

In order to collect these macroscopic elements, hand lenses are the most effective method to describe and analyse large sets of samples. Systematic observations help to create macroscopic groups. The

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<sup>1</sup> This topic is central to the PhD research by MPP, under the supervision of SM and AB.

criteria used to define macroscopic groups combine the colour of the paste, its texture, and the mineral and vegetal temper. The shaping techniques, surface treatment, possible decorating techniques and motifs, and firing techniques of the vessels are also explored (Rice 1987: 310). Moreover, in order to increase the thoroughness of our analysis, it was also decided to rely on further technological study (by MPP) based on the systematic observation and description of macro-traces of shaping and finish visible on the surface and in some sections of the potsherds.

Our study first began with a macroscopic study of the whole pottery corpus of Masafi-5, representing more than 24,000 sherds. In a second phase, one of us (MPP) was given the opportunity to study the complete assemblage of Shimal SX (20,499 ceramic fragments) with the kind permission of C. Velde from the Department of Museums and Antiquities, Ras al-Khaimah. The opportunity to make a brief study of thirty-four samples of pottery from Kalba 4 was given thanks to C. Phillips, and analysis of a pottery sample of LBA and Iron Age I levels from Tell Abraq (3332 potsherds) was conducted with the kind permission of P. Magee and the Sharjah Archaeological Authority for both Tell Abraq and Kalba. The macroscopic description of all samples showed significant variation in the composition of the ceramic paste between the four contemporaneous sites. Ultimately, it was possible to define twelve macroscopic groups for the studied ceramic assemblages.

Based on these macroscopic groups, a sampling was prepared for microscopic examination. The characterization of the pottery was undertaken by ceramic petrography with the aim of checking the conclusions of their macroscopic study. For the present study sixteen fragments from Masafi-5, four samples from Shimal SX, and eight samples from Kalba 4 were selected and prepared as polished thin sections, 30  $\mu\text{m}$  thick, mounted on glass slides (Fig. 2). These were then analysed under a polarizing light microscope, Nikon Eclipse E600 POL, and photographed. It allowed SM to make a classification of petrographic groups through the identification of the mineralogical composition of the clay and temper.

[insert Fig. 2 near here].

Sample number	Site	Type	Macroscopic group	Petrographic group
LBA01	Masafi 5	Necked jar	Group LBAM.1	Group LBAP.A
LBA12	Masafi 5	Large open vessel	Group LBAM.1	Group LBAP.A
LBA21	Masafi 5	Large open vessel	Group LBAM.1	Group LBAP.A
LBA22	Masafi 5	Spooned bowl	Group LBAM.1	Group LBAP.A
LBA07	Masafi 5	Small bowl	Group LBAM.1	Group LBAP.A
LBA05	Masafi 5	Large open vessel	Group LBAM.1	Group LBAP.A
LBA11	Masafi 5	Big jar	Group LBAM.2	Group LBAP.B
LBA15	Masafi 5	Fragment	Group LBAM.2	Group LBAP.B
LBA02	Masafi 5	Storage jar	Group LBAM.2	Group LBAP.B
LBA03	Masafi 5	Closed vessel	Group LBAM.2	Group LBAP.B
LBA06	Masafi 5	Fragment	Group LBAM.2	Group LBAP.D
LBA10	Masafi 5	Fragment	Group LBAM.4	Group LBAP.E
LBA18	Masafi 5	Fragment	Group LBAM.4	Group LBAP.E
LBA19	Masafi 5	Fragment	Group LBAM.4	Group LBAP.D
LBA13	Masafi 5	Large open vessel	Group LBAM.3	Group LBAP.C
LBA14	Masafi 5	Fragment	Group LBAM.3	Group LBAP.C
LBA24	Kalba 4	Big jar	Group LBAM.1	Group LBAP.A
LBA27	Kalba 4	Base	Group LBAM.1	Group LBAP.A
LBA28	Kalba 4	Bowl	Group LBAM.1	Group LBAP.A
LBA25	Kalba 4	Necked jar	Group LBAM.2	Group LBAP.B
LBA31	Kalba 4	Necked jar	Group LBAM.2	Group LBAP.B
LBA32	Kalba 4	Spooned bowl	Group LBAM.4	Group LBAP.D
LBA29	Kalba 4	Bowl	Group LBAM.3	Group LBAP.C
LBA31	Kalba 4	Large open vessel	Group LBAM.3	Group LBAP.C
LBA71	Shimal SX	Fragment	Group LBAM.1	Group LBAP.A
LBA75	Shimal SX	Fragment	Group LBAM.1	Group LBAP.A
LBA72	Shimal SX	Fragment	Group LBAM.1	Group LBAP.A
LBA73	Shimal SX	Fragment	Group LBAM.1	Group LBAP.A

**FIGURE 2. Top:** description of the samples analysed. **Bottom:** comparisons of macroscopic and petrographic groups with other authors.

Macroscopic groups	Petrographic groups	Méry 2000	Benoist & Méry 2010	Valde 1998	Mageo et al. 1998	Mageo et al. 2017	Degli Esposti & Benoist 2015
Group LBAM.1	Group LBAP.A	Shimal 1 Céramique grossière Petrographic Group R					Orange to brown fabric with grey-greenish elongated grits
Group LBAM.2	Group LBAP.B	Shimal 3 Céramique semi-grossière Petrographic Group U		Main ware D		Fabric 1	Light buff, orange to brown fabric with sharp white calcareous grits
Group LBAM.3	Group LBAP.C	Céramique grossière "de Hill" Petrographic Group J					Red to brown-greyish fabric with sharp dark grey-brown inclusions
Group LBAM.4	Group LBAP.D Group LBAP.E	Céramique sablée "de Hill"	"Sandy buff ware" group		Group β, Sandy fabric		Light buff fabric with a sandy texture and vespetal temper

In this article we present the results of the analysis that was conducted on four macroscopic groups which were renamed LBAM.1, LBAM.2, LBAM.3, and LBAM.4. LBAM is the Late Bronze Age Macroscopic group and LBAP refers to the Late Bronze Age Petrographic group.

### [A]The macroscopic group LBAM.1

The vast majority of potsherds from group LBAM.1 correspond to a common orange ware, with a light orange to brownish-reddish fabric and grey grits. The paste contains moderate to abundant amounts of greyish shining elongated grits of a very cracked rock, in some cases accompanied by sparser and smaller white and sometimes red inclusions measuring up to 3 mm. According to the size and quantity of the grits it is possible to identify three subgroups: coarse, medium, and fine. The potsherds have smoothed surfaces that sometimes show traces of pebble burnishing. Slips are

infrequent, as only some fine potsherds have a thin buff or whitish slip, generally with a matt finishing. A few sherds bear traces of reddish painted decorations, others whitish and brownish paint. The motifs mainly include wavy lines, not always continuous, located under the rim on both the exterior and interior of the vessels and around the spout of spouted bowls. Other motifs include triangles, simple points, and irregular lines. Traces of painted decoration are also present above the rim.

The vessels of group LBAM.1 are hand-modelled and coiled. Some bases show traces of finger impressions made during the modelling. Numerous potsherds are broken at the point of the junction between two coils; thus, the coils are clearly visible in the section of the sherds. It is clear that the potters used different techniques to join the coils. For example, some coils preserve the impressions of a small tool, to facilitate the junction with the next coil, while other coils show ‘nail’ imprints or finger impressions at the junction of two coils (Fig. 3).

[insert Fig. 3 near here]



FIGURE 3. Some examples of macro traces associated with the coiling technique. a. Coil with ‘nail’ imprints; b. coil with small imprints of a tool, to facilitate the join with the next coil; c. traces of finger impressions at the join of two coils; d. base with traces of finger impressions made during hand modelling.

Group LBAM.1 represents 90% of the material collected in Masafi-5 but it only occurs in small quantities (less than 5%) in Shimal SX, Kalba 4, and Tell Abraq. The most typical shapes are large

open vessels, medium and small simple bowls, large and medium necked jars, closed vessels, big storage jars, spouted bowls, dishes, and miniature vessels (Fig. 4).

[insert Fig. 4 near here].

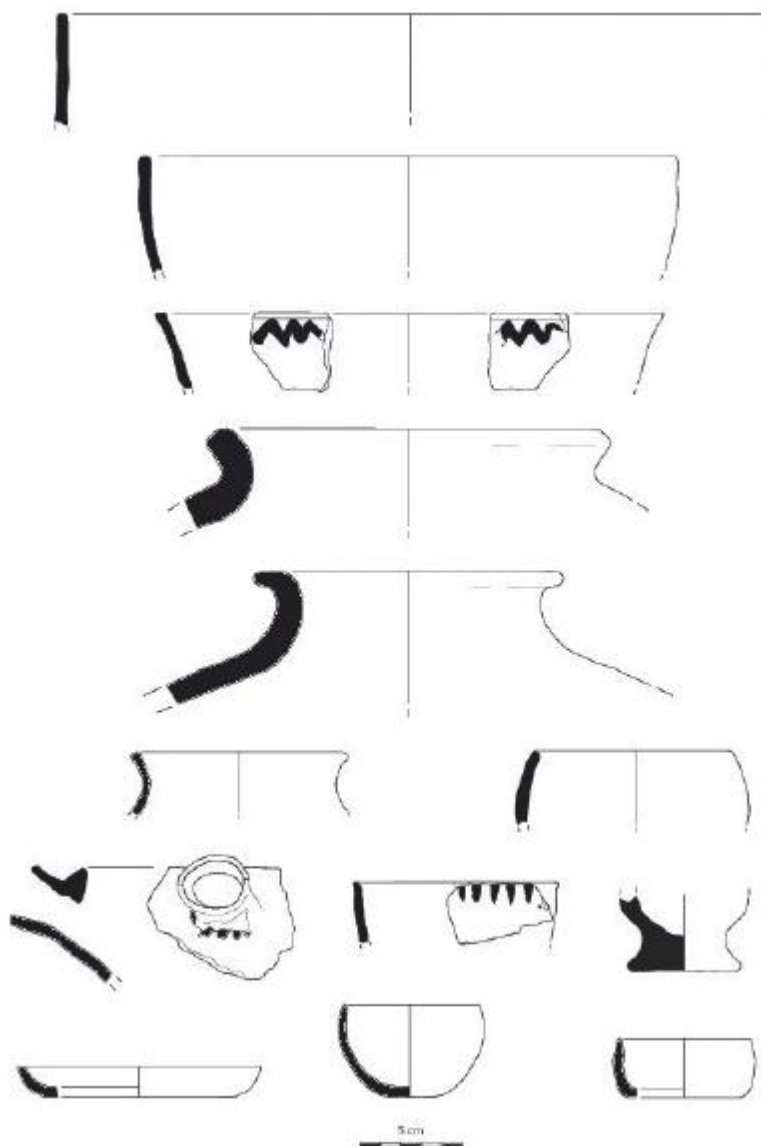


FIGURE 4. Characteristic shapes of the Late Bronze Age pottery of the northern UAE.

Based on its distribution, group LBAM.1 clearly characterizes Masafi-5. The high percentage of vessels of this group is not insignificant, as in archaeology the ‘criterion of abundance’ states that the most abundant material found on one site should be considered as ‘local’ due to cost and economic principles (Velde & Druc 1999: 240–258). When carefully employed, the criterion of abundance is



reliable in the case of utilitarian products. How does the petrographic analysis document and confirm the possibility of group LBAM.1 production in the area of Masafi?

Twelve samples of group LBAM.1 from three different sites were studied in thin section. Six samples come from the settlement of Masafi-5 (LBA01, LBA05, LBA07, LBA12, LBA21, and LBA22). Samples LBA71, LBA72, and LBA73 were found on the site of Shimal SX; the last two samples are from Kalba 4 (LBA24, LBA28). All these samples belong to the same petrographic group, group LBAP.A described below (Fig. 5).

[insert Fig. 5 near here]

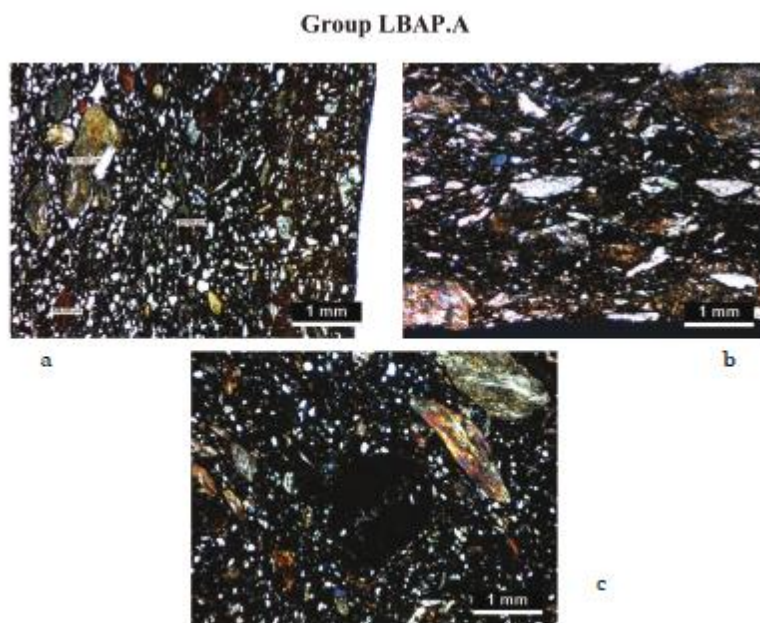


FIGURE 5. Microscopic views (crossed polarized light microscope) of samples. a. LBA05 (Masafi-5); b. LBA71 (Shimal SX); c. LBA24 (Kalba 4).

The matrix is characterized by a drying and firing shrinkage. Its fabric is a natural combination of clay phyllites and very fine micas which can be clearly distinguished from the oxidized parts (LBA05, LBA07, LBA22), while the rest does not show an optically active clay matrix (LBA121, LBA71, LBA72). The degree of firing and the changes of atmosphere have a strong impact on this type of matrix, especially under XPL. Furthermore, when the matrix is oxidized, it presents a mesh

structure, clearly visible in the samples where the degree of firing is reduced. The fine mineral fraction contains grains up to 500  $\mu\text{m}$  in length and represents only 5–7% of the thin section's surface. Monocrystalline quartz inclusions prevail, with a mix of crystals and most of them are slightly blunt and irregularly shaped. Alkali feldspars and plagioclases are also present with some rock fragment of polycrystalline quartz. It is also made up of numerous red-brownish opaque minerals — in which the optical activity decreased when the degree of firing increased, as in the case of LBA05 — which are primarily eroded (sub-rounded) fragments of serpentinite and olivine and sub-automorphic pyroxene crystals. The coarse fraction includes inclusions that may reach about 3 mm in extent and constitute 15–20% of the surface of the thin sections. It mainly consists of crushed fragments of sericite schist of all dimensions followed by fragments of serpentinite and micritic limestone in varying proportions.

In the present study, ceramic petrography was chosen because it drastically increases the identification rate of inclusions and allows direct comparisons with available regional geological data (Rice 1987: 415; Méry 2000; Quinn 2013). In order to determine whether the ceramic type was locally produced in the region of Masafi, we compared different mineral inclusions identified in the thin sections with some locally available materials including sands, rocks, and sediments. This test matches pottery with local raw materials and provides a certain degree of probability as far as the origin of the vessel body goes (cf. Méry 2000: 109–111 on Early Bronze Age pottery in eastern Arabia).

The geological background of Masafi includes three main formations. The first, Masafi schist Formation 1, is composed of thinly laminated quartzite and green-grey mica schist and constitutes the major part of Jebel Haryan, the main relief in the centre of the oasis and around which the occupations are organized. The second is a mix of chlorite quartz schist and quartzite and appears on the western slope of Jebel Haryan and along Wādī Sidji, which flows west of Masafi. The third is a



The second macroscopic group, LBAM.2, is represented by a light orange, orange to brownish compact fabric with very small and rounded white calcareous fragments. It is tempered by sub-rounded gravel inclusions, red-brown to dark grits measuring up to 10 mm. Vegetal temper was added, leaving numerous rectangular vegetal prints. Two subgroups — coarse and medium — can be identified due to the frequency of the inclusions. The potsherds are mainly unslipped, although a few sherds preserve traces of a possible thin red wash. The presence of a red painted decoration is quite rare, with a few medium sub-group potsherds bearing short parallel lines under the rim. Group LBAM.2 also provides new interesting technological features. Potsherds do not show traces of finger impressions as in group LBAM.1, but regular sub-horizontal bands are often visible on their internal surface. Some potsherds also present faint horizontal lines visible on their internal or external surfaces. Traces of string cutting are also visible on the bases of the goblets. All these marks suggest that this type of pottery was hand-modelled and coiled but finished on a ‘wheel’, as defined in the study of the Hili pottery (Méry, Dupont-Delaleuf & Van der Leeuw 2010) (Fig. 7). Group LBAM.2 forms more than 70% of the assemblage of Shimal SX and Tell Abraq, while it only appears in small quantities (less than 10%) at Masafi-5 and Kalba 4. At Shimal SX it mainly consists of pottery types such as large jars and medium necked jars, large open vessels, medium bowls, and characteristic footed goblets.

[insert Fig. 7 near here].



FIGURE 7. Some examples of pottery sherds from group 2. This group was coiled and probably finished on a slow wheel. a. Base with sub-horizontal bands showing the use of rotation; b. a goblet's base with traces of string cutting.

Five samples of this macroscopic group were studied: LBA02, LBA03, LBA11, and LBA15 from the site of Masafi-5 and one from Kalba 4 (LBA33). No sample from Shimal SX was selected for petrographic analysis but a series of previously studied thin sections was reanalysed (Méry 1991b; 2000). Although the thin sections show some variability, all the samples belong to the same petrographic group, LBAP.B (Fig. 8).

[insert Fig. 8 near here]

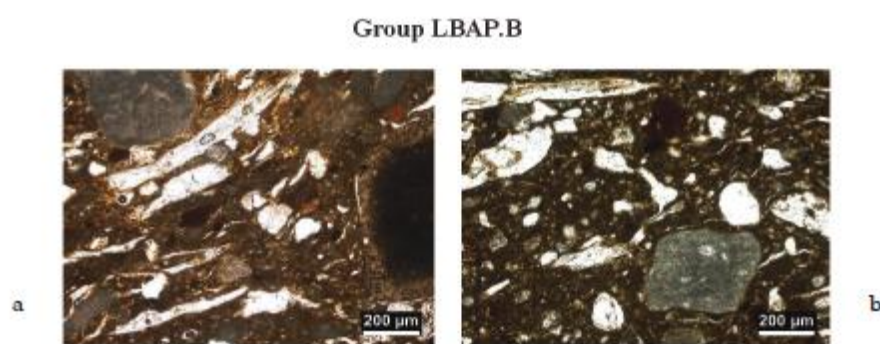


FIGURE 8. Microscopic views (plane-polarized light microscope) of samples LBA15 (Masafi-5) and LBA33 (Kalba 4).

In thin section, group LBAP.B is characterized by a clay-carbonate matrix and the abundance of sparry and micritic limestone gravel fragments which were intentionally added by the potters as

temper. Some brownish-black fragments of argillite (claystone) are also present together with some rock fragments of polycrystalline quartz. The fine mineral fraction, which represent about 5% of the thin section's surface, consists mainly of rounded recrystallized micrite grains and monocrystals of quartz, as well as some fragments of polycrystalline quartz. The more the pottery firing degree increases, the less the matrix has optical activity. Thus, the matrix of LBA02 and LBA03 pottery sherds, with a fairly low firing degree, includes micrite grains, clayey/argillaceous phyllites, and micas in its ultra-fine fraction. These minerals are optically altered at 'low' temperatures during the firing process (Echallier & Méry 1991a). By contrast the other two samples, LBA11 and LBA15, show a high degree of firing as their matrix has very low to no optical activity.

Finally, sample LBA33, as already mentioned, belongs to the same petrographic Group LBAP.B. Its matrix is similar to that of LBA15. Its abundance of rounded grains of recrystallized micrite resembles sample LBA02 and it is also close to LBA11 due to the presence of polycrystalline quartz fragments in its coarse mineral fraction.

Three additional samples are reminiscent of LBA33: A740, A741, and A742 from SX-SY. They were classified in Petrographic Group U in a previous study (Méry 2000: 266, table 69 — 'céramique semi-grossière', Shimal 3 Macroscopic Group).

The geological background of the Shimal area is known to include different facies of limestone formations (British Geological Survey 2006a; 2006b). In particular, the Bih formation crops out on the southern and eastern sides of Wādī Haqil and north of Wādī Bih, which also includes the limestone formations of Ghalilah, Milaha, and the Musandam group. They are composed of alternating pale grey dolomitic limestones and in thin sections we can observe layers of finely laminated micrite (see Fig. 6). Therefore, as demonstrated by Méry (2000) the minerals of petrographic group LBAP.B are a good match with locally available materials of the Shimal region. Thus, one can suppose that the material of group LBAM.2 was at the time locally produced and not

imported into the Shimal area. Beyond the existence of a local production of such wares in the Shimal area at this time, our research now also demonstrates that such items were exported to Kalba 4 and Masafi-5, where no limestone formations are available. This information constitutes a new and significant foray into the study of ceramics exchanges in the region during the LBA.

### **[A]The macroscopic group LBAM.3**

The third group is very homogeneous and easy to identify. It is characterized by a reddish-brown and quite friable paste which is tempered by numerous black, grey, and red grits (granules–medium pebbles between 2 and 10 mm). A few white inclusions and rare vegetal prints are also macroscopically visible. This group includes hand-modelled vessels with irregular walls whose surfaces are usually matt, unslipped, and without painted decoration. The rarity and the fragmentary nature of this type of pottery prevents us from gathering further information about their shape and surface treatment.

Group LBAM.3 appears in small quantities in all the sites included in the present study. The large open vessels and simple bowls are the most common shapes attested in the assemblages. The analysis of five samples gathered from two different sites — Masafi-5 (LBA13, LBA14) and Kalba 4 (LBA25, LBA29, LBA31) — leads us to establish a third petrographic group (LBAP.C), although some variations are observed between the studied samples (Fig. 9):

**[insert Fig. 9 near here]**



## Group LBAP.C

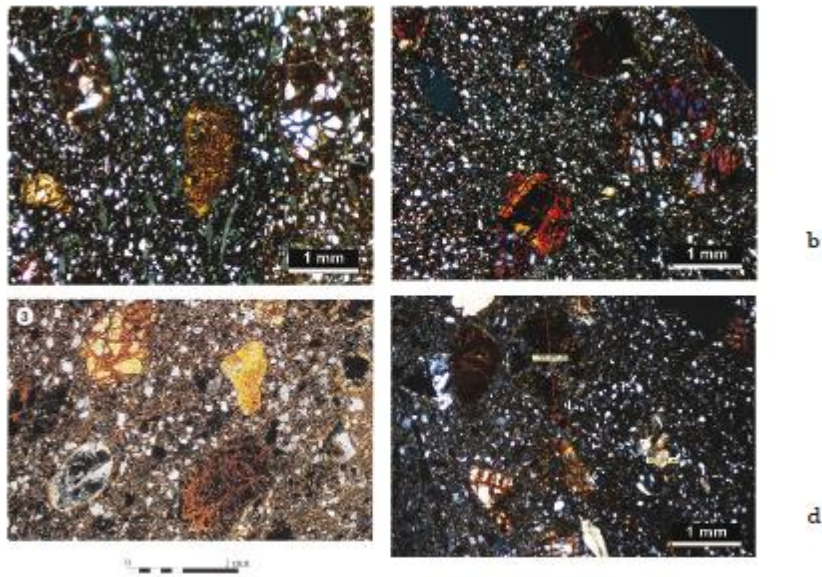


FIGURE 9. Microscopic views (crossed polarized light microscope) of samples. a. LBA13 (Masafi-5); b. LBA31 (Kalba 4); c. Wadi Suq Petrographic Group J example (Méry 2000: 70, pl. I, n. 3); d. Wadi Suq Petrographic group J example (image 2018).

[indent next section]

— the coarse temper from the two samples of Masafi-5 contains fragments of gabbro and peridotite rocks. The rock fragments' type and degree of alteration are similar in both samples. Their matrix includes the same variety of finely dispersed iron oxides;

— the three samples from Kalba 4 have a fine micaceous, mesh-structured matrix but are also not as rich in iron oxides as the Masafi-5 samples, which may explain their lighter tone;

— the particle size distribution of the Kalba 4 samples is variable: LBA29 and LBA31 show a bi-modal size distribution of the mineral fraction, while the fine fraction of LBA31 is much more substantial and the mineral fraction LBA25 is uncalibrated;

— a mixture of sharp and rounded rock fragments and minerals is present in LBA29 and LBA25, but this is not the case in LBA31.

[end of indent]



In conclusion, despite the fact that only a few samples have been characterized, they seem to reveal a compositional diversity related to the two studied sites, Masafi-5 and Kalba 4. As mentioned before, macroscopic group LBAM.3 is present at Masafi-5 and Kalba 4 but it is not possible yet to determine whether it circulated between the two sites. The same macroscopic group is recorded at Shimal SX and Tell Abraç but no petrographic analysis of samples from this group has yet been undertaken.

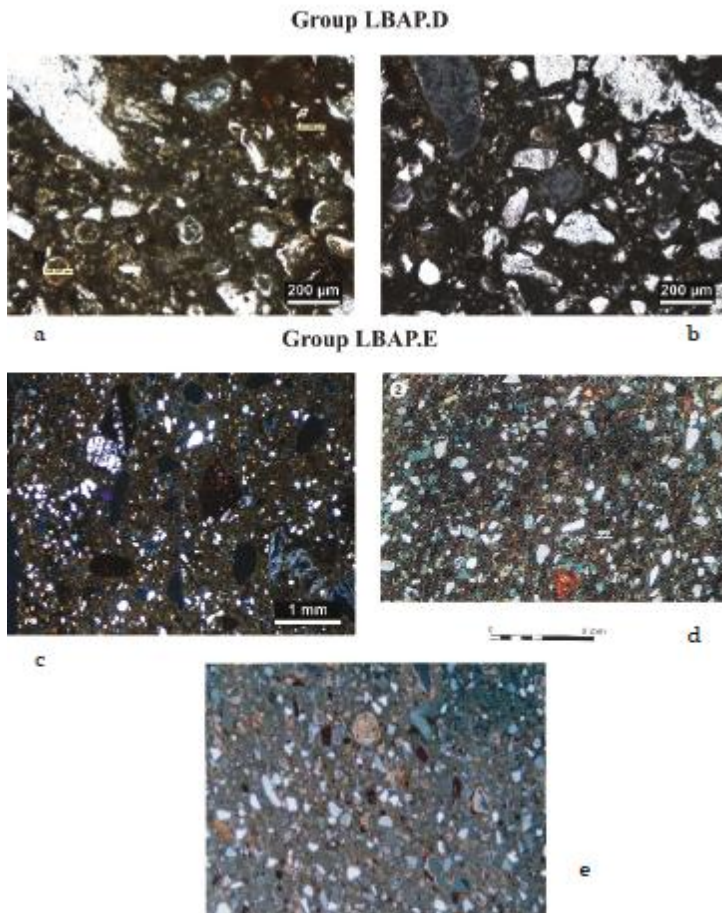
Today, no precise geographical origin is deductible for petrographic Group LBAP.C, but some features point to the al-Hajjar mountains and foothills south of Dibba, where peridotite and gabbro are widely distributed (British Geological Survey 2006c; 2006d; 2006e; 2006f). The petrographic composition of Group LBAP.C is close to Petrographic Group J, a previously identified group found at Hili 8 that corresponds to the ‘céramique grossière’ of the Wadi Suq period at this site (Méry 2000: 39, table 8; 70, pl. 1/3; p. 250; p. 252, table 69). Sample LBA29 of Kalba is particularly close to sample A49 of Hili 8.

#### **[A]The macroscopic group LBAM.4**

Group LBAM.4 is characterized by a pale buff friable paste ware with a sandy temper including fine red inclusions. Vegetal imprints are numerous. The potsherds are usually undecorated and a thin reddish or brownish slip is quite rare. Due to the brittleness of the fabric, all the fragments are highly eroded. The potsherds within this group usually do not preserve diagnostic information about the vessel shape.

Macroscopic Group LBAM.4 is present in very small quantities in the assemblages of Masafi-5 and Kalba 4 and in medium/small quantities at Shimal SX and — based on the sample one of us (MPP) has studied — the same at Tell Abraç. The analysed samples of Macroscopic Group LBAM.4 correspond to two distinct petrographic groups, LBAP.D and LBAP.E (Fig. 10).

**[insert Fig. 10 near here]**



**FIGURE 10.** Microscopic views (crossed and plane-polarized light microscope) of samples. a. LBA06 (Masafi-5), PPL; b. LBA32 (Kalba 4), PPL; c. LBA19 (Masafi-5), XPL; d. EBA Petrographic Group B example, XPL (from Méry 2000: 71, pl. 2 n. 2); e. Iron Age 'Sandy buff ware' group, sample A1444 from Muwattlah, XPL, magnification X40 (Benoit & Méry 2010: 10, fig. 5).

Samples LBA06, LBA19, and LBA32 are characterized by opaque mineral grains and numerous rounded grains of micrite, among which some recrystallized foraminiferal limestone fragments are distinguishable. The matrix of LBA06 and LBA19 is characterized by a high firing degree (no increase of optical activity of the matrix, with a very dark green colour; primary carbonates of the coarse fraction heavily impacted as well). Sample LBA32 differs from the two previous samples as it is less heavily fired. It comprises a micritic clay phase and a more clayey phase coloured by the iron oxides. It shows the imprints of added vegetal temper. It should also be noted that secondary carbonate elements (sparitic crystals) are present in two of the Masafi-5 samples (LBA06 and LBA19), particularly along the large vacuoles left by the vegetal temper after it had completely burned. In contrast, the presence of carbonate elements in LBA32 is only due to secondary (post-

depositional) micritic microcrystals which impregnate the matrix. Interestingly, our three LBA sherds are petrographically close to a small group of sherds from the Early and Middle Bronze Age at Hili 8, which are yet to be published and belong to Periods IIc2, IIf, and III. However, there is a noticeable difference as the Hili 8 samples contain less — and a different composition of — vegetal temper.

The composition of the last two Late Bronze Age samples from Masafi-5, LBA10 and LBA18, is very close to Petrographic Group B at Hili which is characteristic of the local domestic pottery from the Umm an-Nar period (Méry 2000: 152–164). They are also petrographically very close to a number of ‘Sandy Buff Ware’ samples analysed by one of us (SM) in the Al Ain area at Hili-17, Rumeilah, and Bida bint Sa’ud, as well as the more northern sites of al-Madam, Muwailah, and Kalba 4 (Benoist & Méry 2012: 3–4, 9, table 69). Due to lack of space, the arguments that brought us previously to consider this pottery to be locally produced at Hili will be not developed here, although we should mention that potters’ kilns and/or wasters from the EBA and the IA were recovered at this site (Frifelt 1990; Magee et al. 1998).

Thus, the pottery of Group LBAM.4 could have the same geographical origin but correspond to distinct raw materials and recipes. Our results also provide new evidence regarding the circulation of LBA pottery vessels from the Al Ain region to the northern UAE and the continuity of this pattern of exchange, from the Umm an-Nar period up to the Iron Age.

## **[A]Conclusions**

To sum up, it has been possible to firmly identify two groups of production dated to the LBA: the macroscopic Group LBAM.1 was probably produced in the Masafi area and the macroscopic Group LBAM.2 probably originates from the north of UAE, close to Shimal.

It seems that at least part of Group LBAM.4 may have been produced in the region of Al Ain, as the analysed samples present similarities with pottery produced during both older and more recent periods in the same region. A long and continuous tradition in the use of the same source of clay and temper can be considered.

The diffusion of pottery groups outside their area of production has also been documented for the LBA. Vessels were exchanged between the east and west coasts of the UAE and possibly from the south to the north between the Al Ain region and the northern region. Further research will help to confirm or define more areas of production and identify further trading patterns.

The approach we have used in the study of pottery assemblages has enabled us to identify the existence of different production centres that were usually ware-specific, and the coexistence of various exchange networks. Regarding the types of vessels exchanged between the east and west coasts, small vessels such as spouted vessels and goblets are more frequent than large jars. It is therefore our belief that as far as ceramic exchange is concerned, the transportation of daily goods was secondary to the diffusion of more 'prestigious' items such as the characteristic footed goblets.

The petrographic analysis of ceramics reveals the multiple origins of LBA pottery and shows the existence of at least two different pottery production areas. The potters from the contemporaneous sites of Shimal SX and Masafi-5 made similarly shaped vessels, using different pottery recipes with locally available raw materials. The two areas of production are very distinct as they differ geologically, meaning that the types of temper and minerals that can be locally sourced are totally different in each region. The differences in pottery composition can be associated with the naturally available raw materials, as schistose metasedimentary rocks are readily available at Masafi-5 but absent in the Shimal area where limestone and sandstone predominate in the geological structure. At Shimal SX, vessels were made predominantly with calcareous fragments which were intentionally added by the potters as temper. At Masafi-5, the schist was the main temper used, in addition to

some fragments of serpentinite, olivine, and pyroxene identified in the thin sections. In both cases, therefore, the minerals used match locally available materials.

This article is a first step in comparing LBA sites and their pottery production in the region. More in-depth knowledge about pottery exchange, production types, and a number of other factors about Late Bronze Age pottery will be gathered in the future for eastern Arabia, and other possible production sites outside the scope of this research will be found. The ongoing study of some pottery from the site of Tell Abraç will certainly help to complete the regional panorama of our research and allow us to draw further conclusions.

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*Authors' addresses*

Maria Paola Pellegrino, Université Paris 1 Panthéon-Sorbonne, University of Bologna, CEFAS, UMR 7041 — APOHR, Maison de l'Archéologie et de l'Ethnologie, 21, allée de l'Université, F-92023 Nanterre Cedex, France.

*e-mail* maria.pellegrino9@studio.unibo.it

Sophie Méry, Université de Rennes 1, CNRS UMR 6566 CReAAH, 263 avenue du Général Leclerc, Campus de Beaulieu, bâtiment 24–25, 35042 Rennes, France.

*e-mail* sophie.mery@mae.u-paris10.fr

Anne Benoist, CNRS-Université Lyon 2, ARCHEORIENT, Environnements et sociétés de l'Orient ancien (UMR 5133), rue Pasteur, 69007 Lyon, France.

*e-mail* anne.benoist@mom.fr

Sophie Costa, Université Côte d'Azur, CEPAM UMR 7264-SJA3, 24 avenue des Diables bleus, 06300 Nice, France.

*e-mail* sophie.costa@cepam.cnrs.fr

Julien Charbonnier, Archaios, Université Côte d'Azur, CEPAM UMR 7264-SJA3, 24 avenue des Diables bleus, 06300 Nice, France.

*e-mail* [julien.charbonnier@cepam.cnrs.fr](mailto:julien.charbonnier@cepam.cnrs.fr)