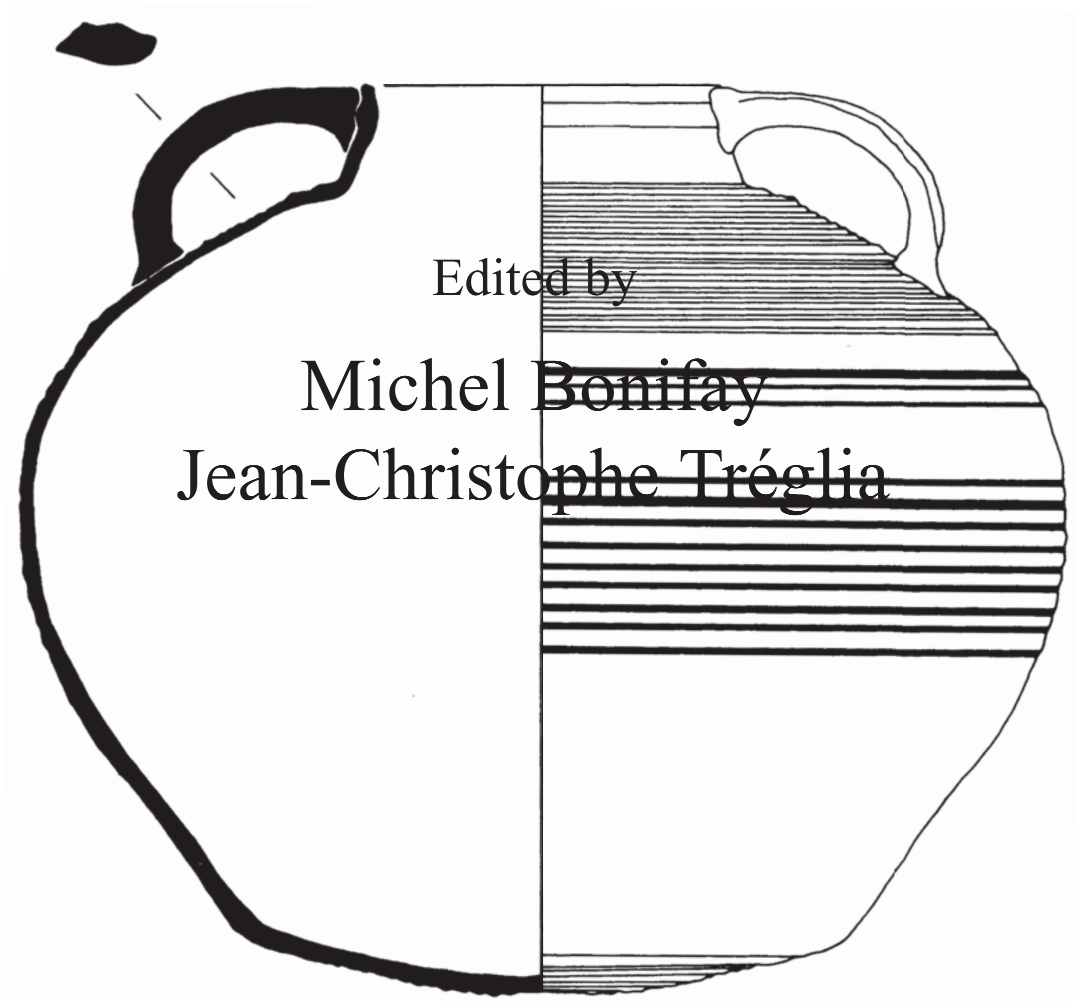
LRCW 2
Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean

Archaeology and Archaeometry



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SOME NEW RESULTS OF ARCHAEOMETRIC ANALYSIS OF BRITTLE WARES

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Brittle Ware from various sites in Syria, from Apamea and Palmyra, and from Beirut were analysed by WD-XRF and studied by thin sections. This paper aimed at obtaining information on workshops and on the distribution of the products. In Syria, ninety percent of the analysed samples belong to only six groups corresponding to six workshops, excepting Palmyra where a local workshop exists. No sample of this workshop was detected on any other site and very few samples found in Palmyra could be attributed to one of the six Syrian groups. The data for two groups of Brittle Ware found in Beirut are also given in a table. Illustrations of those shapes and of the main Syrian types from the Hellenistic to early Islamic periods are shown. Several workshops produced the same shapes and shared a similar technology using non-calcareous clays, probably from terra rossa. One centre is assumed to be located west of Aleppo, another near Apamea.

KEYWORDS: BRITTLE WARE, COOKING WARES, WORKSHOPS, CHEMICAL ANALYSIS, SYRIA, PALMYRA, BEIRUT

1. INTRODUCTION

As witnessed by this second venue of the LRCW, interest for Late Antique common and cooking wares is steadily growing. Recently, eastern Mediterranean cooking wares, which were long-neglected or only typologically studied, have been examined from a technological point of view (for a review of the bibliography, see Joyner 2005). In those regions, most cooking wares are made of red-coloured, non-calcareous clays. They broadly share a morphological repertoire stemming from a common Hellenistic-Roman background. Eastern cooking wares, often called Brittle Ware, form a homogeneous oriental tradition, which will survive into the Early Islamic period. This tradition is however composed of several facets, characterised by specific assemblages of shapes and produced by regional workshops. The existence of several production centres was also confirmed by archaeometric studies (see among others Adan-Bayewitz 1993, Adan-Bayewitz and Wieder 1992, Bartl, Schneider and Böhme 1995, Joyner and Politis 2000, Orssaud and Sodini 2003, Vokaer 2005, Waksman *et al*. 2005). Petrographic and chemical analyses of Syrian Brittle Ware have indeed indicated several workshops, although no major production sites are so far known in Syria (Bartl, Schneider and Böhme 1995, Orssaud and Sodini 2003, Vokaer 2005).

This paper aims at providing further evidence on these eastern productions, by doing chemical analyses WD-XRF of Brittle Ware from Syria and from a few sites in Lebanon and Iraq.

2. RESULTS OF ANALYSES

Brittle Ware from various sites in north-eastern Syria have already been analysed by WD-XRF before 1992, resulting in three major groups which correspond to at least three unknown workshops (Bartl, Schneider and Böhme 1995). The former groups 4 and 5, identified in Bartl, Schneider and Böhme (1995), could not be confirmed by more samples in this study. They will thus not be included here and will be taken as independent results, distinct from any grouping. In the meantime, new analyses were carried out, reaching up to a total of 200 samples of Brittle Ware from various sites in Syria (Fig.1) and from Ain Sinu (Iraq). In addition 44 samples were analysed from Beirut and Chhim (Lebanon) and from Gadara/Umm Qais (Jordan). We will only deal here with the samples from Syria, Iraq and from Beirut; the results of the other analyses will be published elsewhere.

Leaving apart Palmyra, 90 percent of the analysed samples from Syria and Ain Sinu can be divided into six groups. These can be considered as six workshops or workshop areas. In Palmyra, four samples could be attributed to two of these six groups, while 24 of the 49 samples analysed from this site belong to a local group. The remaining 18 percent of the total of samples from all Syrian sites is non-attributable.

The averages of the chemical composition determined by WD-XRF are given for each group in Table I, together with the standard deviations and the coefficients of variation. Two elements are used in a binary plot to illustrate the clear distinction between the six Syrian groups (Fig. 2).

The locally made Brittle Wares from Palmyra were partly published by Daszkiewicz, Krogulska and Bobryk (2000) and more analyses are added here. Since these data overlap with group 2, the Palmyra group is included in the binary plot by only one point, indicating the group mean. The Palmyra group can however be clearly distinguished from group 2 when regarding titanium (Ti) contents (Table I).

The limited working basis does not allow to consider the numbers of analyses for each group, each site and each period as representative (Table II). On the other hand, the results may show a statistical tendency as the samples were selected quite randomly and mostly without knowing their attribution to a certain fabric or chemical group.

For Apamea, Aleppo, Dibsi Faraj, Andarin and the sites of the Euphrates survey, a much larger number of sherds than the amount of samples analysed here has been attributed to the groups identified macroscopically by Vokaer (this volume). This procedure brought a more general perspective on the results. The chemical groups will be detailed as following, starting with the groups discussed by Vokaer.

2.1 Workshop/group 1

As previously shown in our first series of analyses (Bartl, Schneider and Böhme 1995), group 1 represents the largest group. Its distribution extends from Tell Jinderes and Aleppo in the north-west to the Khabur in the east. It includes vessels dating from the Roman to the Early Islamic periods. The large variation in contents of calcium (Ca), sodium (Na), phosphorus (P), strontium (Sr) and barium (Ba) is mainly due to contaminations from burial deposition (the large variations in copper (Cu), niobium (Nb) and lead (Pb) are also due to limited analytical precision). Geochemically, group 1 is characterised by high chromium (Cr) and nickel (Ni) contents, matching thus a terra rossa clay sample, collected some twenty kilometres west of Aleppo (Table I). Silica is lower in this clay sample than in the pottery because the clay does not contain quartz sand. The firing behaviour determined that calcitic inclusions were responsible for the relatively high Ca (and Mg?) content of this clay. The provenance area of these workshops might thus be somewhere west of Aleppo. It is also worth noting that at Tell Jinderes many samples of Brittle Ware (5 out of 15) cannot be attributed to any of the six Syrian groups defined. Other workshops would have played an important role in this area further north.

2.2 Workshop/group 4

Unlikely to other Syrian sites where group 1 dominates, at Apamea, the major group is constituted by group 4 (Vokaer, this volume). A large variation of the same elements as in group 1 can be observed. The variation in potassium (K) characterises such clay originating from terra rossa weathering. Within the 16 analyses, K varies between 0.7 and 1.6 % K_2O (in group 1 between 1.1 and 2.3 % K_2O). Generally, group 4 shows a composition similar to group 1 but with somewhat lower Cr and Ni traces. On the basis of these elements or by using multivariate statistical methods, the two groups can clearly be distinguished. This is also true for the two fabrics under the polarising microscope, more chert inclusions were observed in group 4 than in group 1 (Vokaer, this volume). A terra rossa clay sample from Apamea has also been analysed. It appears to be much too rich in Ca (and thus to low in silica) to be considered as the raw material for Brittle Ware. However, it shows the same tendency as the trace elements of group 4 to differ from group 1. The hypothesis of a production centre near Apamea seems plausible. Besides finds at Apamea, dating to ca 1^{st} to 9^{th} c. A.D., other samples belonging to group 4 have been identified at various sites, including Tell Jinderes, Aleppo, Palmyra and others.

2.3 Workshop/group 5

Group 5, as groups 1 and 4, display the characteristic high iron (Fe) and low calcium (Ca) contents of Brittle Ware. Geochemically, low traces of Ni distinguish group 5 from the others, pointing towards another geological region of provenance. The difference with the other groups in terms of Cr contents is less pronounced (Fig. 2). As already stated by Vokaer (this volume), group 5 corresponds to workshop X published by Waksman *et al.* (2005). The chemical similarity is obvious in all characteristic elements except Cr, which is lower in Waksman's data (the mean is included in Table I and in Fig. 2). The difference in Cr content could be caused by a difference in calibration. Recent analysis undertaken in our laboratory of an international ceramic reference sample (SARM69) resulted in values between 214 and 217 ppm, compared to the certified value of 223 ppm (thus not giving reason to change our calibration which is based on about sixty international reference samples).

Three samples from Palmyra with an unclear date also belong to group 5. The similarity of these samples is confirmed by thin section studies. Two of these samples were published by Daszkiewicz, Krogulska and Bobryk (2000). Waksman *et al.* (2005) already mentioned this matching with the still not located workshop X. In sum, the three samples, a spout from a jug, a pot and a jug, clearly differ from all other Brittle Ware finds in Palmyra and certainly represent imports at this site.

2.4 Workshop/group 6

Five analyses of Islamic holemouth pots from Aleppo and the Euphrates survey compose this group. It is characterised by very high Cr contents, ranging between 700 and 850 ppm. This points towards a specific geological region, which may be near to the ophiolitic zone between Antioch and the Taurus mountains.

2.5 Workshop/group 2

Brittle Ware group 2 was described by Bartl, Schneider and Böhme (1995). This group seems to be restricted to the north-east of Syria. Only four new samples, from Raqqa and from the upper Khabur area, have now been attributed to this group. Furthermore, no samples belonging to group 2, were detected within the 2000 sherds macroscopically studied by Vokaer, originating from sites from western Syria (see this volume). Group 2 certainly comprises shapes from Byzantine to Early Islamic periods.

2.6 Workshop/group 3

Since group 3 is limited to the Roman period, it has not been presented in the paper written by Vokaer (this volume). While, it appears to be absent west of the Euphrates, it represents all five samples analysed from Ain Sinu (Oates and Oates 1959, plate 58, nos. 75, 76, 78, 83 and 84), the most eastern site included in this work. One of the five samples (no. 76 from Oates) is much coarser, macroscopically and microscopically, and deviates chemically from the others. Nevertheless, it certainly comes from the same geographical area as the other Brittle Wares of its group.

The region of production differs from those of groups 1, 4, 5 and 6. Although, the raw material also represents a non-calcareous iron-rich clay, the inclusions not only consist of quartz sand (e.g. as group 1 in Fig. 3a) but contain minerals and rock fragments of a large variety (Fig. 3b). Under the microscope, the inclusions are similar to those of clayey sediments studied from various sites on the Euphrates, between Raqqa and the Iraqi border, although all 25 clay samples analysed from this area were calcareous. They contained more than 13 % CaO, and were geochemically deviating in their trace element contents. Bearing this in mind, the geographical attribution of the workshops of group 3 still remains open.

2.7 Palmyra group

A series of 49 Brittle Ware sherds from Palmyra, in part published by Daszkiewicz, Krogulska and Bobryk (2000), has been analysed. One group stands as local as it consists exclusively of kiln finds. These are dated to the 2nd and the beginning of the 3rd cent. A.D. This group clearly differs chemically and microscopically from all other groups discussed in this paper (Table I), as well as from the other Brittle Ware finds from Palmyra. A photomicrograph of a sample of this local group is illustrated in the paper written by Daszkiewicz, Krogulska and Bobryk (this volume). Characteristic of the chemical composition are very low barium (Ba) contents. This element, however, is sensitive to changes during burial of the sherds in the soil and is correlated to high phosphorus contents (the samples from Beirut in Table III are an exception to this rule). Therefore, Ba and P contents of samples having values above 0.2 % P_2O_5 are not included in the mean given in Table I. One sample with 0.8 % P_2O_5 and 750 ppm Ba (and 9.8 % CaO), unquestionably due to secondary changes, also belongs to the local group.

The remaining samples of Brittle Ware found in Palmyra, ranging from 1st cent. B.C. to the Islamic period, differ from the local group by low potassium (K) contents. They cannot be combined to groups and, except the four samples already discussed with groups 4 and 5, are also different from the six groups identified at other sites in Syria. This low content of K was also detected in samples of terra rossa found in very small outcrops near Palmyra (Table I), also displaying the characteristic very low Ba traces as the local Brittle Ware. They, however, differ so much in other elements that they cannot represent the raw materials for the local group. Under the microscope these clays, after firing at about 800°C, reveal a typical Brittle Ware fabric of quartz sand as the main inclusions in a non-calcareous non-micaceous matrix (Fig. 3c). Chert, as it appears in a photomicrograph of a sample from Palmyra which does not belong to the local group (Fig. 3d), is also present in the clay samples.

If we take low Ba contents as characteristic of Palmyra, about 15 of the 20 ungrouped samples may stem from a local production. It could be manufactured from terra rossa collected from the limestone areas north and south of Palmyra and characterised by varying composition, although not identical with our analysed samples. This could be explained by the diversification of such loams which may have been used by various potters over a long period of time.

2.8 Beirut groups

Two series of Brittle Wares from Beirut have been analysed from finds in Beirut, resulting in two chemical groups (a and b) when leaving aside Ca, P and Ba which changed through burial influences. The statistical parameters were calculated excluding the most deviating values (Table III). The fabric of a sample of the group of Roman Brittle Wares under the polarizing microscope (F866, Fig. 3e) shows very characteristic inclusions of microfossils. One sample from the Hellenistic period found in Aleppo (T088) may be an import from Beirut (Table III).

The Brittle Wares of the 10-11th cent. A.D. do not have any characteristic minerals or rock fragments besides quartz and a few hornblende. This group b is chemically similar to group B5 formed by Brittle Wares from Beirut from the same period, analysed and published by Waksman (2002). Most probably it must be considered as the same workshop (for the difference in Cr see the above discussion for group 5 and workshop X).

3. SHAPES AND FABRICS

3.1 Brittle Ware from Syria (A.Vokaer)

The shapes sampled for analysis represent the most common types through the various periods considered here. The earliest shape can be dated between the 3rd and the 1st c. BC. It is a cooking pot with a convex neck and two handles on the rim (often angular) (Fig. 4, 1). This shape has several published parallels in Ibn Hani (Bounni *et al.* 1976, fig. 28, 18), in Lebanon, Beirut (Aubert 2002, figs. 5, 6, 12 and 14) and Umm al-Amed (Dunand and Duru 1962, fig. 78, b), but also in Greece at Corinth (Edwards 1975, pl. 27, 651). The analysed cooking pot illustrated in Fig. 4, 1 does not belong to any of the six Syrian groups.

The cooking pot with a triangular rim and two angular handles dates to the first c. A.D. (Fig. 4, 2). This shape, which has been sampled at Apamea and Dibsi Faraj, is known from several sites in Syria: for instance Qara Qozaq on the Euphrates (González and Matilla 1994, fig. 3,5) or Qusair as-Saila near Resafa (Konrad 2001, pl. 84, 32). It is produced in groups 1 and 4.

The most common type during the 3rd and 4th c. A.D. is the cooking pot with an out-turned rim (Fig. 4, 3-4). It is well known in the publications for the Roman Period in Syria (for instance Dyson 1968, fig. 19 III D4, fig. 13, 429, 433; Konrad 1992, fig. 8, 15; Bartl 1999-2000, pl. 12, 2-4). Analysed sherds corresponding to this type have been sampled from Aleppo, Dibsi Faraj, Ain Sinu (Oates and Oates 1959, pl. LVIII, 83-84) and Tell Sheikh Hassan (Bartl, Schneider and Böhme 1995, fig. 3.3). They belong to groups 1 and 3.

Two uncommon shapes seem to date to the end of the Roman period: the cooking pot with no neck and a small angular rim (Fig. 4, 5) and the cooking pot with a small concave rim and an oblique neck (Fig. 4, 6). Both have few parallels published. The first one (Fig. 4, 5) is commonly found at Apamea in levels dating before the 6th c. A.D. It has no clear comparisons on other sites; to the exception of a type in Dehes, slightly similar but dating to the 7th c. A.D. (Bavant and Orssaud 2001, fig. 2, 14) and a potsherd from the Basilika B in Resafa dating to A.D. 425-450/475 (Konrad 1992, fig. 8, 8). This type belongs to group 4. The second (Fig. 4, 6), also from Apamea, can be compared to a cooking pot found in Dehes, dating to the 4th c. A.D. (Orssaud 1980, Type 2) and to another fragment found in the Basilika B in Resafa and dated between A.D. 475 and 518 (Konrad 1992, 332 and 344, fig. 8, 5). It is from group 1 and constitutes one of the rare Brittle Ware fragment from Apamea that does not belong to group 4.

Four Byzantine types have been sampled (Fig. 4, 7-10). The cooking pot with a carinated neck, dating to the 4th/5th c. A.D. is a very common shape at Apamea, but also at Dibsi Faraj and Andarin (Fig. 4, 7). It belongs to group 4. Comparisons are also known from the Basilika B in Resafa, where it mainly dates to the third quarter of the 5th c. A.D. (Konrad 1992, fig. 8, 9-14) and from Tell Sheikh Hassan (Bartl 1999-2000, pl. 12, 8). The cooking pot with a banded rim, identified as from group 3 (Fig. 4, 8) is less common in Syria. This type has comparisons in Lebanon at Tell Arqa, where it dates to the 6th and 7th c. A.D. (Thalmann 1978, fig. 38, 3-4). A very common type for the end of the Byzantine period is the cooking pot with a triple-ribbed rim (Fig. 4, 9) (see Vokaer in this volume for a distribution map of that type). Samples from this type belong to groups 1 and 4. At Apamea, Dibsi Faraj and Andarin, this shape comes together with the jug with a sieved-neck (Fig. 4, 10) also dating to the 6th/7th c. A.D. (see Vokaer in this volume for a discussion on that type). All the samples analysed for this jug (6 in total) belong to group 5.

Three Early Islamic and one Middle Islamic shapes are illustrated here (Fig. 4, 11-14). Very typical of the Early Islamic period is the holemouth pot, a cooking pot with no neck and two ledge-handles (Fig. 4, 11 and 12). Samples belonging to this type were analysed from Aleppo, from Tell Aswad, from Qasr al-Hayr, from the survey on the Euphrates as well as the survey on the Balikh (Bartl, Schneider and Böhme 1995, fig. 3,10). They belong to groups 1, 4 and 6. This cooking pot is known on many excavations; for instance Resafa (Konrad 1992, fig. 9, 2-4), Kürban Höyük in Turkey (Wilkinson 1990, fig. B. 17, 32-36), Ana (Northedge *et al.* 1988, fig. 39, 9-10C) and Tell Abu Sarifa (Adams 1970, fig. 5i) in Iraq (see also Vokaer in this volume for a distribution map of that type). The cooking pot with a long neck illustrated in Fig. 4, 13 represents another characteristic type of the Umayyad and Abbasid periods in Syria. The rim can be thin, rounded or angular. Similar comparisons are published in Tell Aswad (Miglus 1999, pl. 33 g-q), Qasr al-Hayr as-Sharqi (Grabar *et al*. 1978, fig. B 13a-b). The sample analysed here is from group 1.

Finally, the last shape dates to Ayyubid period (Fig. 4, 12). It is a holemouth cooking pot with a folded rim. The inner bottom is covered with a transparent glaze. Glaze patches are also found on the shoulder. This type is also frequent on Ayyubid sites, let mention Balis/Barbalissos (Leisten 1999-2000, 52), Qala'at Ja'bar (Tonghini 1998, fig. 145), Tilbeshar (Rousset-Issa 1998, fig. 36). Although later, this type can be considered as Brittle Ware since the fabric is macroscopically identical and since it belongs to the same chemical group as the typical Brittle Ware production from Apamea (group 4).

Several observations can be made from the comparisons between shapes and chemical groups. First, several distinct workshops produce the same shapes. Second, these workshops, especially workshops/groups 1 and 4, supply many sites in Syria. Finally, the typological study allows for determining a chronology for each workshop. Workshop/group 1 seems active from the Roman to the Islamic Period, as workshop/group 4. Workshop/group 3 is only producing Brittle Ware during the Roman period. It is worth noting that Ain Sinu, which is located at the eastern point of Roman Syria, on the frontier of the Empire, is also supplied by group 3. Group/workshop 5 produces during the end of Byzantine Period, while group/workshop 6 is mainly active during the Early Islamic Period.

3.2 Brittle Ware from Beirut - Bey 080 and Bey 006 (K.Bartl)

The central part of Beirut which was heavily destroyed during the Lebanese civil war has been under reconstruction since more than one decade. Since 1993, in preparation of the reconstruction work large-scale excavations were carried out, aiming at documenting as exhaustively as possible the ancient history of the city (AA. VV. 2001-2002).

Among the numerous excavations in the core of city, the investigations at Place des Martyrs and the former area of the Souks are parts of the largest sites. Most of the cooking wares sampled here derive from Bey 080 (Bartl and Heinz 1996), a site at the north-western part of the Place des Martyrs excavations which was bordered by the sites Bey 069 (Bouzek 1996) to the south and Bey 048 to the east (Mongne, Stephan and Zarazir 2003) and formed a substantial part of the antique town. Some further sherds come from Bey 006/Souks area, another huge quarter of the Roman-Early Byzantine city. Within this area, a well-stratified context of the Islamic periods was excavated. The Islamic sherds presented here were found in this context (el-Masri 1997-1998; 1999).

The results of the chemical analysis point towards two different groups within the Beirut samples, which correspond to the Classical and Islamic periods represented here by Bey 080 and Bey 006.

The samples of Bey 080 come from the lowest level of the site, i.e. they were found in contexts immediately founded on the bedrock, which probably date to the Hellenistic period. However, due to the intensity of later construction work (Roman to Late Ottoman periods) the archaeological material is of a mixed nature. Therefore, the date of some of the samples cannot be given with certainty. All of the sherds consist of fine red brown to brick red clay. The surface is mostly plain and shows only rarely corrugations (Fig.5, 1-2). The Hellenistic period is represented by two cooking pot rims and one bowl or lid. The former (Fig. 5, 1-2) can be compared to Hellenistic shapes from Syria (see Fig.4, 1), the latter (Fig. 5, 3) is known from Beirut (Aubert 2002, fig. 15). However, at Tall Anafa in northern Galilee, similar shapes are defined as lids and date to the early to mid 1st century A.D. (Berlin 1997, pl.36, 327-330; pl.37, 339).

Most of the other potsherds belong to the Roman period. One rather homogeneous group in shape is formed by the cooking pots without neck and with flaring rim (Fig. 5, 4-7). As all the comparisons show, they could originally have handles. Various dates are given for this type. At Bey 027, where it was found together with coins, it seems to date to the second half of the 4th century A.D. (Arnaud, Llopis and Bonifay 1996, pl.9.14). A similar type from the Souks excavations seems to be from the 2nd century A.D. (Reynolds 1997-1999, no.207-269). At Tiberias in northern Galilee, a comparable piece was found in a context of the 1st century BC to the mid of the 2nd century A.D. (Amir 2004, Fig. 3, 1 no.5), while at Tall Anafa very similar types are known from levels dating to the late 1st century BC to the early 1st century AD (Berlin 1997, pl.31, pw 266, pw 267). According to chemical analyses of various cooking wares from Tall Anafa, this type seems to have been produced near Meiron (Gunneweg and Yellin 1997, 238ff.). In general, this type is reported from many other sites of the southern Levant and its hinterland (Berlin 1997, p.102). Another shape of the Roman period dating to the 2nd century A.D. is a rim with a pinched lid-seat (Fig. 5, 9). Comparable rim forms are known from Bey 006. However, the neck has here a different shape (Reynolds 1997-1999, Fig.150-154).

Finally, the samples (Fig. 5, 12-15) deriving from Bey 006 date to the 10th-11th century. Various sherds of specific glazed wares of the Fatimid period were found together with this type of kitchenware, confirming thus their chronology (el-Masri 1997-98, 108). Occasionally this type was found with glaze on the interior surface (el-Masri 1999, fig. II, 10-13). As determined by the chemical analysis, this type forms a separate group comparable to the samples investigated by S.Y. Waksman (2002).

4. CONCLUSIONS

The majority of Brittle Ware found in northern and north-eastern Syria were the products of a few workshops/groups, characterised by their chemical element patterns. Within one chemical group, probably several workshops or one major production centre used the same non-calcareous and iron-rich clay with a high amount of natural or intentionally added quartz sand. This applies to the Brittle Ware that were likely produced from terra rossa clays formed in limestone areas, as e.g. in the west of Syria (e.g. Apamea, Aleppo) or near Palmyra. The two groups showing a more eastern distribution (groups 2 and 3) were made from very different clays, although also non-calcareous and iron-rich. Some of these workshops/groups were active from Roman to early Islamic periods, while others were more limited in time. Shapes within Syria appear to be less connected to workshop groups than to periods. This means that different workshops produced the same models and, by using similar raw materials, in the same red (or black) colour. It reveals that they were sharing a technical common knowledge, which concerned the raw material used and the repertoire produced.

The repertoire of forms in Syria and the Levant seems to differ. As far as we can tell from our data, the Syrian products are not represented in the Levant or in Palestine. This observation is confirmed by the typological study (see Vokaer in this volume). In Syria, workshop/group 1, probably somewhere west of Aleppo, has a wide distribution from Roman to Early Islamic periods. Workshop/group 4, near Apamea, produced nearly all the vessels for this site (Vokaer, this volume) but its products were also traded on other Syrian sites. At Palmyra, a series of analyses reveals that probably most analysed samples are locally made from various raw materials. Palmyra seems thus to stand as an exception. One group gathers all samples from the excavated kilns from 2nd cent. AD. The remaining analyses from Hellenistic to Islamic periods at this site do not allow in forming significant compositional groups. Moreover only a part would have been locally made. So far, neither the local nor the probably non-local products from Palmyra, except the four samples attributed to groups 4 and 5, are known from any of the other sites studied.

The chemical analyses revealed so far the existence of six workshop groups in Syria, leaving Palmyra apart. Furthermore, a total of 15 samples from Tell Jinderes, Aleppo and Raqqa could not be attributed to any of these groups. If we accept two samples as a minimum for a group, these analyses may represent more than eight new workshops/groups. These groups were probably not local at the sites where the samples were found but they were not observed on other sites either.

In conclusion, the databank of analysed Brittle Ware in Syria and in the Levant opens a new view on production and distribution of cooking wares in this region.

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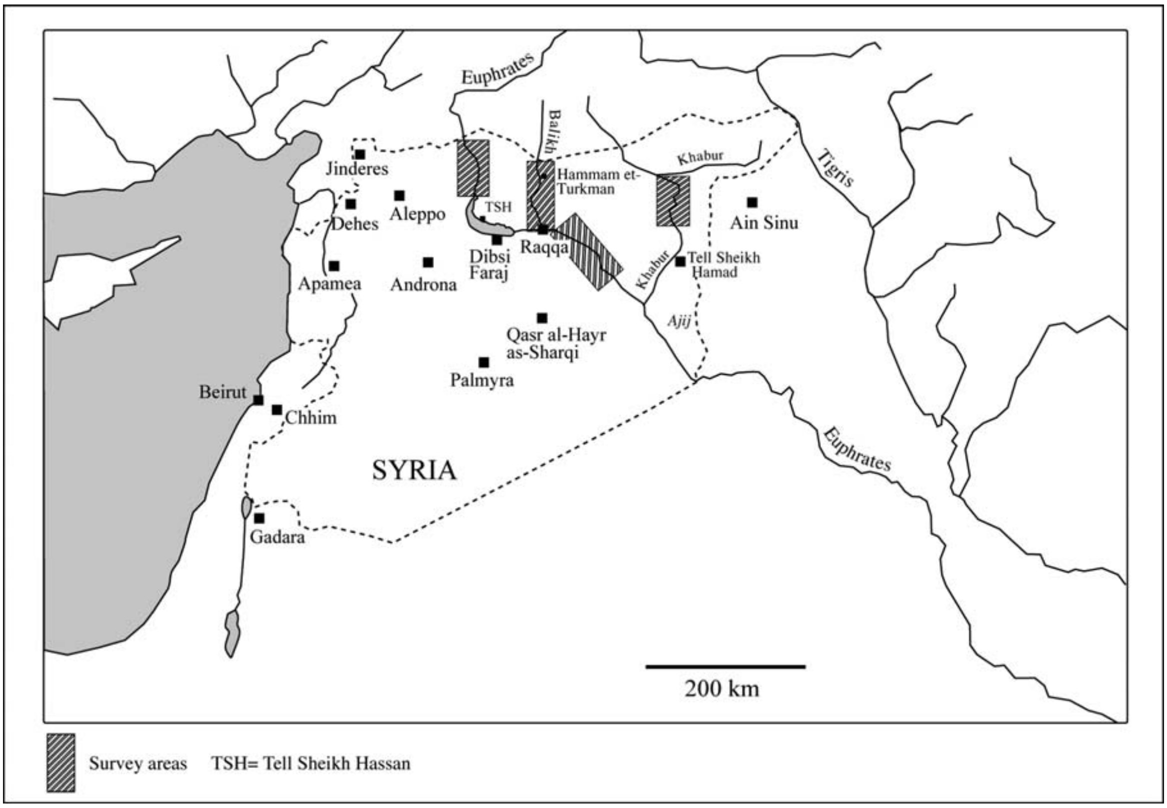

Fig. 1. Sites and regions from where samples of Brittle Ware have been analysed.

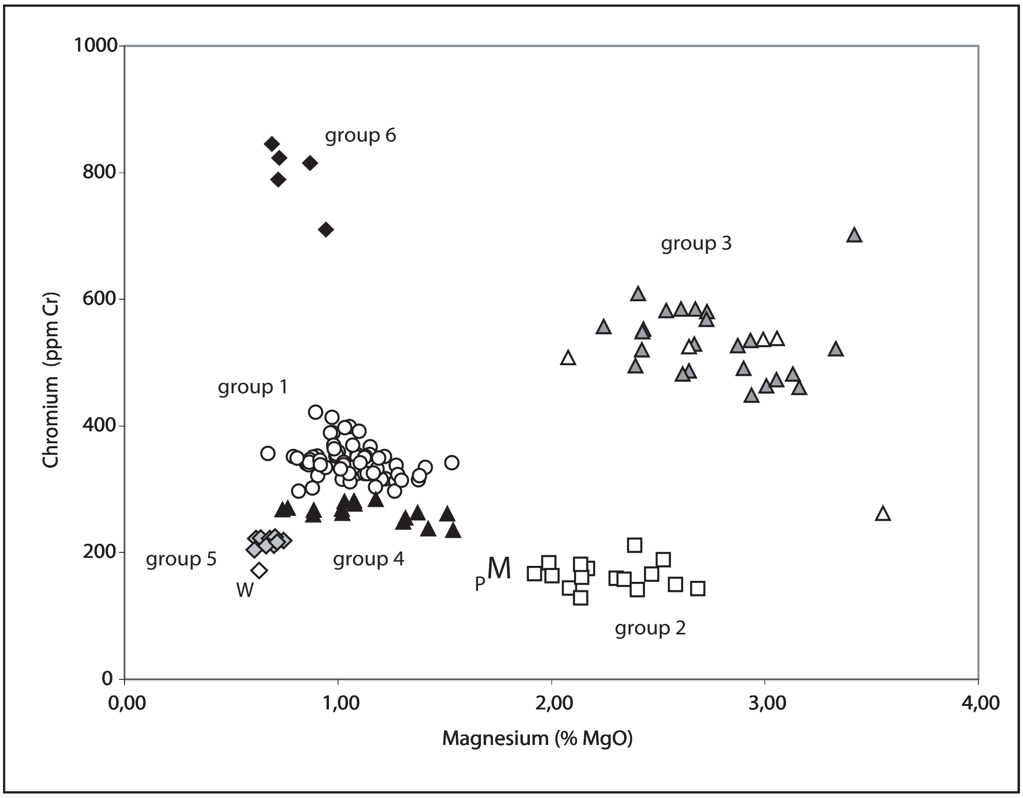

Fig. 2. Six major groups of Brittle Ware in Syria shown in a binary plot of chromium vs. magnesium. The empty triangles are five samples analysed from Ain Sinu, the open rhomb (W) represents the mean of workshop X (Waksman *et al.* 2005), the star indicates the mean of the local Palmyra group (P).

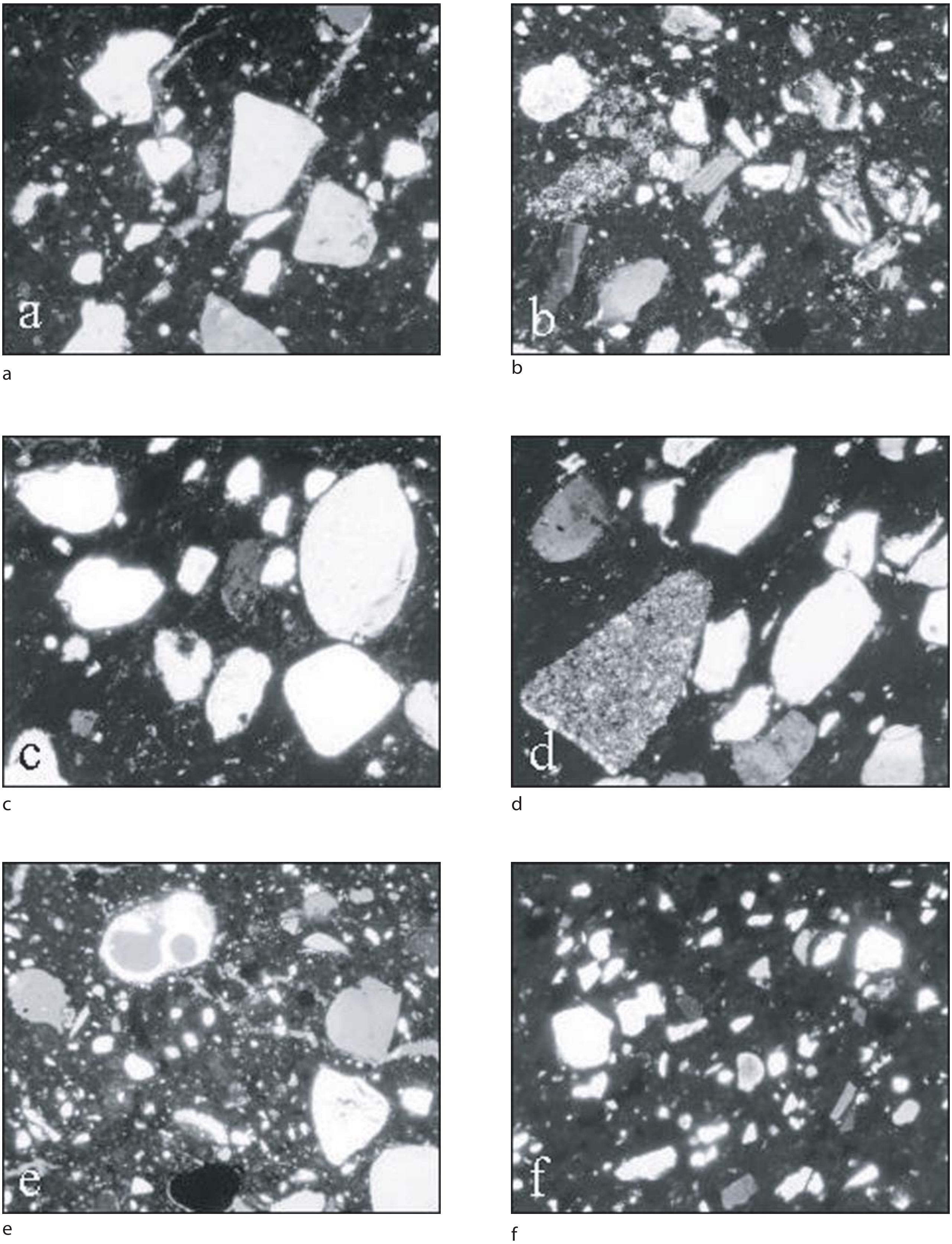
a b c d e f

Fig. 3. Photomicrographs of typical fabrics (XPL or not totally crossed, width of field 1 mm): a = group 1 (inclusions of quartz), b = group 3 (quartz, feldspar, mica, volcanic rock fragments), c = clay sample from Palmyra (coarse quartz inclusions), d = Brittle Ware found in Palmyra (quartz, chert), e = Roman Brittle Ware from Beirut (quartz, iron oxides, foraminifera), f = Brittle Ware from Beirut 10-11th c. A.D. (quartz, hornblende).

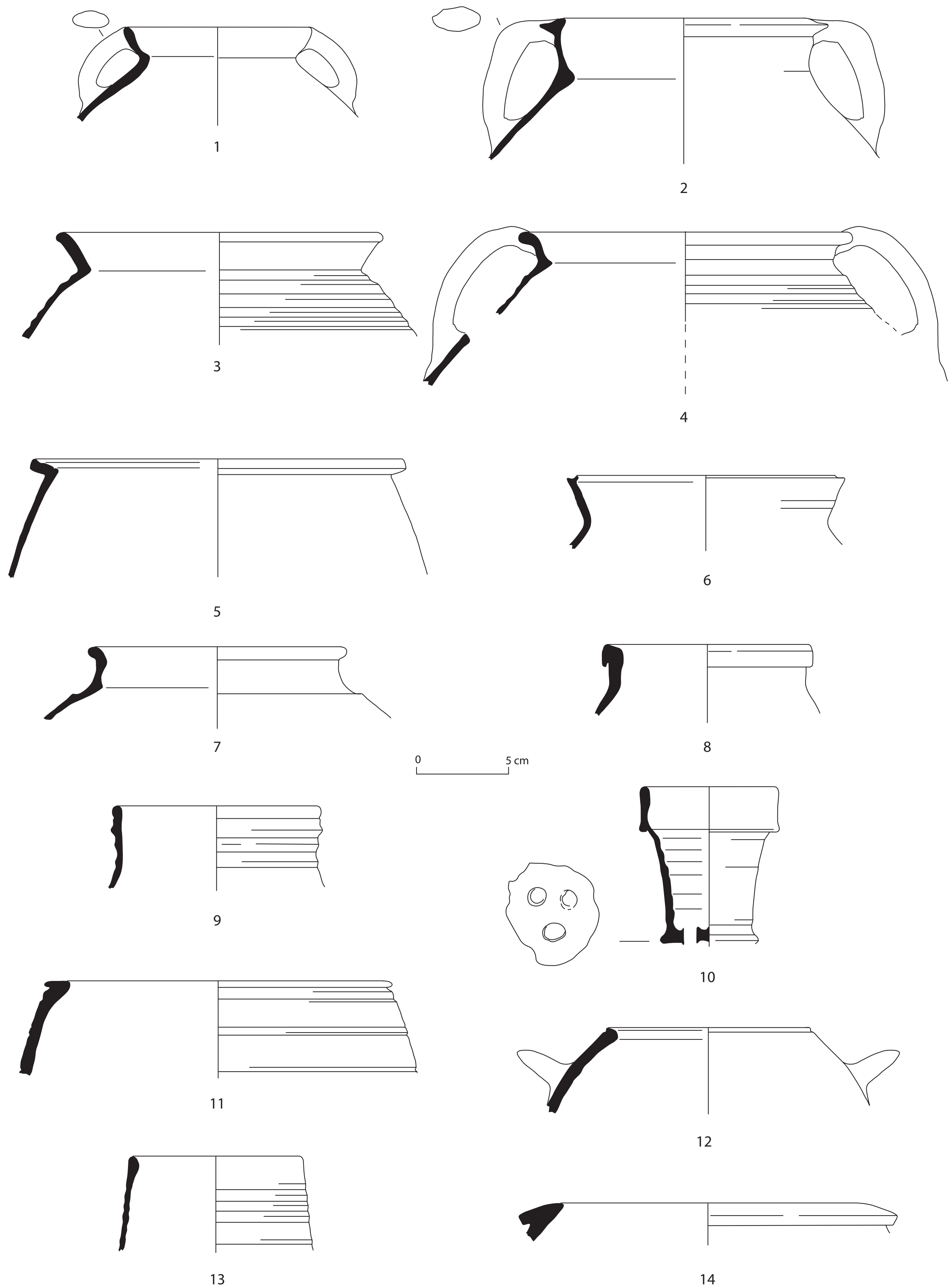

Fig. 4. Typical shapes of Brittle Ware.

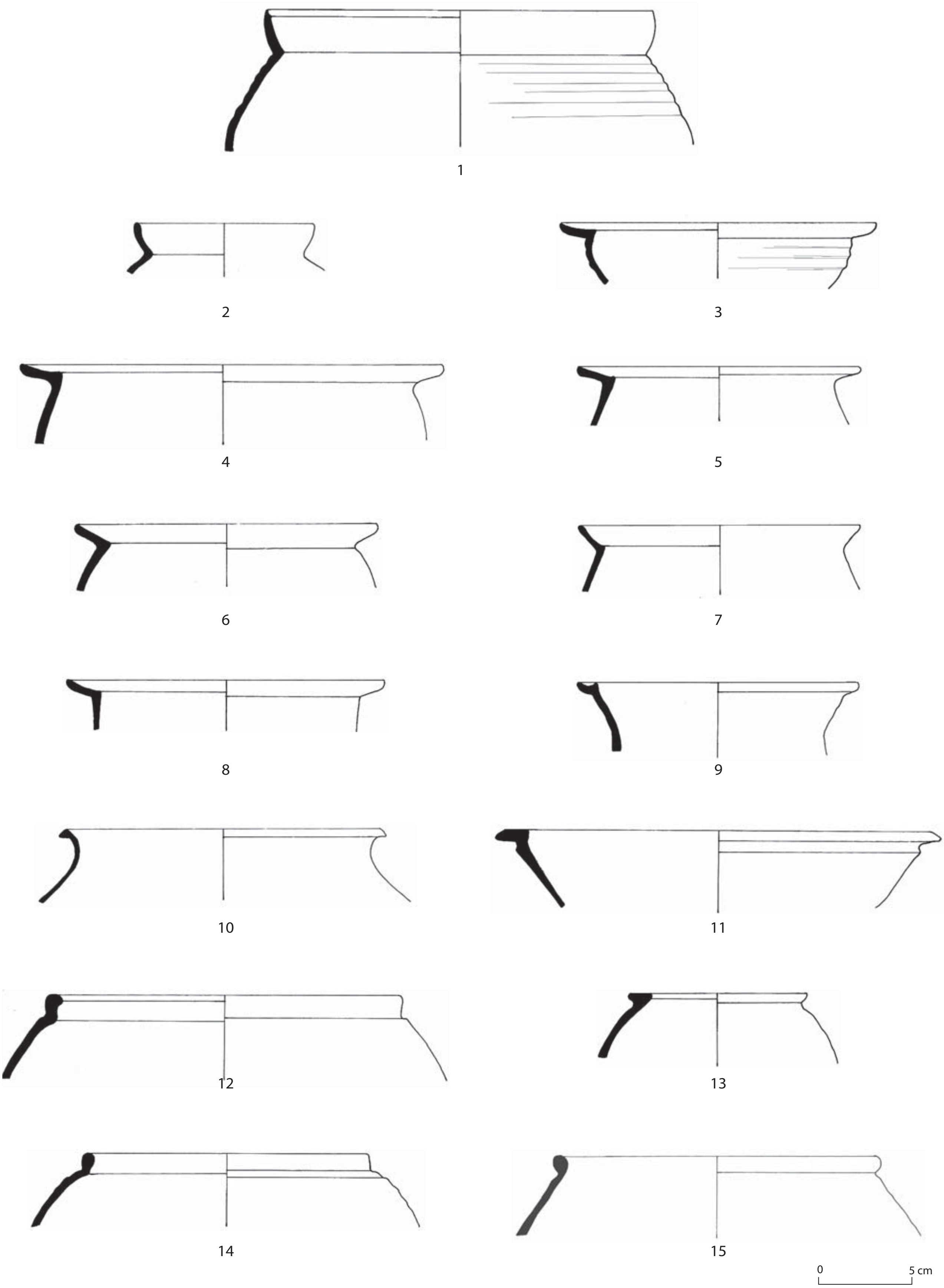

Fig. 5. Shapes of analysed Brittle Ware from Beirut (1-F865, 2-F870, 3-F875, 4-F874, 5-F869, 6-F871, 7-F868, 8-F873, 9-F867, 10-F872, 11-F866, 12-C388, 13-C389, 14-C390, 15-C391).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	V	Cr	Ni	(Cu)	Zn	Rb	Sr	(Y)	Zr	(Nb)	Ba	(La)	(Ce)	(Pb)
group 1 (n = 66)																								
mean	66,84	1,287	18,13	9,11	0,156	1,06	1,59	0,23	1,42	0,204	147	341	178	34	98	85	123	54	317	23	346	52	116	26
std	1,91	0,124	1,25	0,51	0,034	0,16	0,41	0,10	0,24	0,096	18	23	15	8	10	9	47	8	30	6	94	9	11	18
CV	2,9	9,6	6,9	5,6	21,9	15,4	26,0	44,6	16,8	47,0	12,0	6,7	8,5	23,1	10,0	11,0	38,4	14,3	9,4	26,1	27,3	18,1	9,8	70,3
clay sample Aleppo																								
F951	57,75	1,295	20,73	10,32	0,178	2,80	4,92	0,24	1,59	0,190	172	321	192	62	120	104	105	44	263	24	382	49	106	35
group 2 (n = 16)																								
mean	63,32	0,797	17,12	7,60	0,108	2,26	4,07	1,16	3,38	0,142	109	161	114	24	80	104	135	38	217	11	610	33	81	11
std	1,84	0,051	0,45	0,28	0,009	0,23	2,03	0,25	0,26	0,045	9	17	12	5	10	8	54	3	15	3	119	5	12	3
CV	2,9	6,4	2,6	3,6	8,6	10,3	49,9	21,6	7,7	32,1	8,3	10,7	10,4	20,8	12,6	7,6	39,8	8,6	7,1	32,2	19,5	14,2	14,7	24,4
group 3 (n = 28)																								
mean	58,58	1,248	19,13	9,82	0,175	2,75	4,70	0,95	2,16	0,204	176	526	216	35	121	86	215	41	240	19	407	46	96	20
std	0,97	0,068	0,72	0,39	0,014	0,33	0,74	0,14	0,25	0,042	8	44	8	6	11	6	37	3	13	5	64	9	11	7
CV	1,7	5,4	3,8	3,9	8,2	11,9	15,8	14,6	11,8	20,7	4,5	8,3	3,9	17,4	8,8	7,3	17,4	8,4	5,4	25,2	15,8	20,4	11,7	34,9
similar to group 3 (Ain Sinu, bowl 76)																								
8448	59,47	0,936	15,87	7,96	0,141	3,55	7,33	0,72	2,11	0,201	0	262	174			56	398		187		344			
group 4 (n = 16)																								
mean	66,02	1,335	16,81	8,97	0,135	1,13	3,64	0,21	1,18	0,212	154	264	128	39	125	66	127	42	293	25	324	43	98	34
std	4,05	0,093	1,70	0,83	0,021	0,25	1,55	0,07	0,35	0,100	19	14	15	19	17	11	41	3	25	2	82	7	11	18
CV	6,1	7,0	10,1	9,3	15,7	22,4	42,5	33,5	30,1	47,5	12,2	5,5	12,0	48,4	13,5	16,5	32,6	8,0	8,5	8,1	25,3	15,8	10,7	52,4
clay sample Apamea																								
T207	47,27	1,091	12,75	7,24	0,102	2,14	28,18	0,15	0,86	0,223	141	204	83	33	94	47	205	35	188	22	298	31	63	17
group 5 (n = 9)																								
mean	66,55	1,983	20,01	8,99	0,038	0,67	0,69	0,21	0,71	0,160	130	217	79	32	80	56	82	27	366	28	145	39	88	26
std	2,48	0,129	2,01	1,06	0,008	0,05	0,23	0,11	0,06	0,039	16	7	9	16	7	7	12	4	39	3	22	13	17	10
CV	3,7	6,5	10,0	11,8	21,3	6,9	32,9	51,4	8,4	24,5	12,3	3,2	11,9	48,4	9,0	11,8	14,1	16,0	10,8	9,4	15,1	34,0	19,6	39,7
workshop X (Waksman *et al*, 2005)																								
	66,51	2,007	20,67	8,13	0,041	0,63	0,81	0,17	0,71	0,180	132	172	91		80	63	88	28	381		187	58	99	
group 6 (n = 5)																								
mean	71,33	1,875	14,96	8,39	0,103	0,79	1,05	0,22	1,18	0,109	157	796	134	29	89	68	82	59	485	30	234	44	102	24
std	1,52	0,099	0,82	0,32	0,030	0,11	0,05	0,09	0,26	0,020	8	52	8	6	4	5	12	3	35	4	48	5	21	4
CV	2,1	5,3	5,5	3,8	29,5	14,1	4,4	39,1	22,3	18,7	5,2	6,6	6,1	20,0	4,9	7,5	14,1	4,3	7,2	13,3	20,5	12,0	20,8	17,4
Palmyra, local group (n = 24)																								
mean	57,39	2,060	22,70	8,38	0,018	1,78	4,45	0,85	2,18	0,138	156	179	87	25	54	79	481	36	528	37	66	52	109	24
std	1,82	0,181	1,88	1,35	0,004	0,33	2,42	0,31	0,15	0,031	18	15	13	8	6	6	211	3	42	6	30	8	14	24
CV	3,2	8,8	8,3	16,1	19,7	18,6	54,4	36,7	6,9	22,1	11,4	8,7	15,4	32,0	10,7	7,2	43,8	7,2	7,9	17,3	46,2	14,9	12,5	98,4
clay samples Palmyra																								
D500	71,58	1,475	13,32	7,92	0,007	0,98	1,12	2,54	1,03	0,026	107	112	19	20	9	34	65	21	967	19	24	19	57	11
D657	72,19	1,484	13,74	8,80	0,001	1,02	1,11	0,54	1,10	0,036	102	105	28	34	4	33	89	20	805	26	12	22	56	10
D759	73,18	1,380	14,64	8,70	0,004	0,84	0,10	0,46	0,58	0,130	124	110	70	38	43	25	208	53	550	23	19	139	950	9

Table I. Brittle Ware groups from Syria - means, standard deviations (std) and coefficients of variation (cv) in percent. Workshop X is the group average of Brittle Ware from Beirut and other sites, published by Waksman *et al.* (2005, 325). Analyses were done by wavelength-dispersive X-ray fluorescence analysis (WD-XRF) based on some sixty international reference samples. Samples were prepared by pulverising fragments weighing 2 - 4 g, after removing surfaces and cleaning the remaining fragments with distilled water in an ultrasonic device. The resulting powders were ignited at 880°C, 1 g melted with 4 g of a lithium-borate mixture and cast into small discs for measurement. This data is, therefore, valid for ignited samples. Trace elements determined with lower precision are given in brackets. The individual data together with a short description of the analysed samples will be published on internet (www.archaeometry.pl).

	group 1		group 2		group 3		group 4		group 5		group 6	
sites	**n**	date	**n**	date	**n**	date	**n**	date	**n**	date	**n**	date
Ain Sinu	-				4	2-3 AD						
Ajij survey (2 sites)	4	8-10 AD	1	?								
Aleppo	3	3 BC-8 AD					1	12-13 AD			3	7-9 AD
Andarin/Androna	-						2	6 AD				
Apamea	1	4 AD					10	1-9 AD	6	6-7 AD		
Balikh survey (5 sites)	5	2-10 AD	2	8-10 AD								
Dehes	6	6 AD?										
Dibsi Faraj	1	1-4 AD			4	1-5 AD	1	4-5 AD				
Euphrates survey (6 sites)	6	7-9 AD									2	7-9 AD
Hammam et-Turkman	8	1-3 AD										
Khabur survey (15 sites)	4	3-10 AD	9	3-10 AD	8	2-7 AD						
Upper Khabur (4 sites)	-		2	Byzantine	2	Roman						
Palmyra	1	8-9 AD					1	3 AD	3	?		
Qasr al-Hayr as-Sharqi	2	Islamic										
Raqqa/Nikephorion	4	Roman	1	?								
Raqqa/Tall Bia	2	Roman										
Raqqa/Tell Aswad	6	8-9 AD	1	8-9 AD								
Tell Jinderes	8	3-5 AD					1	?				
Tell Sheikh Hamad	-				8	2-3 AD						
Tell Sheikh Hassan	5	3-7 AD			2	3-7 AD						
total number of analyses	66		16		28		16		9		5	

Table II. Numbers of analysed samples of Brittle Ware from various sites in Syria (**n**) and approximate ranges of dates (c. B.C. or c. A.D.).

sample	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	V	Cr	Ni	(Cu)	Zn	Rb	Sr	(Y)	Zr	(Nb)	Ba	(La)	(Ce)	(Pb)	l.o.i.	total
group a (n = 12)																										
C387	65,75	1,45	14,56	8,94	0,090	0,99	*6.54	0,17	0,84	*0.68	148	147	65	48	91	47	151	49	387	23	431	37	97	49	3,53	99,60
F865	71,72	1,55	15,06	8,76	0,137	0,72	1,27	0,13	0,56	0,10	154	164	79	41	89	48	57	53	380	23	207	43	131	16	0,12	99,58
F866	69,00	1,37	14,75	8,40	0,155	0,94	4,47	0,13	0,59	0,20	150	169	87	34	90	40	118	52	340	22	247	40	108	14	0,60	100,73
F867	71,75	1,31	13,40	7,89	0,118	0,92	3,60	0,32	0,56	0,14	141	157	80	42	81	44	107	49	333	21	460	42	92	*84	0,82	100,15
F868	73,41	1,63	14,11	7,41	0,119	0,60	1,41	0,29	0,91	0,12	113	159	74	29	85	45	85	51	423	25	467	36	128	17	2,35	100,26
F869	73,32	1,68	13,90	7,69	0,166	0,63	1,35	0,28	0,88	0,11	121	164	77	29	87	48	86	53	451	22	460	51	140	18	2,01	100,57
F870	71,92	1,50	14,87	8,38	0,107	0,73	1,45	0,32	0,64	0,09	149	171	88	27	84	44	70	51	369	24	232	47	125	19	1,61	100,17
F871	71,86	1,63	14,28	8,10	0,146	0,64	1,95	0,31	0,97	0,13	125	163	77	34	79	46	98	50	435	23	*830	55	144	22	3,23	100,40
F872	75,05	1,31	12,16	6,80	0,163	0,64	3,08	0,19	0,50	0,11	127	137	66	24	70	37	88	44	358	18	233	46	109	13	0,79	100,74
F873	74,42	1,39	13,15	7,54	0,126	0,67	1,56	0,24	0,77	0,14	133	149	72	27	79	50	71	47	366	20	295	48	106	13	0,76	100,32
F874	73,70	1,64	13,77	7,39	0,165	0,63	1,39	0,31	0,91	0,10	118	157	75	26	80	45	88	53	441	22	503	62	131	14	2,23	100,30
F875	72,21	1,61	14,40	8,18	0,157	0,65	1,43	0,30	0,87	0,19	145	161	76	31	83	51	84	51	415	22	479	60	132	18	1,77	100,59
mean	**72,01**	**1,51**	**14,03**	**7,96**	**0,14**	**0,73**	**2,09**	**0,25**	**0,75**	**0,13**	**135**	**158**	**76**	**33**	**83**	**45**	**92**	**50**	**392**	**22**	**365**	**47**	**120**	**19**		
std	**2,52**	**0,14**	**0,83**	**0,62**	**0,03**	**0,14**	**1,05**	**0,08**	**0,17**	**0,03**	**14**	**10**	**7**	**7**	**6**	**4**	**25**	**3**	**40**	**2**	**114**	**8**	**17**	**10**		
cv	**3,5**	**9,0**	**5,9**	**7,8**	**18,4**	**19,1**	**50,5**	**30,3**	**22,4**	**26,4**	**10,5**	**6,2**	**9,1**	**22,8**	**7,1**	**8,7**	**26,9**	**5,4**	**10,3**	**8,3**	**31,3**	**17,9**	**14,2**	**50,3**		
T088	72,79	1,50	14,00	7,96	0,114	0,60	1,53	0,41	1,00	0,11	151	166	60	18	65	37	69	46	402	28	179	54	119	15	2,91	99,65
group b (n = 5)																										
C388	64,06	2,49	17,16	13,72	0,045	0,78	0,87	0,12	0,64	0,12	127	220	101	49	110	27	75	39	535	40	35	24	86	110	0,98	100,31
C389	62,07	2,33	17,90	14,31	0,103	1,03	0,92	0,18	1,02	0,15	145	214	126	55	149	46	89	49	476	38	*122	48	102	210	1,51	100,75
C390	62,90	2,67	17,32	14,44	0,051	0,84	0,96	0,07	0,64	0,11	146	235	104	38	102	28	81	41	548	42	41	28	80	230	1,01	100,91
C391	66,60	2,33	15,22	12,81	0,062	0,84	1,10	0,16	0,75	0,13	138	207	108	36	102	28	75	44	542	34	72	36	102	103	1,58	100,89
C392	67,11	2,18	15,19	12,80	0,082	0,81	0,91	0,11	0,69	0,13	140	198	106	25	102	33	74	49	540	32	89	35	107	76	0,93	101,00
mean	**64,55**	**2,40**	**16,56**	**13,61**	**0,068**	**0,86**	**0,95**	**0,13**	**0,75**	**0,13**	**139**	**215**	**109**	**41**	**113**	**32**	**79**	**44**	**528**	**37**	**59**	**34**	**95**			
std	**2,23**	**0,19**	**1,27**	**0,79**	**0,024**	**0,10**	**0,09**	**0,04**	**0,16**	**0,01**	**8**	**14**	**10**	**12**	**20**	**8**	**6**	**5**	**30**	**4**	**22**	**9**	**12**			
cv	**3,5**	**7,7**	**7,7**	**5,8**	**34,8**	**11,2**	**9,4**	**33,1**	**21,3**	**11,0**	**5,5**	**6,5**	**9,0**	**28,9**	**18,1**	**24,6**	**8,0**	**10,3**	**5,6**	**11,1**	**37,4**	**26,8**	**12,3**			
Waksman 2002, group B5 (n = 9):																										
mean	66,34	2,31	16,58	11,62	0,061	0,79	1,14	0,17	0,66		126	180	109		90	33	79		515		147	50	88			

Table III. Results of analyses of Brittle Ware from Beirut
(WD-XRF, data valid for ignited samples and normalised to 100 %, l.o.i = loss on ignition, data with asterisk are not included in the mean).
Group b matches group B5 from Waksman (2002, 73).