AN UPPER EGYPTIAN IMPORT AT SIDON

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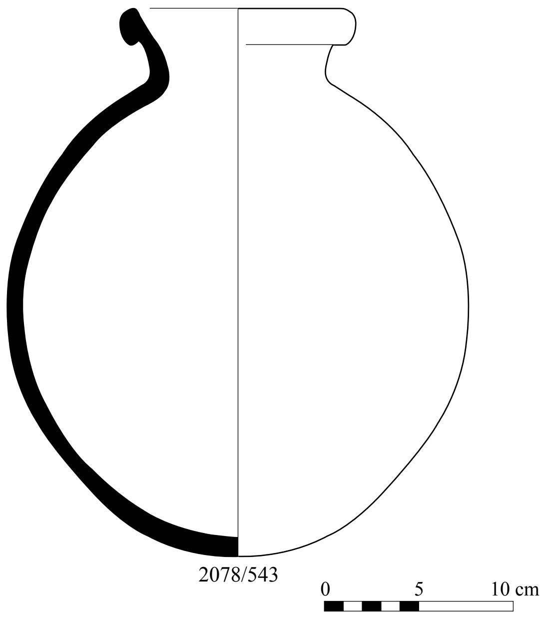
I would like to thank Ernst Czerny for his help in identifying at a meeting in Vienna the Egyptian pottery from Sidon, (claude Doumet-Serhal).

The burnished globular jar which was found above a warrior burial, on a higher level, therefore preliminarily attributed to level 2, is an import from Egypt (fig. 1). This jar was produced on the slow wheel. Its rim, above a short neck, is everted. By smoothening the rim the potter created either with a tool or more likely with his finger a gentle horizontal groove inside. At the outside the vessel was horizontally burnished at the rim and the shoulder, vertically burnished at the neck and the body. It is made of Marl A2 which appears in Egypt from the Middle Kingdom onwards and is most common in Upper Egypt. Therefore one assumes that it origins are from this region, most likely from the Theban area[1]. Usually fired from white over pink and beige to brick-red [2], the Sidon example has a whitish colour (Munsell: 10R 8/2 white). With its height of 29,4 cm and a max. diameter of 24,3 cm this jar fits well into the group of similar vessels found in Middle Kingdom Egypt and Nubia.

Most of the vessels found in Egypt originate from burials or were found out of context. Only a few examples come from well-stratified settlement sites. One complete [3] and several fragmentary examples are known from Ezbeth Rushdi, near Tell el-Dabᶜa (fig. 2). They were discovered in layers attributed to the Middle Kingdom, preliminarily dated to the period around Amenemhet II [4]. Another jar comes from within a pit below "Bauschicht" 13 [5] at Elephantine[6]. Vessels of this type were most probably found in the tombs from the Middle Kingdom in Tell Edfu [7] and Kom el Hisn [8]. From a tomb in El-Kab comes another example [9] which has been identified by J. Bourriau as made of Marl A2 and dated to the period between Sesostris I and Amenemhat II [10]. The largest amount of such vessels are known from tombs in Kerma in Nubia [11]. Recently J. Bourriau published similar jars from the Kerma Ancien III until Kerma Moyen VI periods, dating them between the beginning of the 12th and the early 13th dynasty [12] (fig. 3). Only the jars of Kerma Moyen III which are dated between the early and the mid 12th dynasty, could burnishing be verified as a surface treatment [13]. Therefore the Sidon jar most probably was produced between the reigns of Sesostris I. and pre-Sesostris III. A period that fits very well withanother jar made of the greenish Marl A3 which was found at Tell Ifshar [14]. Although this vessel shows no signs of surface treatment, it is also dated into the first half of the 12th dynasty, not later than the early reign of Senwosret III.

It is known from the annales of king Amenemhat II [15], which were discovered in Memphis, that Egypt went about showing interest in the Levantine region. This text describes mainly military expeditions, but also an exclusive trading expedition is mentioned, which brought back to Egypt different kind of woods, metals and other raw materials. It has been noticed recently that this is also the period in which the first imports of Levantine painted pottery appear in the settlement of 'Ezbet Rushdi [16] near Tell el-Dabᶜa in the north-eastern Nile Delta and further south in the capital city of the Middle Kingdom, *Iṯ-tawy*, modern Lisht [17].



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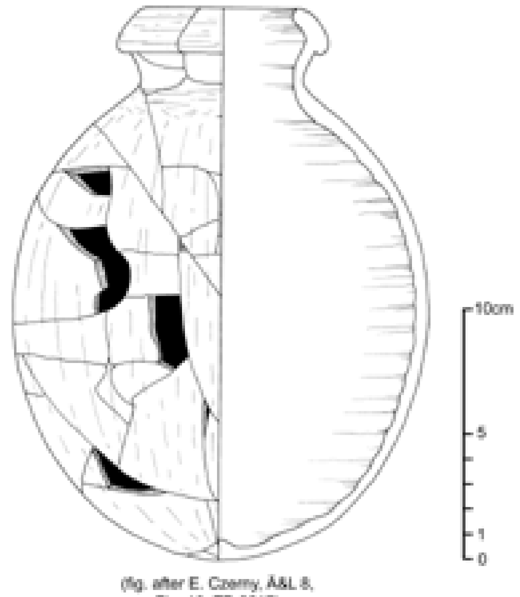

(fig. after E. Czerny, Ä&L 8, Fig. 18, TD 8617)

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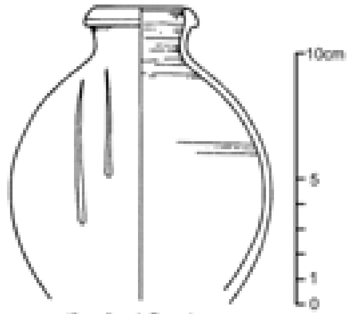

(fig. after J. Bourriau, Nubian Studies, Fig. 2)

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NOTES

1 J. Bourriau, 2004, "Egyptian Pottery Found in Kerma Ancien, Kerma Moyen and Kerma Classic Graves at Kerma", p.12.

2 H.-Å. Nordström and J. Bourriau, 1993, *Ceramic Technology: Clays and Fabrics,* p. 176.

3 E. Czerny, 1998, *Ä&L,* 8, p. 45/fig. 18. For a picture of this object see: *idem*, 2001, Egyptian Pottery from Tell el-Dabʿa as a context for Early MB IIA Painted Ware, p. 142/, fig. 27.

4 M. Bietak, 2001, *Ä&L,* 11, p. 31, fig. 2.

5 This pit seemed to contain material of a longer lasting period. It cuts into "Bauschicht" 15 and was covered by a building of "Bauschicht" 13. See C. v. Pilgrim, 1996, *Elephantine XVIII*, p.72/Abb. 21 and p. 86/Abb.25. T. Rzeuska, 1999, *MDAIK,* 55, p. 197, 203 dates "Bauschicht" 15 into the late 1st Intermediate Period and 11th dynasty "Bauschicht" 13 into the late 12th, early 13th dynasty.

6 C. v. Pilgrim, 1996, *Elephantine XVIII*, p. 361, Abb. 161 a.

7 J. de Linage, 1950, *Tell Edfou 1939. Fouilles franco-polonaises rapport III*, pl. XXXV, top row, 9th vessel from the left. The pottery shown on the plate seems to date to before the late 12th dynasty.

8 A Hamada and Sh. Farid, 1947, *ASAE, 46*, pl. LIII/19.

9 J. E. Quibell, 1897, *El Kab*, pl. XVI/62.

10 J. Bourriau, 1981, *Umm el-Gaʿab. Pottery from the Nile Valley before the Arab Conquest*, p. 68/124.

11 D. Dunham, 1982, *Excavations at Kerma*, p. 175, tomb K5611 pl. XIVc-middle; p. 187, tomb M41 p. XXVIa.

12 J. Bourriau, 2004, *Nubian Studies, 1998*, p. 5-9, figs. 2, 5, 6, 7, 8, 11.

13 J. Bourriau, 2004, p. 7.

14 S. M. Paley and Y. Porath, 1997, "Early Middle Bronze Age II A Remains at Tel el-Ifshar: A Preliminary Report", p. 376, fig. 13.5/4.

15 H. Altenmüller and A. M. Moussa, 1991, *SAK* 18, p. 4-25.

16 M. Bietak and J. Dorner, 1998, *Ä&L,* 8, p. 15; E. Czerny, 2002, CChEM 3, p. 133; T. Bagh, 2002, CChEM 3, p. 101.

17 Co. Arnold, F. Arnold and S. Allen, 1995, *Ä&L,* 5, p. 17-18.

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ASSESSING THE OCCURENCE OF EGYPTIAN MARL C CERAMICS IN MIDDLE BRONZE AGE SIDON

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Introduction

Excavation of the Middle Bronze Age deposits on the College Site at Sidon has revealed a number of vessels that appear on the basis of both their form and their fabric to come from Egypt. Two vessels of this fabric were discussed by Bader in an earlier volume of this journal [1]. The fabric of these vessels is known as "Marl C" in Egypt [2]. In addition to complete vessels, many sherds of a similar fabric have been recovered from the Middle Bronze Age deposits at Sidon, all apparently from jars of various types and sizes (see also Forstner-Müller, Kopetzky & Doumet-Serhal in this issue p. 52).

This paper reports the results of an analytical study which compares these Sidon fabrics with samples of Marl C fabrics from Egypt. The analyses were conducted in an attempt to determine whether the Sidon fabrics may be of the same provenance as the Egyptian Marl C fabrics, or if the Sidon and Egyptian fabrics, although of similar appearance, are more likely to have been manufactured from different materials in different locations.

While there is literary and archaeological evidence of contact between Egypt and the Levant, this evidence has hitherto been rather too scattered to provide a firm basis for assessing the scale of interaction and changes in the scale of interaction over time. The particular significance of this investigation is that it holds the key to the possibility of being able to quantify an aspect of trade or exchange in the Middle Bronze Age. If the Sidon fabrics can be securely identified as coming from Egypt, the ceramics of this fabric will for the first time provide an archaeological means of assessing the scale of the transport of certain commodities from Egypt to Sidon. The ceramic objects made of the Sidon and Egyptian Marl C fabrics are all jars (see doumet-Serhal in this issue p. 39) so it may well be that it was the contents of the jars, rather than the jars themselves, that were regarded as the important commodities being transported.

The information that potentially may be gleaned from studying these ceramic fabrics is made all the more significant by the fact that the current excavations at Sidon provide a continuous succession of stratified deposits extending from around 3000 BC at least to around 1250 BC as well as later Iron Age deposits. The Middle Bronze Age remains discovered hitherto at Sidon provide a succession of excavated contexts unique in the Levant. If the Sidon Marl C fabrics can be securely identified as being of Egyptian origin, correlation of the frequency of this Sidon Marl C fabric with the stratigraphic phases at Sidon will provide a measure of the changes in the scale of the import of these jars (and their contents) throughout most of the Middle Bronze Age. Present indications are that such measures would be based on substantial assemblages of Marl C sherds and will thus provide a basis for at least semi-quantitative modelling of changes in the level of imports from Egypt to Sidon during the Middle Bronze Age [3].

A securely based measure of imports to Sidon from Egypt, and changes in the scale of such imports over time, would provide a highly important basis for modelling of trade with a wider geographic base if in the future comparable information becomes available from other stratified contexts in the Levant. For the present, however, the Middle Bronze Age deposits being excavated at Sidon provide the first prospect of obtaining a chronologically well-defined archaeological measure of the changing economics of the movement of goods from Egypt to the Levant during the Middle Bronze Age.

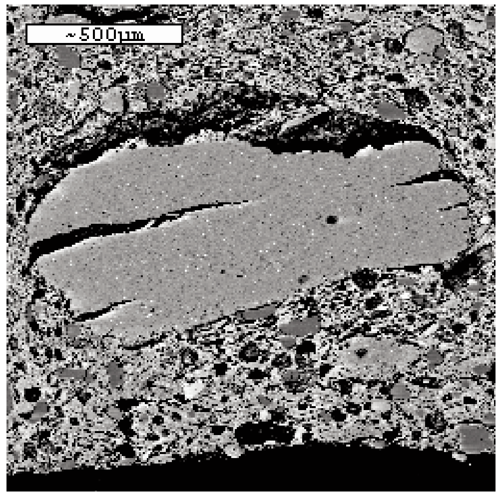

Plate 1
Backscattered electron micrograph of an argillaceous inclusion in an Egyptian Marl C sample from tell el Daba. The scale bar in the top left of the image is 0. 5 mm long.

In the wider archaeological perspective, just as the movement of containers may imply the movement of their contents, so the movement of either implies the movement of the people transporting them. While the immediate evidence relates to the movement of ceramic jars, the evidence has a far wider significance in terms of the movement of commodities and people. The ceramic evidence will thus be highly relevant to improving our understanding of the technological, economic, political and cultural systems within which those movements occurred.

The styles of Marl C vessels changed over time [4]. Another important potential outcome of the study of the Marl C ceramic vessels may thus be to elucidate chronology by providing new and independent archaeological stratigraphic correlations between contexts excavated in Sidon and contexts excavated within Egypt.

The essential key to assessment of the quantity of imports from Egypt (and all that could follow from that) is to establish whether the Sidon Marl C sherds are in fact imports from Egypt as opposed to fabrics of similar appearance manufactured in the Sidon region or elsewhere. This paper presents the results of analyses of sherds of Egyptian Marl C fabric in comparison to analyses of sherds of similar appearance excavated at Sidon.

Contacts between Sidon and other parts of the Eastern Mediterranean

Doumet-Serhal has cited a number of parallels of style between ceramic objects excavated at Sidon and similar objects found in Egypt. These parallels are a part of a wider network of parallels between ceramic items excavated at Sidon and material originating elsewhere in the Eastern Mediterranean, including Palestine, Syria, Minoan Crete, Mycenaean Greece and Cyprus [5].

These parallels are however primarily parallels of ceramic style and thus the possibility of a foreign style having been copied in local workshops must be considered as an alternative to the hypothesis of physical transport of a finished complete object from abroad. Where the fabric, as well as the appearance or style of the object, is also found to be similar to that of known foreign objects, the argument for the actual transport of the ceramics becomes considerably stronger.

An example of a study based on ceramic fabrics in addition to style is given by the work of Bourriau *et al.* [6] who studied the provenance of Canaanite amphorae excavated from New Kingdom contexts at Memphis and Amarna. Five broad fabric groups were identified and it was suggested on geological grounds that each of these was likely to have its origin in a particular region of the Levant, these regions being on the coast or at least not very far inland. Analysis of organic residues and the study of inscribed jars have demonstrated that amphorae of two of the fabric groups were associated with trade in pistachia resin while amphorae made of two other fabrics were associated with oil [7]. It may well be that the contents were seen as of greater significance than the containers, a consideration which is also relevant to some of the vessels excavated at Sidon.

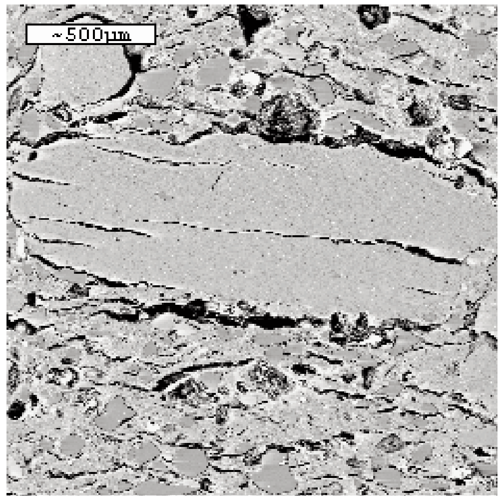

Plate 2
Backscattered electron micrograph of an argillaceous inclusion in a Marl C sample from Sidon. The scale bar in the top left of the image is 0. 5 mm long.

Two ceramic jars from Sidon have been identified by Bader [8] as being very probably of Egyptian origin based both on their form and on their Marl C fabric. (See below for discussion of the fabric). Both the vessels were found in burial contexts. These burials were dug into a layer of sea sand up to 1.5 m thick deposited between the Early Bronze III B and the Middle Bronze I or IIA [9]. The first Marl C jar from Burial 13 is a small handmade globular jar 9 cm high [10]. Bader sites the occurrence of similar jars at several sites in Egypt and dates the production of the Sidon jar to the 12th dynasty. The second Egyptian Marl C vessel identified by Bader was a large bag-shaped storage or water jar 66cm high dated by Bader to the 12th dynasty [11].

Marl C fabrics

In addition to the two vessels described by Bader [12], other jars and a large number of ceramic sherds composed of a fabric that is visually very similar to the Egyptian Marl C fabric occur in the Middle Bronze Age contexts at Sidon. The essence of the research presented in this paper is comparison of the fabric of these sherds excavated at Sidon with the fabric of sherds excavated in Egypt and identified as Marl C.

In this paper, the term Egyptian Marl C fabrics will be used to indicate fabrics excavated in Egypt and identified as Marl C. The similar fabrics found in Sidon will be referred to by the term "Sidon Marl C fabrics". This term is used to indicate fabrics excavated at Sidon that have a visual appearance similar to the Egyptian Marl C fabrics. The term "Sidon Marl C fabric" does not imply any particular place of manufacture nor does it imply that the Sidon Marl C fabrics are necessarily the same as the Egyptian Marl C fabrics in any aspect beyond their visual appearance: the very purpose of the project is to determine whether or not the Egyptian and Sidon Marl C fabrics are likely to have a common provenance.

Marls are calcareous muds or mudrocks, essentially mixtures of clay minerals and calcareous minerals. They may occur in a wide variety of degrees of compaction and lithification varying from material that can be crumbled in the hand to hard, rock-like deposits. Material of intermediate compaction may still be useful for making pottery after mechanical crushing and soaking in water. Mudrocks may occur in a massive form displaying a hackly, conchoidal fracture or they may be laminated due to variations in grain size and composition during deposition. Lacustrine sediments are frequently laminated. Mudrocks also display different degrees of fissility, the ability to split parallel to the depositional layers. Muds and mudrocks formed in marine or non-marine environments may merge into marls or limestones depending on the relative contributions of clay and calcareous material. Calcareous material may be inherited detrital material washed in from elsewhere, may be deposited by organisms with carbonate skeletons or may arise from precipitation of calcium carbonate due to photosynthesis by planktonic algae [13].

The term Marl C was introduced as part of the Vienna system for classifying Egyptian ceramic fabrics. The Vienna system is described by Nordstrom and Bourriau [14]. The system provides a broad general classification framework for Egyptian ceramic fabrics on the basis of freshly fractured cross-sections of sherds examined visually, with the aid of a hand lens, or using a low power reflected light binocular microscope. The choice of this simple basis for the system was deliberate, recognizing the need to be able to classify the fabrics of large amounts of ceramic material in the field with fairly simple equipment and with reasonable rapidity. The characteristics of Marl C described by Nordstrom and Bourriau [15] have also been summarized elsewhere [16]. The components of the fabric are a hard fine-grained matrix firing red to brown, often with a darker core, and containing inclusions of limestone (which give the fabric a speckled appearance), flakes of unmixed marl clay (referred to in this paper as argillaceous inclusions) and quartz sand. White mica and dark mineral inclusions may also be present [17]. These inclusions vary in their frequency and size range and firing conditions also vary, with the higher firing temperatures causing various extents of decomposition of the limestone inclusions.

Three sub-divisions of the broad Marl C category have been defined on the basis of these variations. In Marl C1 limestone inclusions predominate whereas in Marl C2 the quartz grains are more numerous [18]. Marl C1 tends to be fired at higher temperatures (estimated as 850-1000 C) and usually has a red fabric with grey or black core. Marl C2 is lower fired (estimated at 750-800 C) and has a pale red to brown fabric. A further sub-division is Marl C compact which, compared to Marl C1 and Marl C2, is denser and lower in quartz sand content. It has distinct flakes of unmixed marl clay visible on the surface [19]. The general category Marl C thus embraces quite a large range of variation in texture, mineral composition, porosity and colour, albeit that limestone, argillaceous fragments and quartz are always present as inclusions.

A further feature of the Marl C fabric is that most vessels have a grey-white or whitish outer surface [20]. This is sometimes thick and might be mistaken for a slip on a single sherd. It is, however, probably the result of soluble salts in the water of plasticity depositing on the surface during the drying of the pot after forming. The thickness of the deposit will vary according to the soluble salt content of the water and according to the amount of water evaporating from a given point during the drying process. The latter will in turn be affected by the local topography of the pot surface and its local permeability. Permeability at any location on the surface may be affected by any surface finishes or coating. An important factor governing the distribution of effloresced salts on the surface of a ceramic vessel is the wind speed adjacent to a given point on the surface, as this governs the rate at which air dampened by evaporation of water from the drying pot is replaced by dryer air. The process is very similar to the drying of washing on a clothes line for a given ambient humidity, evaporation (drying) is faster on a windy day. Air replacement rate, and thus the rate of evaporation and the amount of salt deposited at a given location on the surface of a pot, is also dependent on the positioning of the pot during drying. If the pot stands on its base on the ground in an open area, the wind speed, the rate of evaporation and the amount of salt deposition will tend to increase progressively with distance above the ground. Relatively little evaporation will take place from the base as that is in contact with a surface, and relatively little will take place through the inner surface of a closed vessel since the air within will soon become saturated with moisture and will only be replaced slowly by turbulent currents generated by air passing over the mouth of the vessel. The density of the white deposit will therefore vary over the surface of a vessel and some sherds will show far more deposit than others even though they are from the same vessel.

A certain amount of redistribution of soluble salts seems to occur during burial as a whitish coating may often be seen on old broken edges of excavated sherds.

Although most examples of the white surface deposit are due to effloresced salts, Bader [21] notes that there are examples where a white surface coating has been deliberately applied as evidenced by thick white drips or broken thick layers of white paste.

The geological source or sources of the Egyptian Marl C fabric is not known although it is considered certain that the sources are in Lower

Egypt [22]. The Memphis-Fayoum area is considered the most likely source region but other source regions cannot be discounted [23]. It is not known whether the geological source material was a naturally occurring secondary clay sediment containing limestone inclusions, argillaceous inclusions and sand inclusions or if separately excavated components were mixed deliberately to make the desired fabric. Butzer [24] describes secondary deposits of clays such as those from the Wadi Qena which might provide naturally occurring mixed raw materials but it is also possible that the Marl C fabric could have been a recognized fabric texture or "recipe" that could be made up wherever suitable raw materials were available [25]. Bourriau *et al.* [26] note that the clay pellets are probably the result of poor mixing but acknowledge that they may have been deliberately added to modify the properties of the product.

Might some of the Sidon Marl C be copies rather than imports from Egypt?

The purpose of this section is to consider the possibility that some of the Sidon sherds that look like Egyptian Marl C are in fact copies made elsewhere.

If the reliable recognition by eye of Egyptian vessels in the Sidon Middle Bronze Age contexts is established, this will allow significant primary data to be gathered. This data will be used to draw conclusions about the scale of imports from Egypt and will form the basis for important economic and cultural inferences about the movement of goods. The unique stratigraphic sequence presented at Sidon will further enhance the significance of the evidence in that it will allow models of relatively high temporal resolution to be hypothesized and tested. All this makes it vital that the primary question of provenance is examined very carefully from a variety of viewpoints.

Based on extensive experience of Egyptian Marl C vessels and extensive experience of the low power microscopic examination of Egyptian Marl C fabrics, Bader has made a convincing case that the two ceramic vessels she examined from Sidon are indeed Marl C vessels imported from Egypt.

While the possibility of copies with both a convincing form and a convincing fabric may not seem very likely, it is certainly not impossible. There are, several reasons why the possibility of copying must be seriously considered. One is that copying of ceramics at locations far from their initial origin is known to occur, as discussed for example by Sherratt and Sherratt [27]. It is important to consider how easily one might be able to recognize a copy. One problem is that some of the material excavated at Sidon occurs in the form of undiagnostic body sherds as opposed to whole vessels so one may be faced with identification on the basis of fabric alone rather than fabric together with form. Egyptian Marl C fabric is defined in terms of a qualitative description of a fracture surface observed at low magnification with the limitations as to precision that this implies. A further problem with identifying copies of the fabric derives from the fact that there is a significant range of variation within the category of Marl C fabric. If a vessel is in homogeneous in its constitution, a given fracture surface may not be representative of the fabric as a whole.

Geological raw materials with at least a certain degree of similarity to Egyptian marl sources are available outside Egypt. Tertiary and Cretaceous deposits near Sidon contain beds composed of shales, detrital limestones and chalky marls. Deposits of chalky marls are also known from the Eocene, Miocene and Pliocene in the Lebanon [28]. Although we have not yet been able to sample these deposits, it is at least possible that such deposits might have been used to manufacture a fabric similar to Egyptian Marl C.

It might be argued that more ornamental ceramics would be more likely to be copied than the functional vessels used for transport or storage. If the function of the Marl C vessels was to act as containers, the interest is likely to have been in the contents. However, the appearance of the container may have had a strong association with its contents. If the content commanded high value or prestige, there may have been the incentive to make copies of the containers as the presence of copied containers might imply the prestige associated with ownership of the associated contents.

Because of the above concerns, we have undertaken comparative analyses of Marl C sherds from Egypt with sherds that look like Marl C excavated in Sidon. We are very grateful to Bettina Bader and to Janine Bourriau for supplying analysis samples of Marl C sherds exported from Tell el Daba some decades ago.

Sample selection

All the Egyptian Marl C fabrics studied in this project were from Tell el Daba. While this might constitute a limitation on the breadth of the Egyptian sample, it should be noted that this site is situated in the northeast of the delta. It was not particularly near any expected raw material source for Marl C and might thus be expected to yield a range of Marl C products from different sources (if there was more than one source). Cyganowski [29] found that the Tell el Daba Marl C fabrics she examined did not show strong grouping chemically or petrographically. Although the numbers of Egyptian sherds studied in the present project (13) is relatively small, it is hoped that it is nevertheless reasonably representative. To compare with the Egyptian material, 13 undiagnostic body sherds were chosen from the Sidon Middle Bronze Age contexts. These were chosen on the basis that their fabric looked very similar if not identical to the Egyptian Marl C fabrics.

Analytical techniques used

The fact that the continuum from mudrocks through marls to limestones is not readily addressed by optical microscopy on account of the fine-grained nature of these materials influenced our choice of analytical approach. One of the limitations of visual identification of fabrics like Marl C as a means of attesting a common provenance is that many of the components of the fabric are too fine grained to be characterized by low power microscopy. Although petrographic microscopy of thin sections of Egyptian Marl C fabrics at higher magnifications has been used with success [30], such study is often of necessity directed towards less common mineral and rock inclusions in the fabric. The clay matrix, argillaceous inclusions, and marl or limestone inclusions may still be too fine-grained to yield much information about their character. Comparison of fabrics by optical microscopy is further complicated by the fact that colour can be much affected by the conditions (atmosphere, temperature and duration) under which the ceramic was fired.

Egyptian Marl C fabrics have also been studied by bulk elemental analysis using neutron activation analysis [31]. The results reported in this paper are also based on elemental analysis of the fabrics but with some differences of technique and approach. Each technique has its strengths and limitations and each has a contribution to make, albeit blinkered in some way.

The analyses reported in this paper were performed in a scanning electron microscope by energy dispersive X-ray spectrometry (SEM-EDS). The technique was chosen because it has the ability to provide elemental analysis of the individual phases in the Marl C fabric, including the fine-grained phases of the clay matrix, the argillaceous inclusions and the limestone inclusions which are relatively inaccessible to optical microscopy. SEM-EDS was also chosen because it provides a set of data (elemental composition of individual phases in the fabric) that is almost entirely independent of the optical data obtained by the low power microscopic examination that is normally used to identify Marl C fabrics.

Slices of the Egyptian and the Sidon sherds were mounted in blocks of epoxy resin to assist with handling. They were ground with progressively finer grades of abrasive to give a flat section and then polished with a succession of increasingly fine abrasives on a soft backing to give a smooth surface. The mounted, polished samples were photographed to provide a guide to the positioning of analytical points when examined in the SEM. The samples were then coated with evaporated carbon to render them conductive.

In the scanning electron microscope, the samples were analysed using an electron beam accelerating voltage of 20kV in an SEM and the X-rays emitted from the sample were detected with a beryllium window detector able to detect sodium and all heavier elements. The detection limit of this technique is about 0.1%. Using previously entered standards, the compositions of the analysed volumes were calculated using an Oxford Instruments Isis system and expressed as oxides based on assumed stoichiometry. To facilitate comparison between areas of different porosity, the results were normalized to a total of 100%. Elemental analysis in the SEM has the advantage of good spatial resolution. The technique provides analyses of the surface and a volume extending a few micrometers below the surface. In the present case, analytical information came from a volume extending to about 3 micrometres (0.003 mm) below the surface. One may obtain an average composition for an area by scanning the electron beam in a raster pattern over a chosen area of a sample or one may choose to analyse a particular spot within a particular phase [32].

Attempts at bulk analysis of our samples by scanning the electron beam over a large area resulted in rather variable results due to the inhomogeneity of the fabrics. The approach adopted for the remainder of the investigation was to use spot analyses. Due to scattering of electrons within the sample, the analytical data from a focused beam of electrons is derived from a pear-shaped, spherical or hemispherical volume whose size depends on the density of the sample and the accelerating voltage (energy) of the electron beam. For the analyses reported here, the analysed volume is approximately 3 micrometres in diameter and depth (Potts, 1987, 336). In the case of the clay matrix or the argillaceous inclusions, such a volume might contain several hundred clay crystals. It was necessary to take several analyses to characterize a phase as a single spot analysis might be affected by an unseen inclusion lying beneath the surface of the sample but nevertheless occupying some of the analysed volume.

In each of the 13 Egyptian and 13 Sidon samples, the fine-grained clay matrix, the argillaceous inclusions and the limestone inclusions were analysed. For each sample, three spot analyses of the clay matrix, two spot analyses of argillaceous inclusions and one or two spot analyses of limestone inclusions were recorded.

In order to prepare the data for principal components analysis, the individual analytical values were standardized by subtracting the mean of all the values for a given element for all the samples from each particular value of that element. The resulting differences were then expressed as multiples of the standard deviation of the values for the element. This was done to eliminate weighting of the results in favour of elements present at high concentrations. Principal components analysis (PCA) was performed using Minitab software using a correlation matrix. The data from each individual spot analysis was entered into the software, not an average for the sample.

Initially, PCA was performed separately on the Egyptian clay matrix data and the Sidon clay matrix data to assess the homogeneity of the separate groups. PCA was then performed on the spot analyses of the Egyptian and Sidon samples taken together, considering the clay matrix data, the argillaceous inclusion data and the limestone inclusion data in turn.

Results

Although all the samples reported here accorded with description of Marl C and all had been identified as being Marl C by others who had experience of the Vienna system, it was apparent visually that the samples exhibited significant inhomogeneity on the scale of the small samples studied and that there was a fair range of variation between the samples.

The argillaceous inclusions in both the Egyptian and the Sidon Marl C samples displayed a number of features in common. Whitbread (1986) has discussed some of the range of variation to be seen in argillaceous inclusions. All of the argillaceous inclusions examined as part of the present project were rounded in their margins and most, though not all, were somewhat elongate. Many contained cracks running roughly parallel to their long axes, and many were surrounded by shrinkage voids which tended to be more apparent adjacent to the long sides of the inclusions. Most of the argillaceous inclusions were fine grained although some had a few inclusions within them. Most of the margins of the argillaceous inclusions were distinct although some showed signs of merging with the matrix. These features appear consistent with their being fragments of a relatively soft but somewhat fissile mudrock. Plates 1 and 2 show backscattered electron micrographs of argillaceous inclusions from a Tell el Daba Marl C sherd and a Sidon Marl C sherd respectively.

For both Egyptian and Sidon samples, the argillaceous inclusions almost always had a lower calcium content than the clay matrix. The magnesium content of the argillaceous inclusions was nearly always higher than their calcium content, a feature which might help to identify their provenance in future.

The ranges of analytical values obtained from the spot analyses of the clay matrices, the argillaceous inclusions and the limestone inclusions were quite wide, as is shown in Table 1. Nevertheless, the spread of results for the Sidon samples appeared broadly similar to that seen in the Egyptian samples.

Sample	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	FeO
Sidon clay matrix	0.6 – 3.5	1.1 – 5.2	21 - 29	51 - 60	0.4 - 4.2	0.7 - 15	0.6 – 2.8	0 – 0.1	3.2 – 13
Egyptian clay matrix	0.6 – 3.4	1.0 – 4.2	17 - 29	49 - 59	0.2 – 3.1	0.5 – 13	0.6 – 2.8	0 – 0.2	5.9 – 16
Sidon argillaceous inclusions	0.7 - 1.5	1.2 – 4.3	18 - 32	52 -74	1.0 – 3.3	0.4 -2.1	0.6 – 8.0	0 – 0.1	4.9 - 18
Egyptian argillaceous inclusions	0.6 – 5.6	0.5 – 4.2	17 - 31	50 - 69	1.3 – 5.2	0.3 - 14	0.2 – 3.1	0 – 0.3	2.2 - 15
Sidon limestone inclusions	0 – 0.3	0 – 2.0	0.1 – 7.9	0.2 - 16	0 – 1.2	68 - 99	0 – 0.7	0 – 0.3	0 – 9.3
Egyptian limestone inclusions	0 – 1.4	0 – 1.8	0 – 3.3	0 - 13	0 – 0.4	88 - 100	0 – 0.4	0 – 0.4	0 – 2.0

Table 1. Summary of the spot analysis results (expressed as wt% oxides normalized to 100% total) showing the ranges of values obtained for the fine grained clay matrix, the argillaceous inclusions and the limestone inclusions for the Sidon samples and the Egyptian samples.
The Egyptian argillaceous inclusion range for CaO would have been 0.3-2.8 (thus matching the Sidon range) if not for a single high CaO result.

Principal components analysis (PCA) of the spot analysis results suggest that the fine grained clay matrices of the Egyptian Marl C samples are similar to those of the Sidon Marl C samples. Some caution is necessary in regarding these results alone as indicating common provenance as PCA was not completely capable of separating Egyptian Marl D and Nile clay samples from the Egyptian Marl C samples. It should also be noted that neither the Egyptian nor the Sidon samples formed particularly tight groupings when considered alone.

PCA analysis of the argillaceous inclusions suggested that those in the Egyptian Marl C samples were similar to those in the Sidon Marl C samples. PCA of the limestone inclusions also suggested similarity between the Tell el Daba and the Sidon samples.

Conclusions

Previous judgements based on low-power microscopy concluded that the Sidon Marl C sherds are indeed imports from Egypt. The SEM-EDS results presented in this paper are based on and entirely different type of evidence but they indicate a similar conclusion.

The SEM-EDS results relate to the elemental compositions of the fine-grained matrix, of the argillaceous inclusions and of the limestone inclusions. Statistical analysis of the SEM-EDS analysis of 26 sherds examined is consistent with, or at least is not inconsistent with, the Sidon Marl C fabrics being derived from similar sources of raw material to the Egyptian Marl C fabrics from Tell el Daba. The breadth of the groups indicates the desirability of further work to improve the certainty of this conclusion (see below). Nevertheless, the fact that the independent views of low power microscopy and of SEM-EDS elemental analysis concur must considerably enhance confidence that sherds of the Sidon Marl C fabric are indeed imported from Egypt.

Future research

The certainty as to the similarity of the existing Egyptian and Sidon samples could be increased by the use of a wider range of samples and/or by the use of analytical techniques which retained the spatial resolution of SEM-EDS but also analysed elements present at lower concentrations. Within the limits of the existing samples, a possible next step would be to repeat the work with electron probe microanalysis (EPMA) which would provide more accurate analyses and give detection limits around 0.01% (as opposed to SEM-EDS at around 0.1%).

A number of the argillaceous inclusions analysed in this project contained inclusions. There were also many small inclusions in the clay matrix. Inadvertent analysis of inclusions just below the surface visible with electron beam imaging has probably introduced a considerable spurious spread in the analytical data. Being able to choose an analysed volume that excludes unseen inclusions would be much facilitated by use of an EPMA equipped with cathodoluminescence imaging. Cathodoluminescence would highlight the existence of cathodoluminescence inclusions not only at the surface but slightly below it.

Much lower detection limits could be achieved with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Here the analysed volume would be far larger than with electron beam analysis although generally still small enough to analyse individual argillaceous inclusions.

A further analytical possibility within the range of elemental analysis but using larger sized samples from Sidon would be to abandon the goal of spatial resolution and pursue bulk trace element analyses of the Sidon Marl C fabrics. A large body of trace element data gathered by neutron activation analysis is available for Egyptian Marl C ceramics (Bourriau, personal communication). If it were possible to cross calibrate analytical techniques and results, it would be possible to use the existing neutron activation data from Egyptian samples in comparison with new trace element data from Sidon samples.

Some X-ray fluorescence spectroscopy of Marl C samples is currently being undertaken. This will provide bulk compositional data with lower levels of detection than can be achieved with EPMA.

Another approach to increasing the confidence that the Sidon Marl C material is imported and not a local copy would be to conduct a geological sampling programme of potential raw material sources in the Sidon region to establish whether the locally available raw materials might be capable of producing fabrics similar to the Egyptian Marl C.

An alternative but similar approach would be to conduct SEM-EDS or EPMA analyses on Sidon ceramics not suspected of being imported from Egypt, particularly analyses on comparable aspects such as argillaceous inclusions. We plan to conduct some such analyses in the near future.

Whichever techniques of elemental analysis are chosen, petrographic analysis of Marl C fabrics has been found to be informative (Cyganowski, 2003) and might well provide a further perspective on the samples that would assist comparison.

Once sufficient confidence can be placed in the fact that Sidon Middle Bronze Age sherds recognized visually as Marl C are indeed imports from Egypt, then the way is immediately clear to start to quantify on the basis of archaeological evidence (through various methods discussed in the literature such as estimated vessel equivalents) the scale of imports and changes in the scale through time. Diagnostic sherds may also help to tie together chronological sequences between Sidon and Egypt as illustrated by Bader's dating of the two Egyptian Marl C vessels from Sidon (see also Forstner-Müller kopetzky & Doumet-Serhal in this issue p. 52 & Forstner-Müller kopetzky, p. 60).

NOTES

1 B. Bader, 2003.

2 B. Bader, 2003.

3 A number of methods of measuring the relative quantities of fragmentary pottery found in different contexts have been discussed in the literature.

4 B. Bader, 2002; B. Bader, 2003.

5 C. Doumet-Serhal, 2004, 108-123; C. Doumet-Serhal, 2003, p. 4-19.

6 J. D. Bourriau *et al.*, 2001.

7 J. D. Bourriau *et al.*, 2001, p. 143.

8 B. Bader, 2003, p. 31-37.

9 C. Doumet–Serhal, 2003, p. 9.

10 B. Bader, 2003, p. 31-34.

11 B. Bader, 2003.

12 B. Bader, 2003.

13 See for example M. E. Tucker, 1991 for further information.

14 H.-A. Nordstrom and J. Bourriau, 1993, p.168-182.

15 H.-A. Nordstrom and J. Bourriau, 1993, p.179-181.

16 See for example J. D. Bourriau *et al.,* 2000, p.131-132 and B. Bader, 2002.

17 H.-A. Nordstrom and J. Bourriau, 1993, p. 179; J. D. Bourriau *et al.*, 2000, p. 131; B. Bader, 2002, p. 29.

18 B. Bader, 2002, p. 29.

19 H.-A. Nordstrom and J. Bourriau, 1993, p.180-181.

20 J. D. Bourriau *et al.*, 2000, p. 131; B. Bader, 2002, p. 29-30.

21 B. Bader, 2002, p. 30.

22 J. D. Bourriau *et al.*, 2000, p.132.

23 B. Bader, 2002, p. 31.

24 K. W. Butzer, 1974.

25 B. Bader, 2003, p. 31-37.

26 J. D. Bourriau *et al.*, 2000, p.131.

27 A. Sherratt and S. Sherratt, 2001, p. 28-29.

28 Z. R. Beydoun, 1977.

29 C. J. K. Cyganowski, 2003.

30 C. J. K. Cyganowski, 2003.

31 J. D. Bourriau, personal communication.

32 See N. Trewin (1988) for further details of the application of SEM to sedimentary materials.

33 P. J. Potts, 1987, p. 336.

34 I. K. Whitbread, 1986.

35 J. D. Bourriau, personal communication.

36 C. J. K. Cyganowski, 2003.

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