PETROGRAPHIC ANALYSIS OF TELL EL-YAHUDIEH CERAMICS

Archaeology & History in the Lebanon Issue Thirty Four-Thirty Five: Winter/Spring 2011/12. Pp. 154-162

DAFYDD GRIFFITHS

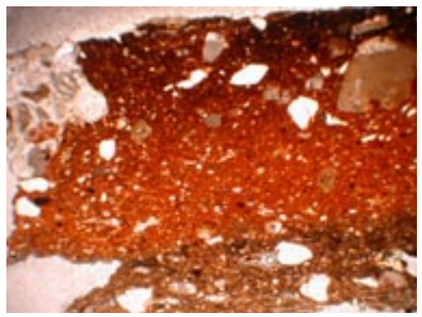
Introduction

The paper presents the results of examination using optical microscopy of the fabrics of juglets in the Tell el-Yahudieh style excavated from Middle Bronze Age contexts at Sidon. The juglets exhibit considerable variety in their style of decoration (see p. 139) and this is reflected in the variety of the ceramic fabrics.

A limitation of this study is that the size of sample available for the preparation of sections was often limited. It was not possible to prepare thin sections of all the samples found and some of the sections prepared are very small. Combined with the fact that several of the fabrics were relatively coarse it is inevitably the case that the samples examined may not always be fully representative of the ceramic fabric of a juglet. For instance, some of the sections examined showed only a single example of a given type of inclusion in the whole of the section examined. Had the section been cut in a different position, that type of inclusion might have been missed altogether. Similarly, some of the less frequent types of inclusion present in a fabric may simply not be present in a particular section. The smaller the section, the greater the likelihood of the section not intersecting less common inclusions. Nevertheless optical examination of the sections does provide some insight into the likely provenance of the juglets. It may also help to infer aspects of the techniques used to manufacture the objects.

Where possible, samples were prepared as thin sections. They were examined by optical microscopy using plane polarized light (ppl) and using crossed polarizing filters (xpl). The petrographic results for each of the fabrics examined are presented in chronological order (see p. 139-153).

S/4213/1966

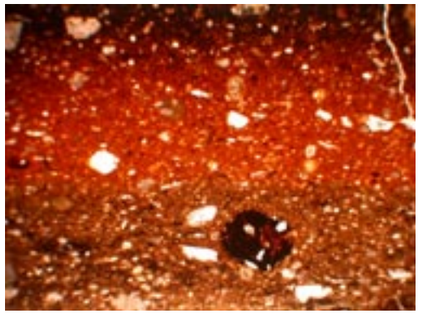


1 S/4213. This image is taken in plane polarized light (ppl). The field of view is approximately 4 mm wide.

This fabric contains fairly common carbonate inclusions, including foraminifera. The carbonate inclusions range from very fine up to over 1 mm diameter. There are a few small chert fragments. The fabric also contains quartz ranging from fine to larger subangular to

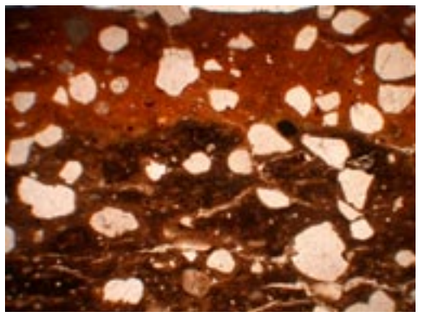
2 S/4213 ppl. The field of view is approximately 4 mm wide.

subrounded inclusions of up to 0. 5 mm diameter. The fabric also contains rounded clay pellets that appear to be more iron-rich than the bulk of the matrix. These clay pellets occur in sizes up to about 0. 6 mm in diameter and contain quartz inclusions (fig. 1 and 2).



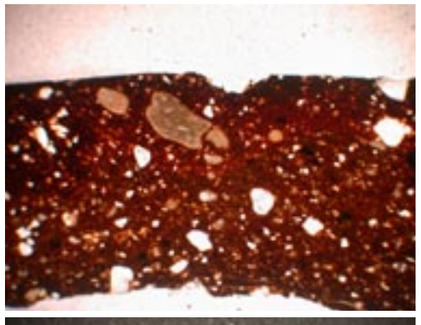
S/5457/6056

3 S/5457 ppl. This figure gives an overview of the section, showing the relatively high density of large inclusions and the presence of elongate voids. (The slight blue tinges are an artefact due to an error on the part of the author: they should be taken as white). The section is approximately 2. 3 cm from end to end. We wish to thank SmartDrive (www.smartdrive.co.uk) for the development and loan of equipment to allow the capture of a high resolution petrographic image of the whole of this section.



This fabric is dominated by numerous angular to subrounded quartz inclusions typically 0.1-0. 5 mm in diameter although many finer fragments of quartz are also present. The fabric also contains numerous fine iron-rich or opaque inclusions. Although fine carbonate inclusions seem to be present in the matrix there are relatively few larger carbonate inclusions, those present being rounded and up to about 0. 2 mm in diameter. Some elongate voids and a few bioclasts including foraminifera are present. Some chert is also present. (Fig. 3 gives an overview of the section while fig. 4 shows a more detailed view of one area).

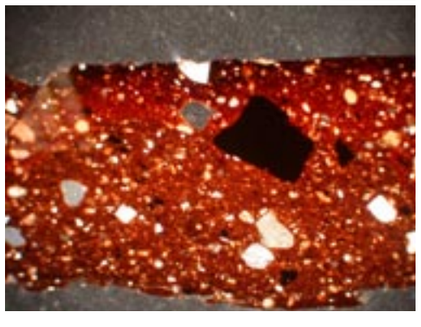
S/2704/1888, burial 67



4 S/2704. Image taken using crossed polarized illumination (xpl) and showing a large opaque inclusion. The field of view is approximately 4 mm wide.

5 S/5457 ppl. The field of view is approximately 4 mm wide and shows some elongate voids

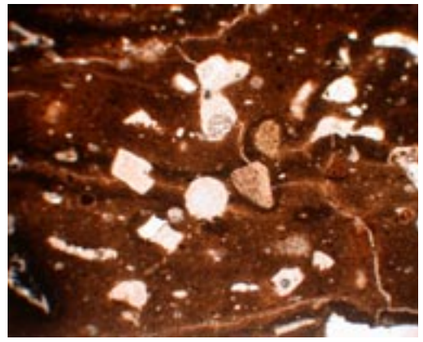
6 S/2704. Image taken using plane polarized illumination (ppl). The field of view is approximately 4 mm wide.



This fabric contained numerous small, often angular quartz inclusions, many less than 0. 1 mm in diameter. In addition the section showed less common larger, generally more rounded, monocrystalline quartz inclusions up to 0. 4 mm in diameter. Subrounded to rounded carbonate inclusions are common, ranging from very fine up to about 0. 6 mm in diameter. Some indistinct bioclasts including foraminifera are present. Iron rich or opaque inclusions are plentiful, ranging from very fine up to about 0. 1 mm in diameter. There are also a couple of larger subangular opaque inclusions in the section, one nearly 1 mm in diameter (fig. 5 and 6).

S/4588/6037, burial 100

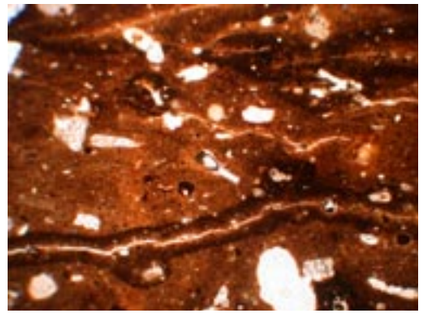
7 S/4588 ppl. The field of view is approximately 4 mm wide.



Quartz is the most common inclusion in this fabric. It occurs as fine inclusions but also as common larger inclusions, mostly subrounded and 0. 2-0. 5 mm in diameter. The fabric contains some bioclasts including shell fragments and foraminifera. The section contains fine carbonate inclusions and a larger carbonate inclusion which in turn contains quartz inclusions. A few chert fragments are also present. (See fig. 7).

S/4649/6037, burial 102

8 S/4649 ppl. The field of view is approximately 4 mm wide and shows elongate voids with dark haloes.

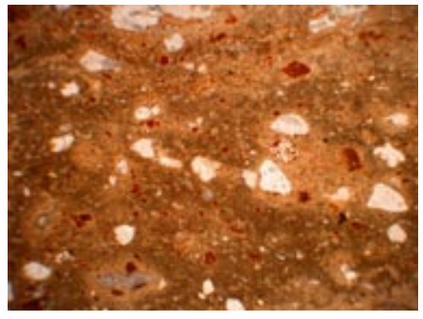


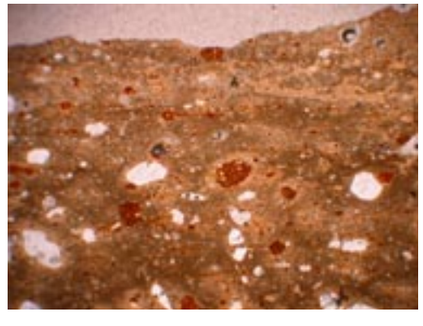
This fabric is characterised by elongate voids, some with darkened haloes, suggestive of their having been formed by inclusion in the fabric of elongate organic material (such as grass) which has been burnt out during firing. The fabric contains many fine iron rich inclusions and some clay pellets containing quartz that appear to be more iron-rich than the clay matrix of the bulk of the section. The fabric contains fine quartz and carbonate fragments as well as coarser inclusions of these materials up to about 0.4 mm in diameter. Chert fragments, some chalcedonic, are also present. (See fig. 8).

S/5458/6037, burial 102

9 S/5458 ppl. The field of view is approximately 4 mm wide.

10 S/5458 ppl. The field of view is approximately 4 mm wide.

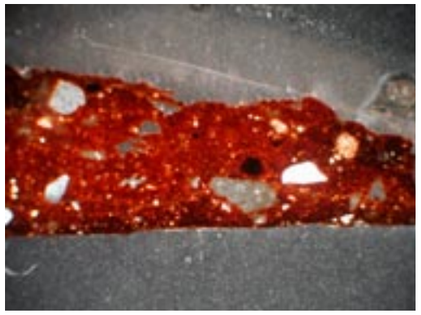


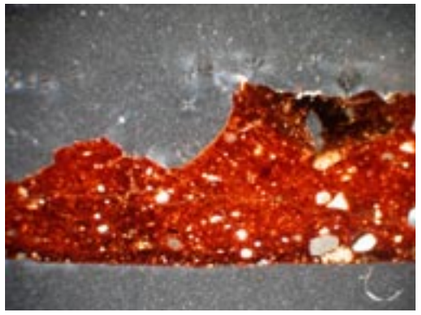


This is a fine, paler fabric with a slightly pastey appearance. It contains many iron rich clay pellets ranging from very fine up to about 0. 3 mm in diameter. Some of these have diffuse margins and some contain quartz inclusions. Quartz is present in the main fabric ranging in size from very fine to about 0. 4 mm diameter subangular to subrounded grains. There are carbonate inclusions both fine and coarser but these are less prevalent than the quartz. There is one fragment of chalcedonic chert in the section. (See fig. 9 and 10).

11-12 S/3722 xpl. The field of view is approximately 4 mm wide.

S/3772/2086, burial 44

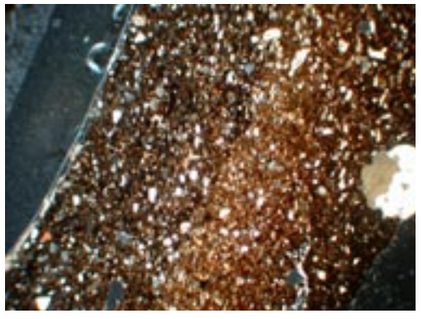




This fabric contains inclusions of quartz ranging from very fine inclusions up to angular to subrounded monocrystalline quartz inclusions 0. 3 - 0. 4 mm in diameter. There are also numerous very fine carbonate inclusions and a few coarser ones ranging up to about 0. 6 mm in diameter. There are a fairly common iron rich or opaque inclusions ranging from very fine up to about 0. 2 mm in diameter.

The larger inclusions occupy only a small proportion of the section and do not appear to be particularly evenly distributed in the fabric (fig. 11 and 12). Although the sample is small and provides only a small sample of inclusions, the size distribution of the inclusions appears to be bimodal: in other words there are many fine inclusions in the matrix, far fewer much larger inclusions and something of a gap in the middle size range, rather than there being a fairly smooth distribution of about an average size. It is possible that the apparently bimodal size distribution of the inclusions arises from the use of a fairly fine matrix with naturally occurring fine inclusions to which coarser inclusions are added by the potter deliberately, perhaps to increase the strength of the object prior to decoration. At present this is only a tentative inference but it may be one worthy of closer attention in the future.

S/1787/197, burial 12



13 S/1787. The image is taken using crossed polars in the light path (xpl). The field of view is approximately 4 mm wide.

This juglet has a fine-grained fabric containing an abundance of small angular to subrounded quartz inclusions, generally less than 0. 15 mm in maximum diameter but many smaller than this. Small rounded iron-rich clay pellets, some with diffuse margins are common. The fabric contains some small rounded carbonate inclusions but these are not common. Among the fine-grained inclusions are mica and a little pyroxene. There are also a number of high birefringence fragments that are too small to identify with confidence.

In addition to the fine quartz grains, the section shows a single large, rounded polycrystalline quartz grain about 0.7 mm in diameter. The grain boundaries within this polycrystalline grain are sutured which is suggestive of a metamorphic source (fig. 13).

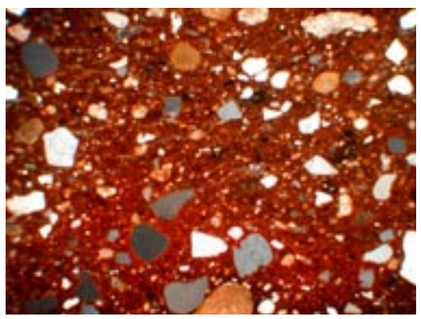
This fabric was distinctive in the context of the Sidon Tell el-Yahudieh fabrics examined both in terms of its fine texture and its mineral inclusions. It is quite unlike any of the other sections examined.

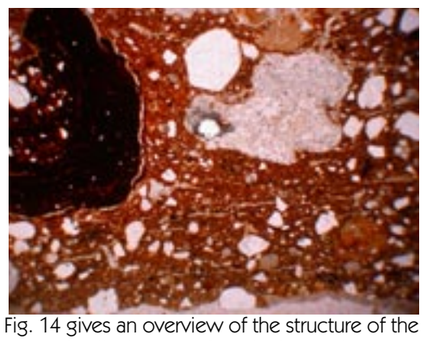
14 S/50273 ppl. This figure gives an overview of the section, showing the very varied size of the inclusions and the presence of elongate voids. The section shown is approximately 1. 4 cm from side to side. We wish to thank SmartDrive (www.smartdrive.co.uk) for the development and loan of equipment to allow the capture of a high resolution petrographic image of the whole of this section.

15 S/50273 xpl. The field of view is approximately 4 mm wide.

16 S/50273 ppl. The field of view is approximately 4 mm wide.

S/50273/4073



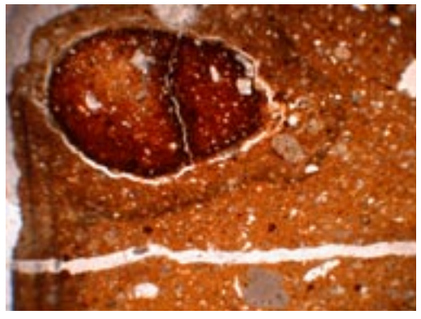


This fabric contains numerous brownish carbonate inclusions ranging in size from very fine up to about 2 mm in diameter. Some of the larger carbonate inclusions contain quartz inclusions and less coloured carbonate. There is also a larger, uncoloured, subrounded more coarsely crystalline carbonate inclusion about 2. 5 mm in maximum diameter. The fabric also contains clay pellets, some which contain fine quartz inclusions.

The main fabric of the sherd contains numerous angular to subrounded monocrystaline quartz inclusions ranging from very fine to about 0. 6 mm in diameter. The fabric displays quite a number of elongate voids.

The large half circle in the bottom left of fig. 14 and in fig. 16 is half an oolith, about 2 mm in diameter, formed with quartz crystals in the core with the outer opaque region probably composed of an iron and/or manganese oxide. Future elemental analysis will elucidate its composition. The opaque inclusion with quartz inclusions in the middle left of fig. 14 may be the core of another broken opaque oolith. Other smaller opaque inclusions are fairly frequent in the fabric. Fig. 14 gives an overview of the structure of the section while fig. 15 and 16 provide more detailed views of particular sections.

S/3940/ 1379, burial 7



17 S/3940 ppl. The field of view is approximately 4 mm wide.

This is a pale orange fabric liberally speckled with small iron-rich or opaque inclusions. The fabric contains fairly abundant foraminifera. The fabric contains quartz, mostly very fine but with a few angular to subrounded grains up to 0. 5 mm in diameter. There are carbonate inclusions, many very fine but a few

18 S/3940 ppl. The grey inclusion near the centre is probably marl. The clear area below the grey inclusion and the clear areas to the left are voids. The clear inclusion to the upper right of the grey area is quartz. The field of view is approximately 4 mm wide.

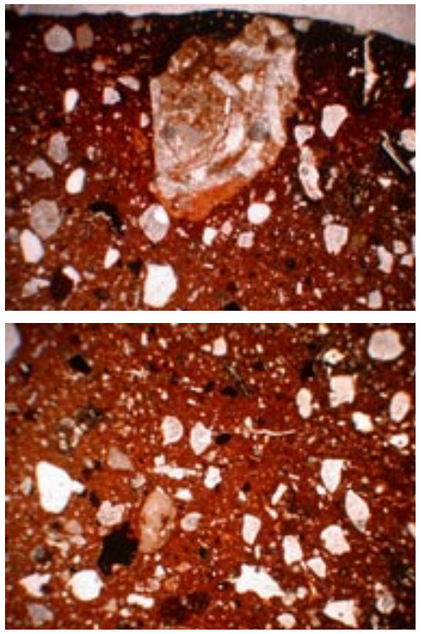
ranging up to about 0. 5 mm in diameter. The fabric also contains a few rounded, slightly more iron-rich clay pellets up to 2 mm in diameter. These clay pellets contain quartz (fig. 17 and 18).

S/41102/859

19 S/41102 ppl. The large inclusion may contain a damaged nummulite fossil. The field of view is approximately 4 mm wide.

20 S/41102 ppl. The field of view is approximately 4 mm wide.

This fabric contains numerous quartz and carbonate grains, generally ranging from very fine to about 0. 3 mm in diameter. The larger quartz inclusions are angular to subrounded, with the larger carbonates being a little more rounded. There are a few small round chambered foraminifera. In addition there are some larger more iron-rich carbonate inclusions up to about 2 mm in diameter. The largest of these may contain a damaged nummulite fossil, a type of Lower Tertiary foraminifera [1] previously noted in a ceramic from Sidon [2] and in sand from a deposit some 9 km south of Sidon [3]. In addition the fabric contains numerous iron-rich and opaque inclusions. (See fig. 19 and 20).



Conclusions

All the fabrics examined have some distinguishing features making it unlikely from a petrographic viewpoint that any two come from exactly the same clay source and workshop.

S/1787 has a fabric entirely dissimilar to all the other samples both from the point of view of its much finer texture and from the point of view of the minerals it contains. Its petrographic characteristics do not appear similar to those commonly seen in other ceramic thin sections from Sidon. On the basis of optical petrology, it may be deduced fairly firmly that this object is an import from an area with distinctly different geological sediments (see p. 147).

While having some distinguishing features, all the samples except S/1787 do share common features in their fabrics such as the presence of fine iron-rich inclusions, fine to coarse quartz inclusions and fine to

coarse carbonate inclusions. The presence of coarse as well as fine inclusions in most samples might reflect the use of sediments that were poorly sorted from a textural point of view, but the frequency of this textural attribute in different fabrics might suggest the deliberate addition of coarse inclusions to make the vessels stronger. Tell el-Yahudieh style vessels, some of which have distinctly thin walls, need to be strong enough to withstand the forces necessarily associated with the creation of incised, impressed and carved decoration on the vessel surfaces prior to firing. This inference of deliberate addition of coarser inclusions by the potter is tentative but may be worth further investigation.

Cohen-Weinburger and Goren have proposed a fabric group of Canaanite jars exported to Egypt (group "B") that exhibit features found in sediments attributed to the Lebanese or northernmost Israeli coastal areas [4]. With the exception of the juglet S/1787, the petrographic features found in Tell el-Yahudieh ware excavated at Sidon appear to fit the description of the above group B and might all have been made on the coastal plain of the Lebanon. It may be noted that fabric analysis of examples of Tell el-Yahudieh ware found elsewhere have been found to be consistent with an origin on the Lebanese coast [5].

While establishing a likely Lebanese coastal origin for most of the Tell el-Yahudieh vessels excavated at Sidon is certainly archaeologically significant, fabric analysis of the rest of Tell el-Yahudieh ware from Sidon has not yet suggested very precise provenances for the vessels. An exception is the tentative suggestion of the origin of sample S/41102 being in the vicinity of the nummulitic limestones c. 9 km south of Sidon.

There are, however, features that are quite common in ceramics from the Lebanese coast in general that are absent from the particular Sidon Tell el-Yahudieh examples studied hitherto. Further study of material of known origin may allow the absence of components to constrain potential provenance just as the presence of certain components has done.

While there are petrographic features that differentiate the individual Sidon Tell el-Yahudieh fabrics, some fabrics are nevertheless quite similar. The fabrics of items S/3940 (see p. 149) and S/4213 (see p. 142), for example, share the presence of foraminifera, very fine-grained carbonate inclusions and the fairly large more iron-rich clay pellets that contain quartz, albeit that S/3940 contains more small iron-rich inclusions. The fabrics are not dissimilar and may originate from a common geological region. The designs of the two vessels are, however, distinctly different to each other in style and execution. They might have been made by different potters and they might have been made at different times but they seem to have been made from quite similar geological material.

Another example of close similarity between fabrics may be seen between S/4588 (see p. 144) from burial 100 and S/4649 (see p. 144)

from burial 102 which was found located underneath it. Common features between these fabrics include the presence of what appear to be elongate organic inclusions that have mostly burnt out during firing.

Apart from analysis of form and decoration, considerable past work on the provenance of Tell el-Yahudieh ware in general has been conducted using bulk chemical analysis of the ceramic fabric. The present petrographic study has highlighted the risk, arising from the inhomogeneous and relatively coarse nature of many of the fabrics, that a small sample drilled out of the fabric might not be fully representative of the bulk composition of the fabric as a whole. Conclusions regarding provenance drawn from bulk chemical analysis from bulk chemical analysis of ceramics used in isolation are also critically dependent on the extent to which the reference material of known provenance is representative and comprehensive. The application of numerical methods to the analysis of the multivariate data is also a factor that may influence the strength of any conclusions concerning provenance.

Despite the above cautions, elemental data can be a valuable adjunct to optical petrography. Each analytical approach has its strengths and limitations so the application of two or more independent approaches may produce greater insights and more reliable geological conclusions. It is therefore planned that future work on the Sidon Tell el-Yahudieh wares will include elemental analysis but, given the problems noted above for bulk elemental analysis, spatially resolved elemental analysis of sections using electron probe microanalysis (EPMA) will be employed. While this will not give the trace element data that might be obtained from LA-ICP-MS (laser ablation inductively coupled mass spectrometry), elemental analysis by EPMA may permit further refinement of conclusions relating to their provenance. EMPA will, for example, elucidate the compositions of the clay matrix, the fine grained carbonates, the iron rich pellets and the opaque inclusions. These further insights will provide new and independent information for assessing similarities and differences between the fabrics. Where geological material of known origin can be analysed using similar techniques, it may be possible also to give some more precise indications of the provenance of the Sidon Tell el-Yahudieh wares.

NOTES

1 A. E. Adams *et al.*, 1984, p. 48.

2 D. Griffiths, 2003, p. 21.

3 M. Ownby and D. Griffiths, 2009, p. 62-63.

4 A. Cohen-Weinberger and Y. Goren, 2004, p. 70, 73-74 and 80.

5 Y. Goren and A. Cohen-Weinberger, 2002, p. 441-442.

BIBLIOGRAPHY

A. E. Adams, W. S. MacKenzie and C. Guilford, 1984, *Atlas of sedimentary rocks under the microscope,* Harlow, Essex.

A. Cohen-Weinberger and Y. Goren, 2004, "Levantine-Egyptian interactions during the 12th to the 15th Dynasties based on the petrography of Canaanite pottery from Tell el-Dab'a", *Ägypten und Levante,* XIV, p. 69-100.

Y. Goren and A. Cohen-Weinberger, 2002, "Petrographic analyses of selected wares", in A. Kempinsky (ed.), *Tel Kabri: the 1986-1993 excavation seasons,* Tel Aviv, p. 435-442.

D. Griffiths, 2003, "Petrographic analysis of Middle Bronze Age burial jars from Sidon", *Archaeology and History in Lebanon,* 17, p. 17-21.

M. Ownby and D. Griffiths, 2009, "The petrographic analysis of beach sand from Sidon to determine its utility for ceramic provenance studies", *Archaeology and History in Lebanon*, 29, p. 56-67.