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Petrographic Examination of the Ceramic Vessels from Tel Shunem (Sulam)

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Introduction

A total of 20 ceramic vessels dating to LB III–Iron I from the archaeological excavations at Sulam (see Covello-Paran and Arie, this volume) were sampled for petrographic examination.

The thin sections were prepared and examined using a stereoscopic microscope at magnifications of ×20–×40 and a Nikon polarizing microscope at magnifications of ×20–×200. The following parameters were examined: mineralogy; the approximate amount of silt-sized material; the optical properties of the matrix; and mineralogy of the sand-sized non-plastic materials (in terms of volume, size, shape and sorting within the pottery sherds). The results of the examination were set against the natural geology and lithology of the surroundings, and existing petrographic databases and prior research results were used for comparison.

Firing temperature was estimated according to the degree of mineralogical changes in the samples. For instance, at 700–750°C limestone and calcite begin decomposing; at 900°C carbonate disappears, leaving behind voids (Rice 1987:97–98). At temperatures higher than 800–850°C hornblende turns to oxyhornblende. Clay turns to ceramic at temperatures higher than 600ºC. At 650–700°C the optical properties of clay minerals start to change. At 800°C clay turns isotropic and milky, through a process called vitrification (Porat 1986–1987:112; Rice 1987:80–110).

Geology of the Site Vicinity

The geology of the Sulam area (including the part of the Jezreel Valley where the village is situated as well as the land to the north) is characterized by Quaternary alluvial sediments. About 2 km west of Sulam are small Pliocene marine sediment outcrops of the Bina Formation. Giv'at Ha-More, to the north of the site, is composed of Lower and Middle Eocene chalk and limestone of the Jezreel and Bar Kokhba Formations, with later (Miocene) gabbro and dolerite intrusions. To the northwest and to the east of the site are outcrops of Miocene lower basalt and to the southeast, Pliocene–Pleistocene cover basalt (Sneh et al. 1998).

Tel Shunem is located at the place where the brown alluvial calcareous soils of the Jezreel Valley meet with the *terra rossa* soils covering the hilly area of Giv'at Ha-More—except the highest part of the tell, where brown basaltic calcareous soils can be found (Ravikovitch 1969).

Petrographic Database

The examined samples were divided into five petrographic groups, according to their matrix and temper affinities. The lithological and technological properties of these groups are presented below.

Petrographic Group 1

This group comprises ten vessels (Table 1) characterized by a foraminiferous marl matrix

Table 1. Inventory of the Examined Thin-Sections, Divided by Group

Petrographic Group / Provenience	Section	Vessel	Locus	Basket	Stratum	Figure (see Covello-Paran and Arie, this volume)
1 (Jezreel Valley)	S1.2	Bowl	113	1045	V	20:6
	S1.3	Pithos	103	1005/1	III	27:16
	S2.5	Chalice	114	1023/3	IV	25:7
	S3.1	Goblet	103	1001/1	III	27:6
	S3.2	Storage jar	103	1010/2	III	27:15
	S3.3	Amphoriskos	105	1016/3	IV	25:15
	S3.4	Chalice	105	1015/1	IV	25:8
	S3.5	Duck bowl	113	1036	V	20:7
	S3.6	Storage jar	113	1043	V	23:1
	S3.7	Jug base	103	1003/2	III	27:10
2 (Jezreel Valley)	S1.6	Storage jar	113	1018/1	V	23:5
	S3.8	Storage jar	105	1015/4	IV	26:2
3 (Jezreel Valley)	S1.1 (Fig. 1)	Storage jar	114	1026/2	IV	26:1
	S1.4	Krater with spout	113	1049	V	21:1
	S1.5	Storage jar	113	1046/1	V	23:3
	S2.2	Bowl	113	1022	V	20:5
	S2.3	Storage jar	113	1039	V	23:2
4 (Central Jordan Valley)	S2.1	Flask	113	1035	V	22:2
	S2.4	Jar	114	1023/1	IV	25:14
5 (South Lebanese coast)	S2.6 (Fig. 2)	Flask	103	1001/2	III	27:11

containing rare silty grains of minerals derived from basalt (i.e., plagioclase, olivine) and silty quartz. Identifiable foraminifers are dated to the Eocene–Paleocene Age.

Non-plastics are badly sorted and represented by two size ranges. One includes fine grained (0.1–0.2 mm) foraminifers and their debris, as well as rare rounded to sub-rounded chert particles (present only in Samples 3.1 and 3.3). The other size range includes coarse (0.8–1.9 mm) rounded grains of foraminiferous and crystalline limestone mixed with occasional chalk balls. In some of the samples, the following are present: olivine basalt—sub-rounded to sub-angular grains (0.5 × 0.8 mm to 2.0 × 1.0 mm), in some of which phenocrysts of olivine are partially (when the olivine nucleus is still seen under the microscope) or completely altered to iddingsite (S3.1–3.3, 3.7); chert—a sub-angular 0.4 × 0.6 mm grain (S2.5); mollusk shell—a 2.0 × 0.6 mm fragment with a clearly visible lamellar inner structure (S3.3); travertine—two 2.0 × 1.5 mm sub-rounded pieces (S3.4); crystalline calcite—1.0 × 1.0 mm sub-angular grain (S3.4); and ferruginous silty clay (possibly *terra rossa*)—a 0.5 mm diameter nodule (S3.2).

Taken together, these minerals make up about seven percent of the sherd's volume. It should be noted, however, that in S3.7 coarse tempers are finer (0.6–0.9 mm) and are present in lesser quantities (~3–4 percent of the sherd volume).

The firing temperature for this group is estimated at 700ºC because the clay minerals of the matrix are optically active and carbonate materials maintain their crystalline structure.

Sample 3.2 was fired at a higher temperature (750–800ºC) because the matrix' clay minerals are optically passive and all carbonate materials within the sherd are milky.

Special attention should be paid to S1.3, the cross-section of which is rather unusual. The exterior is vitrified, while in the interior it looks as though tiny crackles within the sherd were refilled by carbonate material during the use-life of the vessel or post-depositional period. There are 'flows' of white and very light brown color, which run parallel to the surfaces of the vessel, surround some of the foraminifers and fill the spaces between them.

The raw materials used to prepare the ceramic paste for the vessels in this petrographic group would have come from an area of exposed foraminiferous marl (Senonian Taqiya marl provides the best match), biogenic chalk of Eocene–Paleocene age and eroded olivine basalt. Use of Taqiya marl is known from many ceramic assemblages, especially from the lower and western Galilee and particularly from the Jezreel Valley (Goren 1990; 1992; Goren and Zuckermann 2000; Shapiro, in prep.). The basalt detected in this petrographic group is holocrystalline and belongs to the alkali-olivine category where olivine phenocrysts are altered into iddingsite. This is typical of the Neogene–Pleistocene basalt outcrop in the vicinity of Sulam (Sneh et al. 1998). Based on these facts, the vessels of Group 1 may be interpreted as locally made.

Petrographic Group 2

This group is composed of two vessels (see Table 1) characterized by a homogeneous, slightly calcareous clayey matrix, which looks 'clean' under the microscope. Rare foraminifers are present in the marl, together with a small quantity of silt-sized plagioclase and olivine grains.

Non-plastics in this group vary in size (0.9 × 1.2 mm and 1.2 × 1.7 mm). They make up about five percent of the sherds' volume, and are represented by rounded grains of foraminiferous limestone or chalk, sub-angular grains of crystalline limestone, rounded to sub-rounded grains of volcanic material (which is mostly glassy with miniscule ore particles), and phenocrysts of augite found in large (~2 mm) grains. Also identified were 0.7–0.9 mm rounded grains of slightly-eroded basalt and 0.8–0.9 mm nodules of silty ferruginous clay (possibly *terra rossa*).

The firing temperature for this group was estimated as close to 750ºC, because carbonate materials are partially cryptocrystalline.

Most of the components of this petrographic group can be found in the Jezreel Valley, but the fresh basalt points can be found on the slopes of upland areas east of the Valley, where Pliocene–Pleistocene cover basalt is exposed (Sneh et al. 1998). Mountainous rendzina soil admixed with brown basaltic Mediterranean soil could serve as raw material for such a matrix (Dan et al. 1975).

In addition, it should be mentioned that the petrographic affinities of the samples comprising this group are identical to those of the samples taken from a wall (and inside a pottery kiln) from 'Ein el-Ḥilu, dated to the Middle Bronze Age (Goren and Shapiro, in prep.: Sample A6.1). Recently, Arie (2011:354–355) has proposed that this petrographic group, his 'Family N', originated at Tel Shadud and its immediate environs. According to Arie, most vessels from this group date to LB III—a period during which 'Ein el-Ḥilu was not occupied.

Petrographic Group 3

This group comprises five samples (see Table 1) characterized by a ferruginous and slightly calcareous matrix containing silt-sized plagioclase, rare olivine, iddingsite, quartz (angular to sub-rounded grains) and rare foraminifers and their debris. There are also two nummulites in the thin-section. Silt-sized grains of hornblende are very rare. Silt makes up about seven percent of the matrix volume.

Sand-sized materials are represented by the following: rounded grains of foraminiferous limestone (0.5 × 0.5–1.8 × 4.0 mm); sub-rounded grains of crystalline limestone (0.3 × 0.3–0.5 × 0.7 mm); and sub-rounded to sub-angular grains of vesicular basic vulcanite, comprised dark brown volcanic glass, a tiny ore component, allusions of elongated plagioclase 'needles', and olivine and augite grains (Fig. 1). Also present are shell fragments (0.2–0.3 mm thick and 0.3–0.5 mm long), some of which are crystalline, with a clearly distinguishable lamellar inner structure. One 0.8 mm nodule of silty ferruginous clay (possibly *terra rossa*), several small (0.3 mm) grits of crystalline calcite and one 0.6 mm rounded grain of crystalline limestone are present in S2.3. The non-plastics make up no more than five–seven percent of the sherds' volume.

The firing temperature of this group is estimated at 700–750ºC (closer to 700ºC) because clay minerals in the matrix are optically active and the crystalline structure of carbonate materials is preserved. Sample 2.3 was fired for a short time; the sherd's core is gray.

The most likely source of raw material for petrographic Group 3's matrix is brown basaltic soil, and the tempers represent wadi sediments from a stream draining an area where chalk, crystalline limestone and basalt are exposed. All of the above may be found in the Jezreel Valley, and therefore, a local provenance may be suggested for the vessels forming this petrographic group (Sneh et al. 1998; Ravikovitch 1969). These vessels show some degree of similarity to those excavated at 'Ein el-Ḥilu, which it has been suggested were locally made (Goren and Shapiro, in prep.: Petrographic Group 5).

Petrographic Group 4

This group includes two samples (see Table 1), characterized by a homogeneous ferruginous and somewhat calcareous matrix with tiny dark brown particles of ferroxide material. Silt-sized grains of minerals derived from basalt and quartz comprise about two percent of the matrix volume.

Temper makes up about 14–16 percent of the S2.1 sherd volume and about 10 percent of S2.4. This temper comprises poly-mineral sand (0.2–0.8 mm). The rock and mineral types are described here in descending order. Rounded to sub-rounded grains of limestone are prevalent. These turned cryptocrystalline during firing, but in some, traces of their biogenic origin are still determinable. There are also several elongated cryptocrystalline fragments, which may be shell remains from the same

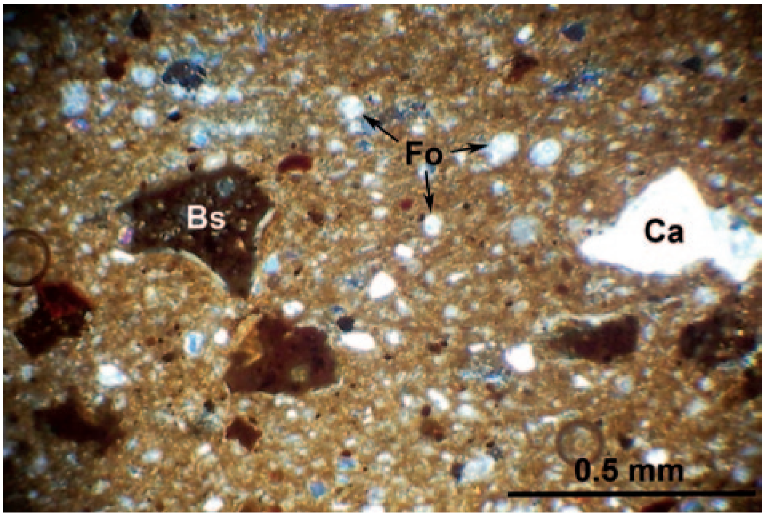

Fig. 1. Microphotograph of thin section S1.1 (storage jar, Petrographic Group 3, Reg. No 1026/2); plain polarized light; Ca = calcite, Fo = foraminifers, Bs = basalt.

biogenic limestone. Rounded to sub-rounded, sometimes elongated grains of olivine basalt, where olivine partially altered to iddingsite, are present in lesser quantities. There are also some rounded to angular grains of chert, phenocrysts of plagioclase and olivine, and rounded quartz grains.

Next in terms of quantity are large (2–3 mm) rounded limestone inclusions, one in each of the thin-sections. Some of the voids seen under the microscope look like negatives of organic material added to the paste, which then disappeared while firing.

The firing temperature for this group is estimated at 800–850ºC: the matrix clay minerals are optically passive (and even show signs of vitrification in S2.4) and carbonate materials in the thin sections are cryptocrystalline.

The tempers characteristic of this petrographic group represent a combination of rock and mineral fragments from river sand, which was collected and sieved, and was then used as the non-plastic component. A main feature of this group is the dominance of limestone, basalt fragments and basaltic-derived minerals. The basalts belong to the alkali-olivine category, where olivine phenocrysts are partially altered into iddingsite. This is typical of the Neogene-Pleistocene volcanics (Williams-Thorpe et al. 1991). Other important components are chert and quartz. Such a mineralogical composition suggests a non-local provenance. The general area where the origin of this group should be looked for can be reduced to the upper and central Jordan Valley (see Goren, Finkelstein and Na'aman 2004:234–237).

Petrographic Group 5

This group is represented by one sample (see Table 1), the matrix of which is a homogeneous, slightly ferruginous calcareous marl containing foraminifers and their debris.

Non-plastics comprise less than three percent of the sherd's volume and may be naturally present in the clay. These are fine-grained (0.1–0.3 mm) and are represented by sub-angular to subrounded grains of limestone, fine sand-sized foraminifers, quartz, chert and aquatic shells fragments. Iron oxide fills the chambers of some foraminifers and/or covers these microfossils (Fig. 2). The identifiable specimens are dated to the Eocene-Paleocene Age. Fragments of

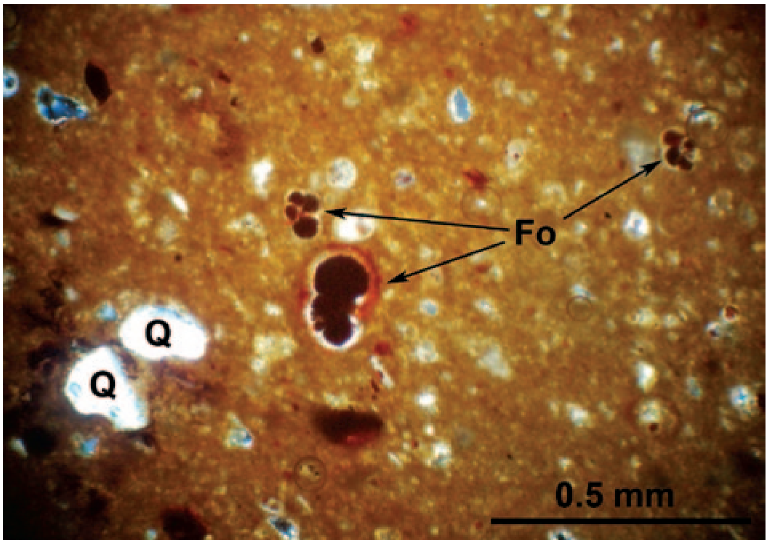

Fig. 2. Microphotograph of thin section S2.6, (flask, Petrographic Group 5, Reg. No 1001/2); plain polarized light Q = quartz, Fo = foraminifers with iron oxide filling/coating.

Amphiroa sp. and one rounded 0.5 mm grain of biogenic chalk are present in the section.

The firing temperature was estimated at 750ºC because the clay minerals of the matrix partially lost their optical properties and because all the carbonate material is cryptocrystalline.

The appearance of the foraminifers under the microscope (i.e., iron oxide filling and coating) is rather different from the micro-fauna of the other petrographic groups. The clay used as raw material for this vessel might originate over Eocene chalk formations and quartz sand. Aquatic shells and especially the presence of *Amphiroa* sp. point to a coastal provenance. Such a coastal area where Eocene chalk formations occur very close to the seashore is found north of Mansuri (southern Lebanon). The discussed vessel was probably imported from there (Sneh et. al. 1998).

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