Ḥadashot Arkheologiyot—
Excavations and Surveys in Israel 134

Appendix: Petrography of Storage Jars From Ẓippori (Southeast)

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Introduction

A petrographic study was conducted on a sample of nine storage-jar fragments—six rims, two bases and one handle (Table 1)—from the small ceramic assemblage found inside and near an installation understood to be a pottery kiln at Ẓippori (Southeast; Fig. 1). The nine specimens date from the first century BCE to the second century CE. In addition to the standard procedure of petrographic analysis (Orton, Tyers and Vince 1993), fresh breaks of the sampled jar fragments were examined under a

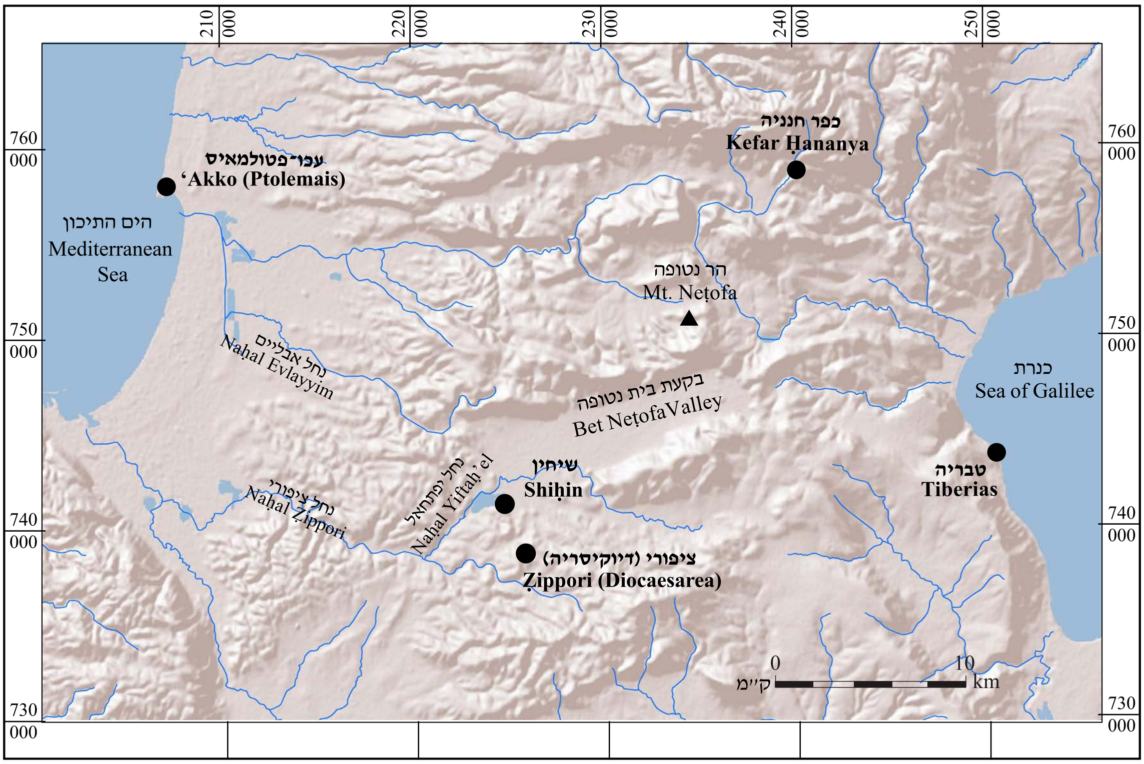

Fig. 1. Map of sites and geographical features mentioned in the article.

Table 1. Inventory of the Examined Storage Jars

No.	Locus	Basket	Part	Color	Firing temperature (°C)	Lithological Group	Fig. 2	Figure in Tzin 2021
1	15	120/1	Rim	Gray	800–900	A		9:11
2	18	133/1	Rim	Brown	700	A	1, 4, 6	9:16
3	18	143/1	Rim	Gray	800–900	A	7	9:9
4	18	143/2	Rim	Gray	800–900	A	5	9:8
5	18	133/4	Rim	Gray	850–900	A	3, 10, 11	Not illustrated, like 9:8
6	18	133/2	Base	Gray	800–900	A	9	10:6
7	18	141/1	Handle	Gray	800–900	A		10:1
8	18	146/3	Base	Brown	700–750	A	2, 8	10:5
9	15	122/1	Rim	Brown	750	B	12	9:12

binocular microscope at magnifications of ×20 to ×40, with the aid of diluted (5%) hydrochloric acid and a steel needle. The main goal of the study was to determine the lithological fingerprint of the jars, and to identify possible sources for the raw materials used in their production.

The installation was uncovered on the western slope of a low hill of Senonian and Paleocene Ghareb and Ṭaqiye chalks (Sneh 2018; personal observation). The chalk is covered with *nari*—a hard limestone crust that forms in the eastern Mediterranean regions over soft marine sediments exposed to pedogenic and biogenic processes (Itkin et al. 2012). The area is characterized by the mountainous rendzina, a type of soil which is not suitable for pottery production. The places closest to the excavation where a clayey alluvial soil can be found are the streambed of Naḥal Ẓippori, about 1 km to the south and southeast of the excavated kiln, and in the valley adjacent to the ancient settlement of Shiḥin, about 1.5 km to the north (Ravikovitch 1969).

Results and Discussion

Two lithological groups were identified in the sampled jars (A, B). Eight of the samples belong to Group A (Table 1:1–8), and only one sample belongs to Group B (Table 1:9).

Group A (Table 1:1–8). The vessels in this group have a ferruginous and calcareous clay matrix, containing 5–10 percent of quartz silt, as well as sporadic silty olivine, plagioclase, hornblende and zircon. This silt is an aeolian dust characteristic of the region, and it is present in all the soils and upper layers of the soft rocks (e.g., clays and marls).

Sand-size inclusions—as defined in petrography—are also clearly seen in the fresh breaks. These comprise 5–12 percent of the volume in each sherd and range in size between 0.05 and 0.4 mm, but are mostly 0.1–0.2 mm. The inclusions are mainly foraminifera (Fig. 2:1, 2), along with ferruginous ooliths, which were observed in several of the thin sections and in all of the fresh breaks (Fig. 2:3);

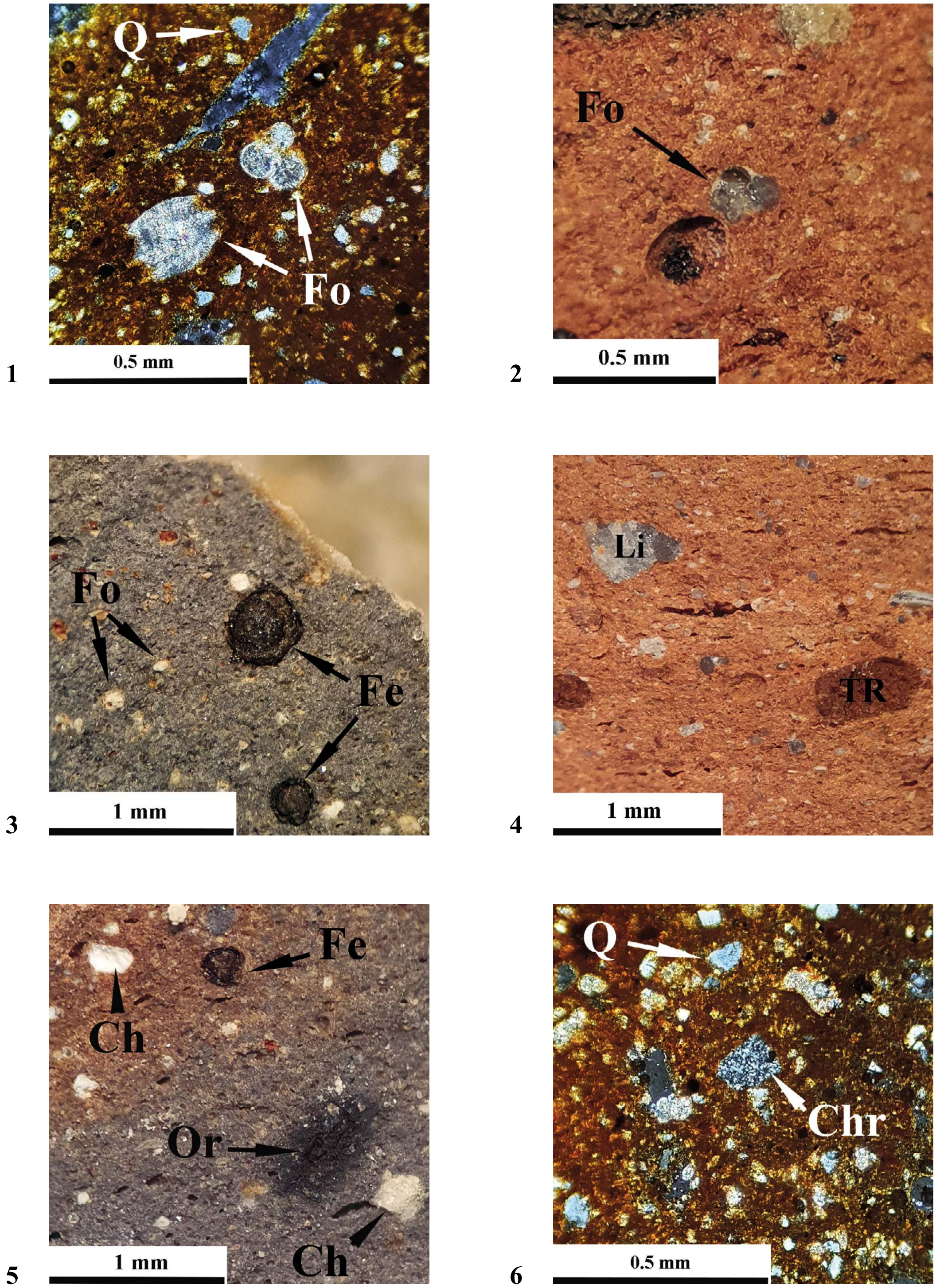

Fig. 2. Microphotographs of the samples' fresh breaks and thin sections in cross-polarized light.

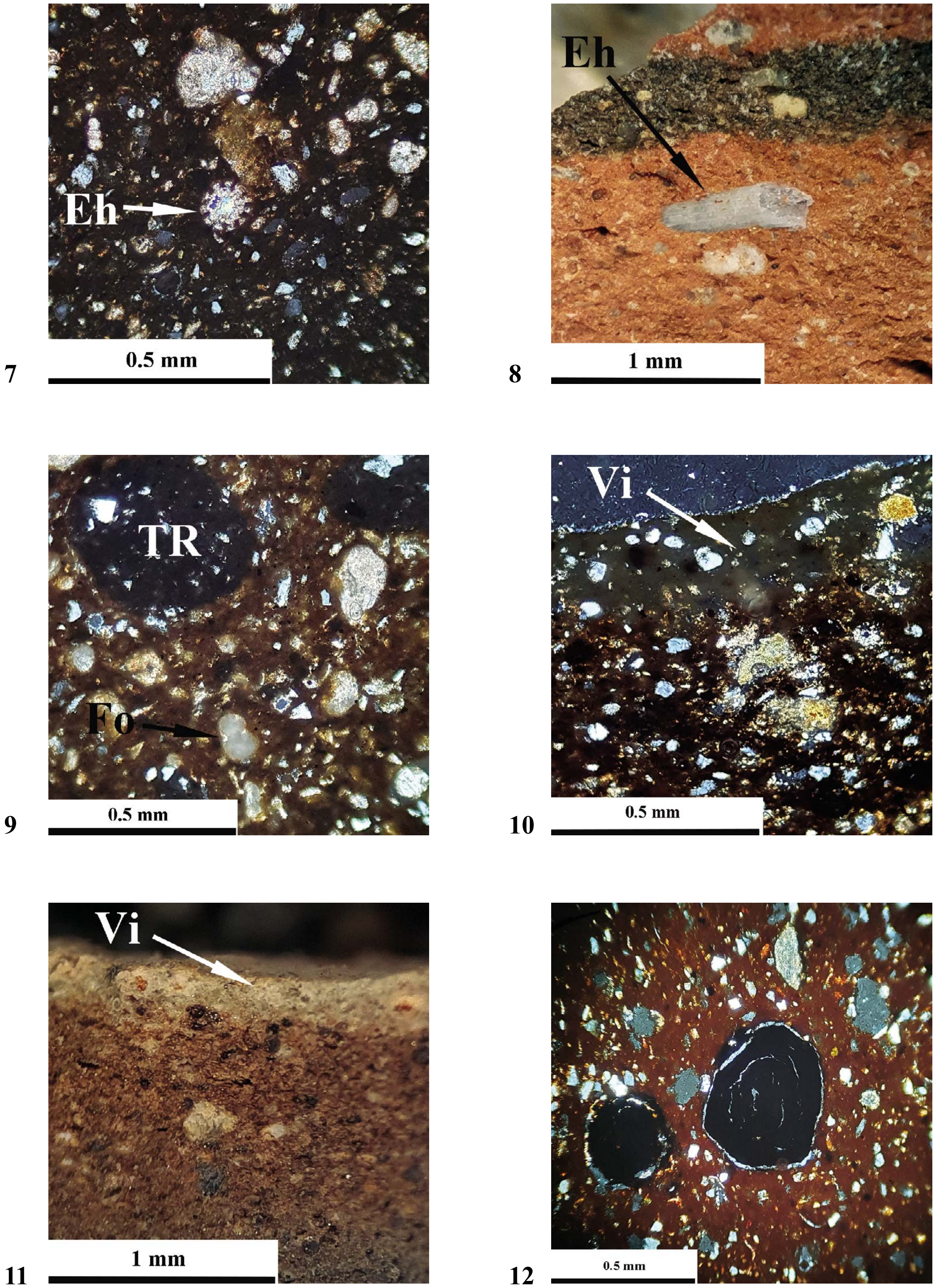

Fig. 2. (cont.).

◂ **Fig. 2.**

Microphotograph No.	Sample No. in Table 1	Description
1	2	Thin section: quartz (Q), foraminifera (Fo)
2	8	Fresh break: foraminifera (Fo)
3	5	Fresh break: foraminifera (Fo), ferruginous oolith (Fe)
4	2	Fresh break: limestone (Li), terra rossa (TR)
5	4	Fresh break: ferruginous oolith (Fe), chalk (Ch), organic remain (Or)
6	2	Thin section: quartz (Q), chert (Chr)
7	3	Thin section: Echinoidea spine (Eh)
8	8	Fresh break: Echinoidea spine (Eh)
9	6	Thin section: terra rossa (TR), foraminifera (Fo)
10	5	Thin section: vitrified surface layer (Vi)
11	5	Fresh break: vitrified surface layer (Vi)
12	9	Thin section: ferruginous oolith (Oo)

crystalline limestone (Fig. 2:4); chalk fragments (Fig. 2:5); chert (Fig. 2:6); fossil shells, *Echinoidea* spines (Fig. 2:7, 8); quartz (Fig. 2:6); and nodules (0.5–0.9 mm) of silty ferruginous soil, most likely, terra rossa (Fig. 2:4, 9). In most of the examined samples, the calcareous inclusions were severely decomposed during the firing, so that those that have survived are a milk-hued chalk (Fig. 2:9). Where these inclusions have vanished, either partially or completely, their volume in the sherd could only be estimated. Elongated and irregular voids in the samples represent organic inclusions; some vanished during the firing, while others partly survived and are surrounded by a dark gray aureole (Fig. 2:5).

Two of the samples (Table 1:2, 8) were fired with enough oxygen at c. 700°C, just slightly below the temperature required for perfect sintering. The rest of the samples in this group (Table 1:1, 3–7) were exposed to temperatures of 800–900°C, which caused vitrification of the clay matrix, resulting in vessels that are too fragile. It thus seems that the firing technology was as follows: most of it took place in an unoxidized atmosphere, and only at the very end of the process was the kiln opened to the fresh air. Such a process, when performed perfectly, produces vessels that, when broken, exhibit gray sherds with a brown exterior; this is one of the characteristic features of the jars produced at Shiḥin, usually observed in breaks. In the case of the six samples fired at 800–900°C, the process resulted in the full vitrification of the exterior surface of the vessels (Fig. 2:10, 11), giving it a whitish hue, and in the strong vitrification of the matrix, which is dark gray to dark grayish brown in polarized light. It can thus be concluded that all the examined storage jars belonging to the main lithological group, both the under-baked and the over-baked ones, can be regarded as pottery production waste, supporting the interpretation that the excavated installation was indeed a pottery kiln.

The closest point with soils suitable for pottery production is about 1 km to the south of the excavation, in the streambed of Naḥal Ẓippori. However, the alluvium along this stream does not contain the ferruginous ooliths observed in the examined sherds (personal observation), eliminating it as a possible source of raw material.

A lithological comparison of both the petrographic thin-sections and the fresh breaks of the samples with typologically similar storage jars produced at Shiḥin, located about 2 km to the north, reveals a very high degree of resemblance. One of the main features in this resemblance is the presence of rare ferruginous ooliths that derive most probably from erosion of the Lower Cretaceous outcrops of the Nabi Sa‘id Formation at the southeastern foot of Mount Neṭofa and carried by running water into the Bet Neṭofa Valley and valleys surrounding Shiḥin (Wieder and Adan-Bayewitz 1999:335–338; Bogoch and Sneh 2014; Shapiro 2017; personal observation). It can thus be proposed that the large-scale pottery workshop at Shiḥin (Adan-Bayewitz 1993:23–25) supplied the potters of the surrounding settlements with ready-to-work clay. This conclusion is further supported by historical sources of the period that attest to the common practice of local trade and transportation of clay balls (“clay eggs”) for the throwing of the vessels (e.g., Tosefta Bava Meẓi‘a 6:3; Adan-Bayewitz 1993:24–25). Such practices explain why it is difficult or even impossible to petrographically distinguish between the pottery produced at the manufacturing center of Shiḥin and the products of neighboring workshops.

Group B (Table 1:9). This group comprises only one storage jar whose lithology is different from the rest of the samples. It has a ferruginous clay matrix, containing c. 10 percent of silty quartz. The sand-size non-plastics observed in the thin-section are ferruginous ooliths (0.2–0.5 mm), with a clear onion-like inner structure (Fig. 2:12); chert grains (0.3 mm); foraminifera cells (0.1–0.2 mm); and irregular chalk fragments. The firing temperature is estimated at c. 750°C.

In general, the fabric of the vessel strongly resembles that of the cooking vessels produced at Kefar Ḥananya, located c. 25 km to the northeast of Ẓippori, and bears much less of a resemblance with the storage jars manufactured at Shiḥin. Furthermore, the traditional Shiḥin products contain smaller quantities of ferruginous ooliths. The presence of the foraminifera suggests a provenance other than Kefar Ḥananya, one that lies outside the vicinity of Ẓippori, possibly at the eastern edge of Bet Neṭofa Valley. However, the jar may be of local production, in which case it could have been made from ‘clay balls’ brought from Kefar Ḥananya, into which local chalk powder was added to alter the clay dough intended for cooking wares into one suitable for producing storage jars.

CONCLUSIONS

The results suggest that the nine examined storage jars were most probably produced at the pottery workshop to which the excavated kiln belonged. However, the lithology of eight of them matches that of vessels produced in the manufacturing center of Shiḥin, and the lithology of the nineth one closely resembles that of the Kefar Ḥananya products. An integrative archaeometrical and historical approach suggests that the sampled jars bear evidence that the excavated pottery workshop was engaged in a local and, apparently, a regional trade network that supplied small, local pottery workshops with raw material from the large-scale manufacturing centers.

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