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THE POTTERS OF FUSTAT (CAIRO) IN 2008: A PRELIMINARY REPORT

Abraham van As, Kim Duistermaat, Niels Groot, Loe Jacobs, Judith Schoester, Nico Staring and Rania Zin El Deen

Abstract

In this preliminary report a short summary is presented of the first results of an ethnoarchaeological documentation project by the Netherlands-Flemish Institute in Cairo (NVIC), executed in cooperation with Leiden University and Delft University, concerning potters of the Fustat area in Cairo. Since 2000 their workshops are being demolished and replaced by new government-built workshops. As a consequence, a traditional potters' quarter will disappear in the near future. When the project started, about ten workshops were still active, of the more than 60 once located in the area. Most of the data described in this report, in which attention is paid to techniques of pottery production, the use of space and the production organization, were collected through fieldwork in November 2008.

Introduction

Nowadays, the potteries of Cairo are located in an area called 'Batn el-Baqara' and 'Fawakhir al-Gedida', situated between the archaeological site of Fustat and the cliffs of the stone quarry to the south (Figure 1). The potteries have a long history. The location of the workshops has changed several times. In the middle ages, the potters were probably active at the edges of Fustat, first built as Egypt's capital by Amr Ibn al-'As in 640 A.D. The pottery workshops, famous for their beautiful glazed pottery, seem to have survived the fire alighted in 1168 in order to keep the city out of the hands of the Crusaders. Later, the potters used to be active in an area near the mosque of Amr Ibn al-'As, north of the present potters' quarter.

In the early 1970s Lucien Golvin, Jacques Thiriot and Mona Zakariya carried out an extensive documentation project of the Fustat potters (Golvin et al. 1982). They documented the techniques of clay preparation, shaping and firing, and provided sketch drawings of all tools, workshop layouts and kilns. In these years, the potters did not produce the once famous glazed pottery anymore. Most of them were then producing 'olla's', water jars that were fired in enormous kilns with two or three floors.

In the years hereafter the Supreme Council of Antiquities fenced off the archaeological site of Fustat, and the potters had to move. Most of them relocated southwards in the present area at Batn el-Baqara. Here, a small NVIC team paid a few visits to

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Figure 1. Overview of the pottery workshops in Batn el-Baqara, Fustat, looking towards the south-west.

them for a short documentation in 1998. They noticed that many changes had occurred over the past twenty years, related to the types of pots, the technology and the production organization (van der Kooij and Wendrich 2002). The production of water jars had stopped, and the potters were making a variety of vessels.

Ten years later, in March 2008, Kim Duistermaat and Niels Groot visited the Fustat potters again. When compared with 1998 much had changed (Duistermaat and Groot 2008: 182, 183). It also appeared that it was one of the last occasions to be able to observe the potters in their present setting. Since the thick black smoke of the potters' kilns causes much pollution, in 1999 the Egyptian government decided to close or relocate the workshops. A year later, the first potters were forced to leave the area. In order to avoid the total destruction of the craft and to guarantee the employment of the craftsmen, the potters' community, with the help of a local NGO (CEOSS), proposed a plan to build modern workshops and housing in the same area. By introducing gas-fired kilns it should be possible to reduce the pollution. After the approval of the plan, one started to demolish the old workshops to make space for new buildings. Those potters who will be able to continue their work will return to the new workshops. However, their work and production organization will undoubtedly change because of the planned presence of gas-fired kilns and electric equipment.

In March 2008 almost all old workshops had already been demolished and the new concrete buildings were under construction. About ten workshops of the more than 60 once located in the area were still active. This situation was a stimulus to begin a new NVIC ethnoarchaeological documentation project at the Fustat pottery workshops (Duistermaat and Groot 2008). The project, sponsored by the Embassy of the Kingdom of the Netherlands in Cairo, is carried out in cooperation with Leiden University and Delft University. The aim of the project is to make a comprehensive description of the techniques of pottery production, the use of space and the organization of production of these modern potters using traditional techniques. These are important aspects to document and safeguard for ethnography and archaeology. Most of the fieldwork was carried out in October and November 2008. The architecture was documented by Dina Bakhoum and her assistants, while Matjaž Kačičnik took care of the photographic documentation. The Dutch team spent three weeks in Fustat. Bram van As and Loe Jacobs (Leiden University) studied the pot making techniques. Niels Groot (Delft University) studied the use of space. Three students of archaeology from Leiden assisted them (Judith Schoester, Nico Staring and Rania Zin El Deen[1]). A visual anthropology student from Leiden University, Floor Breeksema, recorded the work of the potters on film. Kim Duistermaat (NVIC) studied the way production is organized, and Peter Sheehan will provide an overview of the archaeological and historical sources for the pottery craft in Fustat.

In this article we present a short summary of the observations concerning the use of space, the manufacturing techniques and the production organization noted in our diary during our visits to five pottery workshops. We understand a workshop to be an economical and organizing unit owned by one person. A workshop exists of several rooms and open working spaces. In the final publication our observations will be presented in more detail and placed in a historical and (ethno)archaeological context.

Layout and development of the workshops

In November 2008 we studied five workshops that had escaped demolition of the potters' quarter. Workshops 1-3 are located in the east of the area (Figure 2). Approximately 125 meters westwards a row of workshops is situated along a street running from north to south. In this complex only workshops 4 (Figure 3) and 5 were studied.

The quarter at Batn el-Baqara grew significantly during the 1970s when most potters relocated to the present area after the forced evacuation from the archaeological site of Fustat. However, it is possible that the quarter existed earlier. According to the potters at least three workshops – workshop 2 (rooms 2 and 3) and workshops 3 and 4 – are forty to fifty years old. Workshop 2 is a brick building consisting of one room (room 3) and an exterior gallery (room 2). Several brick columns carry a flat roof of wooden beams covered with clay. The building was adapted several times, as is shown by bricked up windows and the closed northern entrance. Also, the large tower-like kiln in the north of the building has been out of use already since ten years.

Workshop 3, constructed in the same period, was also adapted several times. The westernmost room (room 2) consists of walls of stone, which are plastered on the inside and which, together with three pillars and several beams, carry a wooden roof covered with clay. In contrast to the buildings mentioned before, workshop 4 is made of concrete, except for the southern rooms that are made of bricks.

Some years after the construction of workshop 2 (rooms 2 and 3) another workshop (workshop 1) was built nearby. Because of the presence of several types of building materials we may conclude that this workshop has often been restored. Workshop 5, constructed shortly after workshop 4, was often adapted too.

After ten to twenty years, room 1 in workshop 2 was constructed between workshop 1 and workshop 2, rooms 3 and 2. It was built with a variety of materials, using roughly dressed stones and brick to construct the walls. The roof was also made from several materials, including beams, wooden poles, iron and plastic. Even younger is room 4 in workshop 2, which was built only ten years ago.

Besides construction activities demolition of buildings has also occurred. For instance, the workshop described by Wendrich and van der Kooij (1999) has been demolished in recent years. Other workshops made way for the building of the new complexes.

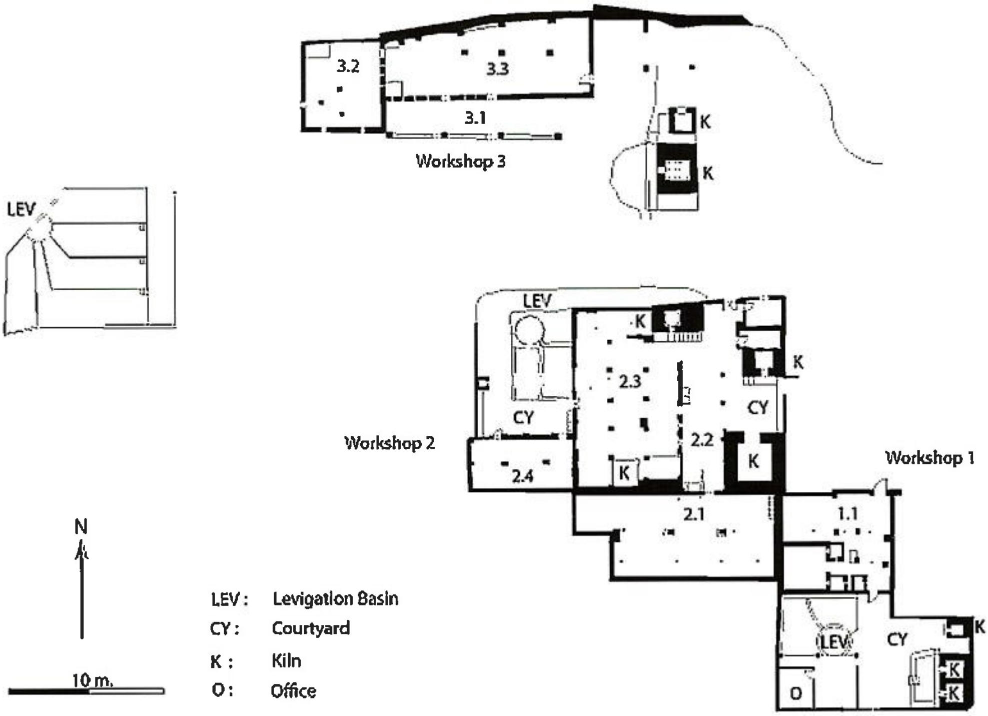

Figure 2. Map of workshops 1–3.

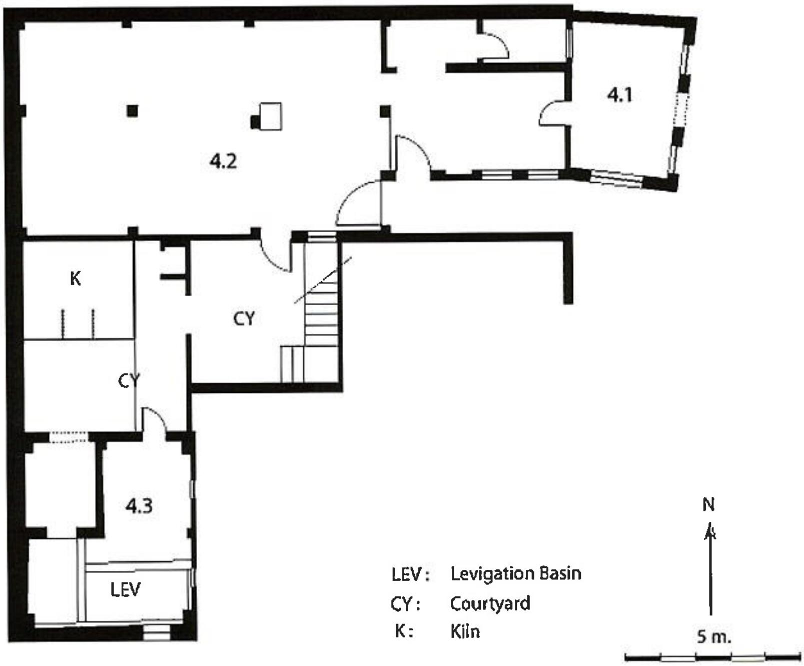

Figure 3. Map of workshop 4.

Use of space and techniques

One of the first observations in November 2008 was that since the short visit of Kim Duistermaat and Niels Groot in March 2008, the use of space inside the complex had not changed much. As in November, in March the potters use a variety of shaping and decoration techniques for the manufacture of garden pots, garden decorations, lamps and decorative pots for use inside. In order to obtain a more complete idea of the use of space and the production sequence of the various ceramic vessels and objects, we visited the workshops on several days at different times of the day.

The use of space and the various manufacturing techniques will be described below per workshop. Apart from a description of workshops 1–4 (Figures 2 and 3), a brief impression is given of workshop 5 (bordering workshop 4 to the north; not on the plan in Figure 3) which we did not visit extensively.

Workshop 1

Workshop 1 consists of a roofed northern building (room 1), which provides access to a southern courtyard containing a levigation basin, a series of kilns and a small office underneath the local mosque. In addition, the space to the north of the workshop is used as an extra activity area.

Use of space

During our visits to workshop 1, it has become clear that the use of space is relatively fixed. When approaching the workshop from the north one first encounters a large heap of unprocessed, quite dry brownish Nile clay, awaiting levigation. Nearby, as well as inside the roofed workshop, pots are drying. Outside, complete vessels are often placed to dry, while inside the semifinished products are put, like pots which are to be closed upside down (see below). Inside the roofed building the central production area dominates the central room. Here the pots are made on fast wheels and decorated on portable wheels. In an adjacent western room the clay from the levigation basin is mixed with dry clay powder. This room serves together with a part of the large room I as a place where large circular heaps of clay are stored under plastic.

In the courtyard filled with fired and unfired objects are two large petrol/diesel ovens, (Figure 4). They are now mainly used for storage. Only a small simple oven is used for firing objects. In the northwestern corner of the courtyard a large and relatively deep levigation basin is situated, in which clay is soaked. To the south of it there is an office.

Techniques

In workshop 1 we got to know the craftsmanship of the 48-year old Karam, who works already in a pottery workshop since he was six years old. He makes pots by throwing them on the fast potter's wheel (Figure 5). The wheel is light, not very stable and does not rotate easily (the wheel has little momentum). Therefore, the potter has to kick the wheel regularly. Karam uses several throwing techniques: throwing from the hump, throwing pots of one single piece of clay and throwing in parts (coils or cylinders).

By throwing from the hump (or throwing from the cone), several small and medium-sized vessels can be made out of one large cone-shaped hump of clay. The clay is worked in a relatively soft condition and shows little coherence (the clay has little 'bones'). With the use of a thread, Karam cuts the small vases from the hump and puts them on a wooden board. As soon as the board is full, the man who kneaded the clay before Karam started to throw the small vases, takes the board out in order to let the vases dry in the sun. Pots made of one single piece of clay are made in two phases. First, Karam throws a pot with a hole in the base. Next, after a drying phase, he puts the pot upside-down on the wheel, throws the still soft clay upwards and closes the base. High objects (a kind of pot stands) are made of cylinder parts. Karam puts a dry cylinder part made earlier again on the wheel. On top, he places a second still soft cylinder, after which he fastens them together by further throwing.

In some cases the pots are decorated. The rims of the small vessels thrown from the hump, for instance, are sometimes decorated with a small wooden roulette wheel. Other pots, which were made by Karam, are decorated by Ahmed. He puts the pots on a kind of turntable, smoothes the outside with a scraper of plastic and provides the rim with a wavy pattern. Next, Ahmed puts the pot upside-down on the wheel, and with a knife he scratches a decorative pattern in the wall. With the use of a wet sponge and a small plastic scraper he finally smoothes the surface of the pot.

Figure 4. Workshop 1: the courtyard filled with fired and unfired objects.
In the background from left to right: a small kiln and two petrol/diesel ovens.

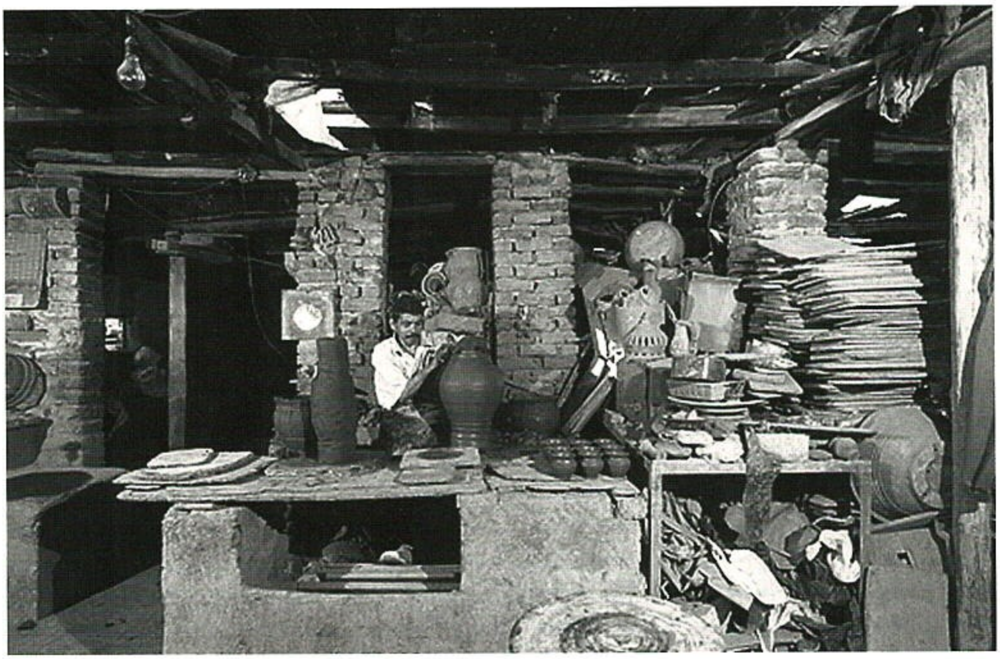

Figure 5. Workshop 1: Karam throwing pots on the fast potter's wheel.

In the courtyard next to the workshop is a clay basin that consists of three parts: a circular water basin, a sedimentation basin and a basin in which one puts the finally well sorted clay. After dry local Nile clay has been thrown into the circular water basin, the basin is continuously filled with water from a tap. Meanwhile, a man steps into the basin. Standing up to ca. 80 cm deep in the water he tramples the clay with his feet and stirs through it with his hands in order to remove the coarsest particles such as small stones. He throws the impurities aside and loosens the clay with a hoe. As soon as most of the coarsest impurities are removed from the clay, he closes the opening between the circular water basin and the adjacent sedimentation basin with clay. Next, he turns the tap off and bails the clay and water with a bucket out of the water basin and throws it through a sieve with a mesh width of three to four mm into the adjacent basin (Figure 6). After a while, as soon as the water level in the circular water basin has fallen completely, he takes the plug out of the opening between the basin and the water basin. Consequently, the water streams back from the sedimentation basin into the water basin. Hereafter the tap is opened and the circular basin is filled with water again. The purification process of the remaining clay starts from the beginning, until all clay is transferred to the sedimentation basin where the purified clay is mixed with powder of red Aswan clay. When the two sorts of clay (local Nile and Aswan clay) are well mixed and have settled down, the clay is transferred to the third adjacent basin. Here the clay stays for some time before it will be moved to the workshop, where the pile of clay waits further preparation. For this purpose, two men begin to trample the clay with their feet after which pieces of clay are taken from the pile. One man tramples these pieces of clay while he mixes the clay with powder of Aswan clay. Next, the clay is brought to a stone table where another man kneads the clay with his hands and mixes it again with powder of Aswan clay. Now the clay is completely prepared and ready to be used by Karam.

During our visits we had the opportunity to observe the entire firing process in the small and simple open updraft kiln. One day, at the end of the morning, Karam and two assistants load the kiln with dried pots of various sizes and shapes. After two hours the kiln is filled. The top of the kiln is closed with a layer of roof tiles covered with a number of sheets of corrugated iron. Karam closes the opening of the pottery chamber with bricks and plaster.

Directly after loading the kiln is alighted. They begin to carefully fire some paper and wood. Next, the fire room is closed with an iron plate. Not much later, new loads of wood are added at irregular intervals until the desired temperature of ca. 900° C is reached. According to one of the men helping Karam to load the kiln, not many people know when the right temperature is reached and one can stop to add fuel. He knows it because of the colour of the flame. In the workshop there are only a few people who are able to fire the kiln. After two to three hours the kiln is at the right temperature. They let the kiln fire during the entire night. The next morning the kiln is still closed, but the firing is completed. The kiln is not unloaded until the vessels are needed or until other vessels have to be fired (Figure 7).

Figure 6. Workshop 1: clay basin in the courtyard. Bailing the clay and water with a bucket out of the water basin and throwing it through a sieve into the adjacent basin.

Figure 7. Workshop 1: unloading the small pottery kiln in the courtyard.

Workshop 2

Workshop 2: room 1

The ground plan of room 1 of workshop 2 of is rectangular, with an extension to the west. Two large columns support a quite flimsy roof of wooden and iron beams. The east-west oriented room can only be entered through a door from room 2. In the north-eastern corner of room 1 is an iron staircase leading to the roof.

Use of space
When entering room 1 of workshop 2 from the north, one is struck by the wide array of activities taking place in this room (Figures 8 and 9). The westernmost part of the room is used for storage of clay brought from the clay basin situated next to rooms 3 and 4 of workshop 2. Here, we find also a smaller heap of fine clay, partly covered with plastic in order to keep the clay moist. Besides a place for storing and preparing clay room 1 includes also two locations where pots are produced. Firstly, two kick wheels are situated against the northern wall west of the door. Secondly, in the eastern part of room 1 we find portable wheels on which mould-made objects are finished and decorated. Room 1 is also used for the first stage of drying. Final drying takes place on the roof of or in room 3.

Techniques
During our visits the wheels are in operation. At the same time a young boy takes clay from the heap to form it into slabs intended for the manufacture of clock-shaped objects in a mould. The finished objects are placed on the shelves against the northeastern wall for drying. The space directly in front of the entire southern wall is used for storage of unfired vessels.

Workshop 2: room 2
Room 2 probably served as a gallery belonging to room 3 leading to a courtyard. After the construction of room 1, however, the gallery became a passage between the two adjacent rooms.

Use of space
Now, no pots are decorated as was the case in March 2008. The space is used as an alley and provides access to the small kiln situated to the east. Across the kiln stands another partially collapsed kiln. In between, a large amount of fuel is dumped.

Techniques
As mentioned hardly any activities take place in room 2. Men and boys walk to and fro through the passage, from the clay basin next to rooms 3 and 4 to the clay pile in room 1, with rubber baskets (*zambils*) loaded with lumps of clay.

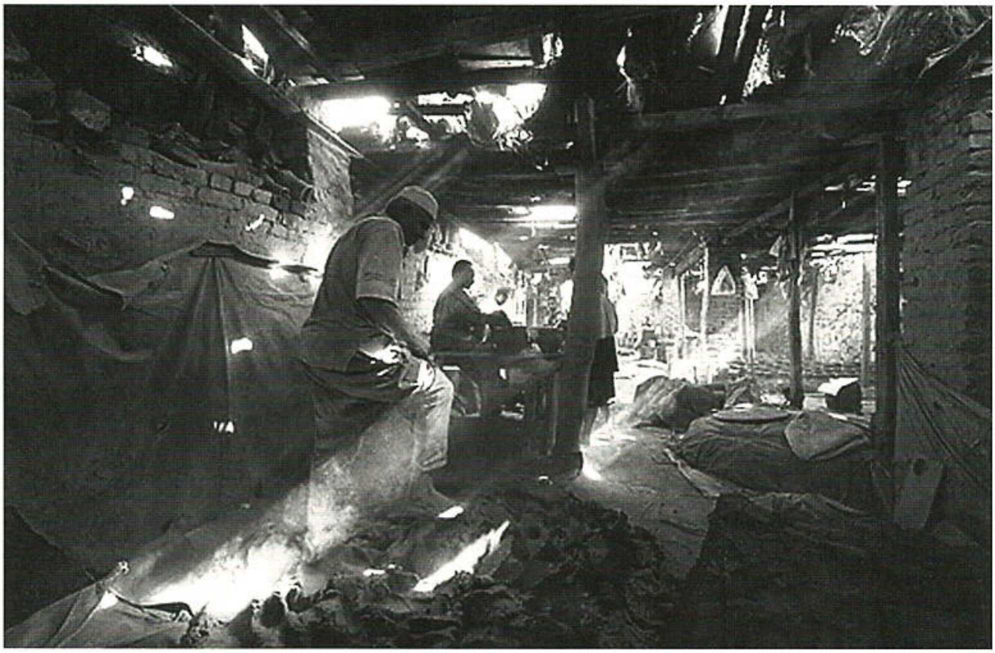

Figure 8. Workshop 2: room 1 (seen from the east).

Figure 9. Workshop 2: room 1 (seen from the west).

Workshop 2: room 3

This complex roofed room is one of the oldest spaces within the workshop. As mentioned before this brick room was adapted several times throughout its existence, which can be discerned by bricked up windows and the former northern entrance. Also, the large tower-like kiln in the north of the building has gone out of use since ten years. It has been replaced by a smaller kiln in the same room (Figure 10). In order to accommodate for this new kiln, the roof over the kiln has been removed.

Use of space

This large pillared room is mainly used as a location for storing many large unfired vessels, awaiting firing or additional decoration. Additional finishing or decoration takes place in the centre of the space, but mainly in the eastern aisle of the workshop. To the south, the new relatively small updraft kiln is partly dug into the ground. The exposed sides of the pit show a superposition of sherds suggesting that prior to the construction of the room earlier pottery producing activities had already taken place. Possibly, the history of the quarter extends even further into time. The three to four years old small kiln has probably replaced the impressive tower-like kiln, which was built together with this workshop. The old kiln, together with a part of the roof, now serves as a storage facility for fired vessels.

Techniques

In room 3 many objects that were made in room 4 are drying. Among these, a woman is finishing the dry mould-made objects by scouring them with a steel brush. In the eastern part of the room, around the door into room 2, a number of men are sitting on chairs behind stands of which the circular plateau can be rotated. They are decorating the high leather-hard objects that were brought in by one of the helpers of room 1, where the objects were made. With a knife they cut decorative patterns of small holes into the leather-hard clay. Per object, the cutting of the holes takes ca. ten minutes. In this tempo two persons decorate ca. one hundred objects per day. In other words, they work ca. eight-and-a-half hours a day. This fits with their saying. One of the men, Alaa, began when he was ten years old and works here for eleven years already. Ibrahim taught him the craft. He has been a potter for thirty-five years now, and makes the high vases that are decorated here.

On one of our visits the (new) small kiln is still hot inside, and completely filled with all kinds of mould-made objects. The fuel of the kiln consists of waste wood of small wooden boxes. During the evening and night before, the kiln was fired until 900-1000° C for twelve hours. The next morning the kiln was opened so that the objects could cool down. To fire one kiln load the potters need ca. 2000 kilograms of wood.

In the courtyard between rooms 3 and 4 of workshop 2 is a clay basin that, just like the clay basin in the courtyard of workshop 1, consists of three parts. Both clay from Aswan transported by boat via the Nile and Nile clay from the direct vicinity of Cairo

Figure 10. Workshop 2: room 3. A small updraft kiln constructed of stone and bricks.

are used. The ca. fifty centimetres thick clay layer in the eastern sedimentation basin is sprinkled with clay powder and loosened by hand. One man and two boys bring the lumps of clay from the basin to room 1.

Workshop 2: room 4

The youngest room of workshop 2 is a ten years old rectangular room measuring ca. 5 x 8 metres. Its walls and two columns are made of brick. The columns carry a roof made of a myriad of materials.

Use of space

In room 4 various objects are made in moulds: horses, elephants, camels, peacocks, frogs and clock-shaped objects to be used for garden decoration (Figures 11 and 12). The working places are situated between the moulds and drying objects that are spread over the workshop. Drying of the objects takes place especially inside the room against the western and northern walls.

Techniques

Three men are working here: Ali, Fuad and Mohamed. Their working hours are from 8 a.m. till 5 or 6 p.m. Everybody has his own task in the manufacture of the mould-

Figure 11. Workshop 2: room 4.

Figure 12. Workshop 2: room 4. Making a mould made object.

made objects: the preparation of the clay slabs, the shaping of the objects in the moulds and the decoration of the objects by scratching and cutting the leather-hard clay. However, it became clear by visiting the workshop on several days and hours that the men in turn carry out the different tasks.

The moulds are made by enveloping a solid clay sculpture with gypsum. They can serve for two years. The larger moulds consist of two or more parts. The slabs of clay are made by placing a large hump of clay on a board with low raised rims and covered with a piece of textile. The clay is pressed with one foot and the superfluous clay above the raised rim is removed with a tool. Finally, the slab of clay is smoothed with a scraper. Before the slabs of clay are put into the moulds, the inside of the mould is sprinkled with dry talc powder. The slab of clay is then pushed into the mould, the surface is wetted with water and some extra clay is added to the rims of the mould. The mould is turned upside-down and then removed. Finally, the superfluous clay of the clay slab is cut away. For the manufacture of horses, elephants, frogs and such-like objects two or more parts of the mould are placed against each other. If the clay does not stay long enough in the moulds in order to harden to some extent, the objects run the risk of collapsing. It is also important that the wall is equally thick everywhere. After a drying phase, the object is put on a turning wheel to be decorated and finished. A pattern of holes is cut into the leather-hard clay. By rubbing the surface with a sponge, the object is finished.

Workshop 3

Workshop 3 is a rectangular 40 years old building constructed of stone and some bricks. It consists of an open gallery (room 1) and two rooms. The square western room (room 2) is plastered on the interior. According to the potters, this serves to keep the clay stored in this room relatively moist. Originally the other room (room 3) seems to have provided access to additional spaces or spaces towards the east. Only some remnants of these buildings were observed now.

Use of space

During our visits room 2 is used for the storage of wet clay. On a bench a set of warped unfired vessels were dumped, possibly for later reuse of the clay. The eastern room is not used. It contains a wheel, moulds and other implements that seem to have been left behind, just like some fired and unfired pottery. The production activity takes place outside in the gallery, where roof tiles are produced as well as on the terrain in front of the workshop, where the roof tiles are laid out to dry (Figure 13).

Techniques

Ahmed is engaged with making roof tiles in the gallery of workshop 3. He places a wet piece of cloth in a metal mould with a raised rim. Next, he takes some clay from a pile

Figure 13. The terrain in front of workshop 3, where the roof tiles are laid out to dry.

of prepared clay lying on the ground, throws the soft clay into the mould and fastens it with his feet. In order to avoid the clay sticking to his feet, Ahmed sprinkles the clay with some dry clay powder. Then, he cuts the surplus of the clay away with the use of a metal thread attached to a wooden frame. Then he lifts the slab of clay together with the piece of cloth from the mould and puts it into another metal mould on his working table. This mould is a solid steel plate bent in the form of a roof tile. The piece of cloth prevents the clay from sticking to the metal mould. With three strokes of a rubber tool, Ahmed presses the slab of clay firmly into the mould. Next, he cuts the surplus clay away with the same cutting tool that he used for making the slabs of clay. He marks the inside of the roof tile with a stamp, indicating the name of the workshop. The roof tile is turned upside-down on a board and the piece of cloth is removed. The roof tiles are laid outside in the sun to dry. As soon as they are almost completely dry the roof tiles are provided with a slip layer consisting of a mixture of iron oxide and clay slip. This gives the roof tiles their red colour and lower water permeability. The wet slip layer is smeared on the tiles with a sponge and finished with a plastic rib. The roof tiles are not allowed to be too dry before applying the slip. Otherwise, the clay slip will not fasten very well to the roof tiles. In workshop 3, also other moulded objects are made. However, no pots are thrown on the fast potter's wheel.

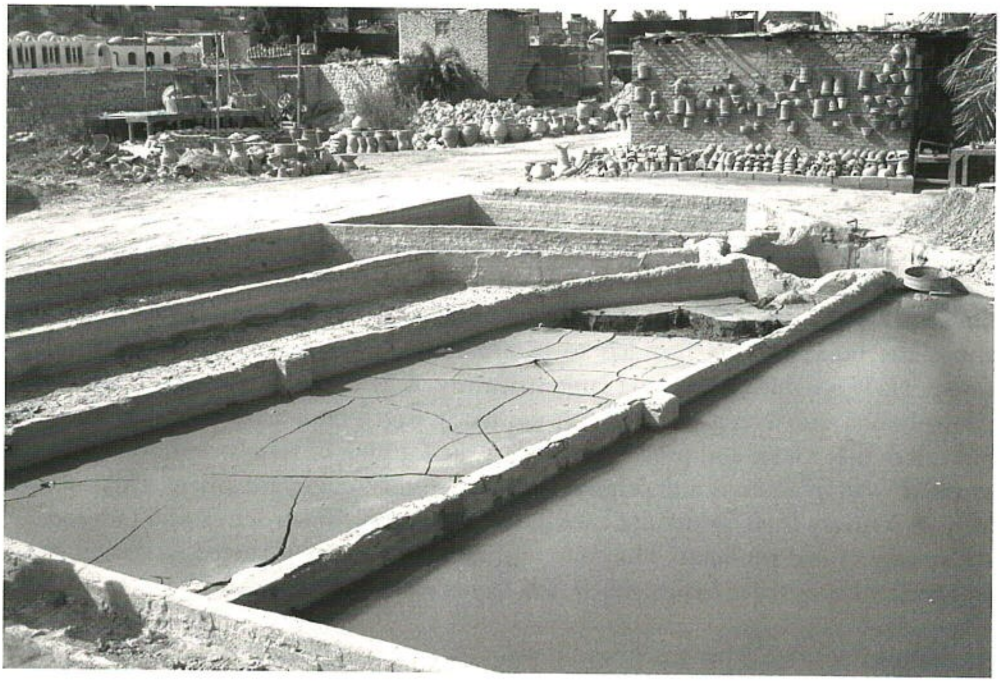

Figure 14. The clay sedimentation basin situated southwest of workshop 3.

East of workshop 3 are two kilns: one kiln with a dome-shaped roof, built against another smaller kiln with a flat roof. Both are updraft kilns constructed of bricks, consolidated with natural stone and plastered with clay. A grid separates the fire chamber from the vessel chamber. These wood-fired kilns last long if they are well kept and regularly repaired. During one of our visits the smaller kiln, which has not yet cooled down, is emptied. A man unloads the roof tiles from the kiln, while a boy takes them in batches of ten to a small truck. Now and then, the man carries roof tiles by the twenty to the truck. He rejects the over-fired roof tiles. The tiles, which will cost 40 piasters each, are loaded on the truck and transported to the distribution location.

Southwest of workshop 3 is a clay sedimentation basin consisting of four east-west oriented basins separated by thin ca. 60 centimetres high brick walls and a smaller north-south oriented water basin (Figure 14). All other basins are connected with the water basin. The water can easily stream into the basins through a small opening. When we visit the clay sedimentation basin, the small basin is filled with half-wet clay. From south to north, the four remaining basins are respectively filled with dry clay, nothing, wet clay, and water. The potters' clay is composed of clay from Aswan and earth from nearby the workshop. After mixing these components in water, the clay is sieved and dried. The settling of the clay takes ca. ten days, in summer only four days. The clay is used for the manufacture of roof tiles and other objects.

Workshop 4

This concrete building complex includes several working spaces and was constructed ca. 40 years ago. The roof can be reached by a stairway in the courtyard, in which a kiln is situated.

Use of space

The space east of the complex close to the entrance is used for the storage of a heap of dry Nile clay. Here also, vessels are placed to dry and fired products are waiting for transport. Upon entering the complex one notices the decorated façade. When one enters the building, one first has to pass a room, used as storage for fired vessels (room 1). It provides access to a large space (room 2) of which the roof is carried by two columns and several pilasters. On the nicely paved floor a range of activities take place, like the storage and processing of clay, the forming of vessels, and drying. In the southern wall of room 2 a door gives access to a small courtyard where a kiln is situated. A stairway leads to the flat roof of the workshop, which serves as a location for the storage of end products. The courtyard also leads to the plastered levigation room (room 3) with its three basins, where the clay is soaked and levigated.

Techniques

The purified settled clay from room 3 is brought to room 2. Here, the clay is trampled with the feet, while clay powder is added. A metal pin is used to cut off pieces of the clay pile in order to be kneaded on a stone table. In the workshop are also two rather light-weighted potters' wheels. The helpers carry and knead the clay, set the pots aside to dry and load the kiln. Elsewhere in an adjacent room somebody is decorating pots. After smoothing the surface of a leather-hard pot, he makes two parallel lines in the clay with help of a pair of compasses. He cuts a rectangular hole in the neck, and with a knife he scratches patterns between the two parallel lines. Next, he smoothes the surface with a wet sponge and sets the pot outside to dry in the sun. After firing, the pot is painted according to the consumer's demand. Finally, the pot becomes a part of a set of three: a standard, a pot and a kind of lid. The pot is used as a debris container, the lid as an ashtray.

In workshop 4 several throwing techniques are observed (Figure 15). Large pots are made in various stages. The debris container, for instance, is made in three phases. First, Hassan throws a pot with a hole in the base. His assistant, Hamdi, places the pot somewhere else in the workshop to dry. After one day, a cylinder-shaped neck is put on top of this pot. In the third phase, the pots are set upside-down on the wheel and a conical base is formed. Various other types of vessels are also made in phases. For the manufacture of an amphora, for instance, first a pot with a thick-walled lower side is made. Then, after a drying phase, the pot is put upside-down on the wheel. With a knife the potter cuts a hole in the bottom and throws the still soft thick clay into the form of a base. Finally, he makes the wall thinner by scraping. Some of the spherical pots made in the first phase are wrapped with rope against tearing during the drying phase. Like in workshop 1, here in workshop 4 pots are also made in cylinder parts.

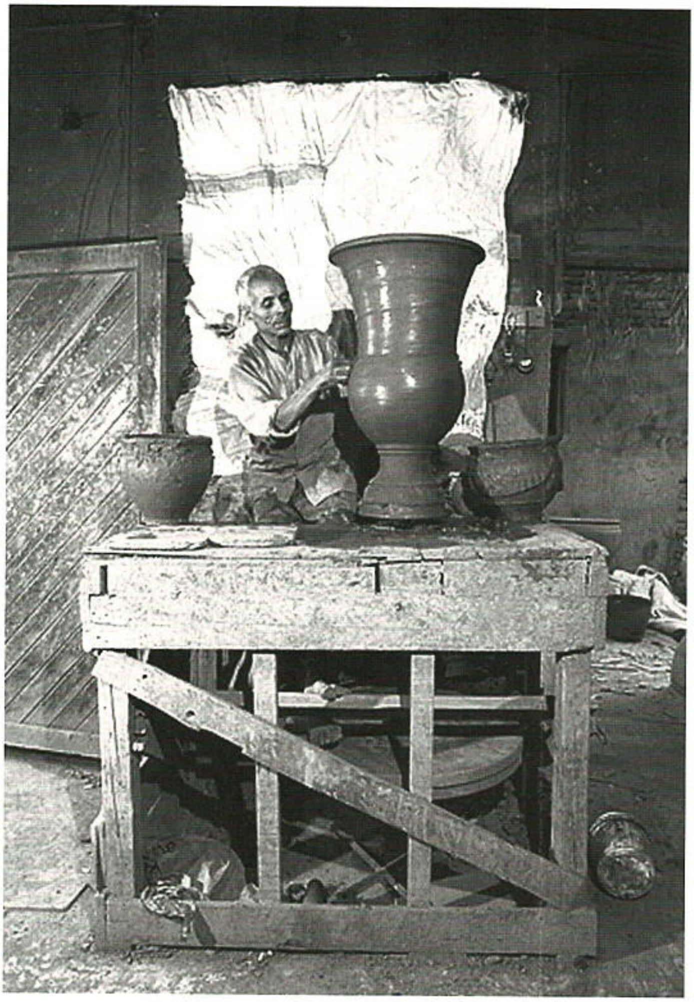

Figure 15. Workshop 4: throwing on the fast potter's wheel.

The kiln in the courtyard is wood-fired. However, a burner using vaporized petroleum is also used during the firing process. The oil is kept in a barrel standing on an elevation near the kiln. A firm blower provides the air supply. In the first phase of the firing process the potters use wood. This fuel enables them to better regulate the temperature. This takes ca. three hours. When the fireman stirs the fire the kiln starts to smoke enormously (Figure 16). Above 600°C, when the water has disappeared from the clay (including the crystal water), they start to use the gas burner as well. The kiln reaches a temperature of 900°C to 1000°C. After three hours of firing at this temperature the kiln is allowed to cool down during one night. The total firing process takes ca. eight hours. The kiln can contain ca. 100 big vessels or 130 smaller vessels.

Workshop 5

Workshop 5 with its dilapidated roof includes clay basins, two potters' wheels and two updraft kilns (Figure 17). Somebody is instructed how to knead the clay. The potters are throwing pots while others are preparing clay (Figure 18) and decorating vessels (Figure 19). A vertical stick with a cross-stick attached at a variable height is fastened with a piece of clay to the tables next to the wheels, and used to indicate the intended height of the vessels. Some vessels are made in phases, for instance by means of placing coils or cylinder parts on top of an earlier made lower part of a vessel. For strength and to prevent collapsing during the throwing of large jars in coils, the jars are wrapped with a rope. The decoration of the large high vessels exists of motifs made of rolls of clay that are fastened on the still soft clay. A woman enters the workshop diffusing a kind of incense in order to drive away the bad spirits.

Post-firing decoration

Post-firing decoration takes place outside the workshops. Outside workshop 5, for instance, fired pots are plunged into an oil drum filled with black colouring-matter. After drying in the sun for a while, the outside of the surface of the pots is painted in red. Finally a kind of white varnish is applied with a brush.

The organization of production

Part of the project specifically addresses issues of production organization, in order to provide context to the information on techniques and use of space. In this way, we aim to contribute to the archaeological study of the remains of pottery workshops, involving the reconstruction of production organization based on material remains. The production organization in the Fustat workshops was studied with the help of a questionnaire. The questions guided the interviews held with the owners and staff of the workshops. The respondents were very friendly and open about their craft and talked easily. However, the course of the conversation and the time permitted during the visits not always allowed for answers to all questions. Moreover, not all workshops could be visited, and not all visits were of similar length. The study is therefore only a qualitative and selective description of various aspects of production organization in Fustat. This first outline of the production organization is based on interviews with the staff and owner of workshop 1, carried out in January 2009.

The workshops in Fustat are by no means a simple household affair. They are part of officially registered, taxpaying commercial enterprises. Workshop 1 is owned by Ali Darwish Ali and his brother Ossama. Apart from this workshop, they own a crusher for crushing sherds and clay to powder, a shop in another area of Cairo (Giza) to sell their wares, another pottery workshop where glazed wares are produced, and a roof tile factory. Moreover, they both are partners in workshops owned by others, investing

Figure 16. Workshop 4: the smoking kiln.

their money for profit. Although the Fustat workshop nowadays looks very simple and poor, it is part of a larger business and is aimed at making a profit. Mr. Darwish Ali is also the head of the Fustat Association for Pottery Production, which aims to represent the potters with the Egyptian government.

Ali and Ossama come from a family of potters and inherited the workshop from their father. Ali's own children, however, are not trained as potters. Ossama's children are younger and do hang around the workshop to carry out simple tasks. When Ali and Ossama were young, the family workshop was located in the area of the Mosque of 'Amr. They estimate that of the people working in the Fustat workshops nowadays,

Figure 17. Workshop 5: one of the kilns.

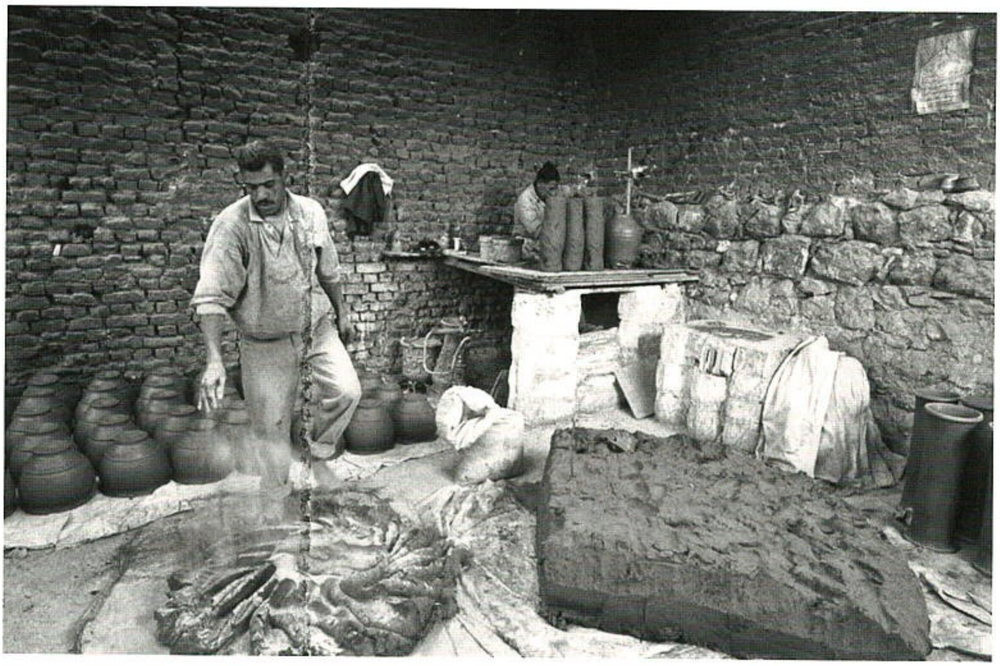

Figure 18. Workshop 5: throwing pots and preparing clay.

Figure 19. Workshop 5: decorating vessels.

about twenty percent come from families without any previous history in the pottery craft. The whole family income of both Ali and Ossama is generated through their pottery business.

The workshop operates on a fulltime basis. They produce year-round, but production is very much depending on the demand. The high season for them are the holidays: Valentine's day, mother's day, and religious holidays, when giving flowers in a nicely decorated pot is customary. In the old days they would produce a surplus in summer to meet demand in winter, because production in winter is slower. Now, the market is more difficult and they stopped doing this. In the old days they made a lot of serial shapes, like drainage pipes or planters for nurseries. Production numbers reached 10,000 pieces per week. Nowadays, their production is both more varied and lower, and hardly reaches 3500 pieces a week.

The employees in the workshop are not related to the owner, apart from the youngest boys. Now there are only men, but in the past women were working here too. They decorated, carried things or sometimes even worked on the wheel. In the past there were about 20 people working in this workshop, but at the time of the survey there were six. All adults work fulltime and derive their complete salary from this job.

Although all workers are able to do most jobs in the workshop, each one of them usually carries out only one or some of these specialized tasks: decorating, throwing on the wheel, preparing the clay, or packing and firing the kiln. They replace or help each other when necessary. Young boys and less talented workers perform simple tasks like clay trampling, carrying the pots or clay around, and cleaning up. Each workshop used to have a foreman dividing the jobs and supervising the work. Now that the workshop has become so small, this is not necessary anymore. Karam, who works at the wheel, organizes most of the work. Ossama and Ali pay daily visits to the workshop to supervise the production. All workers are paid per produced piece: about 7 Egyptian Pound (LE) for one hundred smaller shapes, up to 3 LE a piece for larger ones. The workers who throw pots on the wheel and decorate the pots earn most. The men who prepare clay or carry things around earn according to the number of pieces finished by the potter, since the potter depends on their speed of preparation. Their wages are often half of those of the more specialized craftsmen. The workshop owner or foreman used to count the output every day. Now Karam counts his own output. The worker who operates the kiln gets paid per kiln load. His salary depends on the size of the kiln. Specialized craftsmen such as the potter who throws on the wheel, the decorator or the kiln operator earn about 350 LE (or ca. 65 USD) per week, which is a reasonable working class income in Egypt.[2]

Workers are trained on the job. Most have started their career as small boys. The youngest children can start at about six years, and they come to the workshop after school to watch their fathers and to carry out small tasks. They start with learning how to carry the fired wares and to carry tools and other items needed by others. Slowly, they will participate more and more in the work. When they are interested and show some talent, they will be trained on the wheel or in decoration. Karam started when he was six years old. He made his first shapes on the wheel at twelve, and was able to do any job in the workshop at around twenty years of age. The children earn a small weekly wage irrespective of production numbers.

Workshop 1 uses three kinds of clay: Aswanli (from Aswan), ball clay (also from Aswan) and local clay from Cairo (called 'tafla'), mined in the area of the Suez road. Although Ali says a proper potter should control the whole process from raw materials to end product, they now procure the clays from a third party. They use between five and seven tons of clay a week. The kilns are fired on wood or diesel. The wood is bought from carpenters, who sell scrap wood per bundle. The workshop uses ten bundles per week. The diesel is bought in barrels from the local gas station; they buy one truckload or 5000 liters per week. Other minor expenses are electricity and water.

Nowadays, most products made in workshop 1 are pots used for plants and garden decoration, such as lanterns and stands. Many are lavishly decorated with cut-out shapes, incised and applied decoration. Workshop 1 sells its products through various channels. The largest market is made up of flower shops in Egypt, selling dry, plastic or real flowers and bouquets. Another large part of the production is sold to touristic projects and holiday villages or hotels, for garden decoration or sometimes as 'ethnic' table ware. The pottery is not sold directly to the hotels, but to middlemen who come to Fustat and buy large quantities on order after comparing offers from different workshops. Workshop 1 also exports pottery abroad, for example to the UK, France, Germany and the Netherlands. Most of the export is done through middlemen. Wholesale markets and shops are another market. Minor amounts are sold to individuals passing by, and to the shops located on the street side along the workshops in Fustat. Workshop 1 regularly produces quantities of pots on order. Actually, the shapes and decoration of the pottery are completely dictated by the customer demand.

The production organization survey covered each of these topics (organizational structure, economics, family relations, labor organization, training, raw materials and costs, and markets) in more detail than can be presented here. Furthermore, information was collected on the output of production: shapes, standardization, quality, the use of potter's marks, etc. This information, as well as information on the other workshops and a comparison between current and past situations will be presented in the final publication.

Epilogue

In this article, the authors have restricted themselves to a short preliminary description of the techniques of pottery production, the use of space and the production organization of the Fustat potters observed in 2008. It was the last opportunity to document the traditional potters' activities in Fustat before they will face major changes in the near future. In the final publication of the project we will present more detailed information and set our data in a historical-archaeological perspective.

Acknowledgements

We cordially thank the potters of Fustat for their warm welcome and willingness to friendly answer our many questions and to tell us all about their work, even when the whole group was roaming the area with their cameras. We wish them all the best for the future when they will have left their old trusty workshops and have started to continue their craft in new circumstances. We also wish to thank mr. Ali Darwish, owner of one of the workshops and chairman of the Fustat Association for Pottery

Production for his helpful cooperation and providing us with useful information. We are very grateful for the funding by the Embassy of the Kingdom of the Netherlands in Egypt that enabled us to carry out the NVIC-Leiden University Fustat Potters Project.

Notes

1. Rania Zin El Deen acted as Arab-Dutch interpreter.

2. According to the International Labor Organization, the official average wages in manufacturing in Egypt were 220 LE per week in 2007 (http://www.ilo.org/global/What_we_do/Statistics/lang–en/index.htm, last accessed on 25-1-2009).

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A SIMULATION EXPERIMENT IN THE CONTEXT OF A TECHNOLOGICAL STUDY OF LEVANTINE IRON AGE CLAY LOOM WEIGHTS

Jeanette H. Boertien

Abstract

Archaeological classifications of clay loom weights are usually based on morphological criteria. In this article on the Iron Age loom weights excavated at Tell Deir 'Alla in Jordan attention is paid to a technological approach of the study of these artefacts. Like in technological pottery studies, this approach focuses on the reconstruction of the manufacturing technique based on the interpretation of technical characteristics followed by a simulation experiment. It gives an explanation for the various morphological loom weight types.

Introduction

In the ancient Levant actual textiles are hardly found, due to adverse soil and climatic conditions, but some artifacts tell the story of textile production. The most important of these are loom weights, used to stretch the warp threads of the hanging vertical loom. These weights were made of stone or clay and are left in the archaeological record. The warp weighted loom can be traced through the recovery of loom weights, usually the only element of the loom that survives.

The warp-weighted loom is a hanging loom on which the loom weights were tied to stretch the warp threads (Figure 1). The looms consisted of two vertical wooden poles linked at the top by a horizontal beam from which the warp threads were hanging. The strands held under tension by the weights, could be lengthened, thus enabling pieces of cloth to be woven, which were far longer than the height of the loom. The work progressed from top to bottom, the cloth being rolled around the upper beam (Barber 1991: 106; Cecchini 2000: 212). Each loom weight was fastened to a bunch of warp threads using a loop in between. The extra warp could be rolled up or looped and tied. One could even wind it around the loom weights (Barber 1991: 106; Hoffmann 1974: 65–66 and 72, fig.32). The possibility of rolling up the finished cloth and the easy way the warp could be lengthened made the warp-weighted loom very popular. No stools or benches were needed to make a long piece of textile, while patterns could easily be woven into the flexible weft which made it much more practical than the fixed vertical loom known from Egypt.

The use of the warp-weighted loom was an innovation in textile production that started in the Neolithic in southeastern Europe. From here it spread to the northwest

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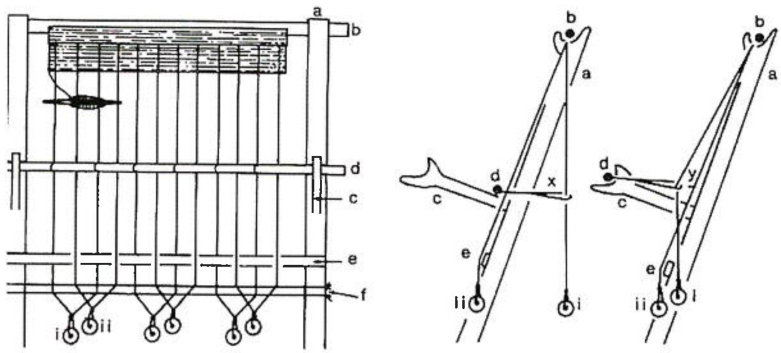

Figure 1. The warp-weighted loom.

and south. Via Greece and Anatolia it came to the Levant. Here the warp-weighted loom was used from the Bronze Age till the end of the 1st century BC.[1]

Nowadays, warp-weighted looms are not used any more. For the reconstruction of the functioning of the loom-weights we depend on documented information from 20th century Scandinavia, where the warp-weighted loom was still in use until about 1950 (Bender Jørgensen 1996; Hald 1946, 1980; Hoffmann 1974; Raeder Knudsen 1998).

Levantine clay loom weights

Levantine loom weights are usually made of clay. Their weight and shape vary over the ages. In the Bronze Ages the loom weights are conical, dome- or cigar-shaped and made of intentionally fired clay. During the Iron Ages the amount of loom weights increases. Now, the loom weights are made of unfired local clay. The pre-dominant group in this period is the donut-shaped loom weight. Unfired clay loom weights were often incidentally fired by the conflagration that destructed the villages. In the Persian period the loom weights change in form, they are slightly pyramidal or oval, and donut-like weights are not found any more. While during the Hellenistic period the weights decrease in weight, the form changes to small pyramidal, rectangular or small spherical balls and they are slightly fired.

The weight of a loom weight is important for the weft, but the form of the loom weight does not influence the weaving process. The shape seems to be based on tradition and not on the functioning of the loom (Boertien 2004: 323). Loom weights do offer a window into the life of ancient artisans, answering questions of where they worked, what tools they used and what products they manufactured (Friend 1998: 11). Loom weights are the main key to the study of textile production in the Iron Ages in the Levant. For this reason, it is important to make a clear and distinctive typology.

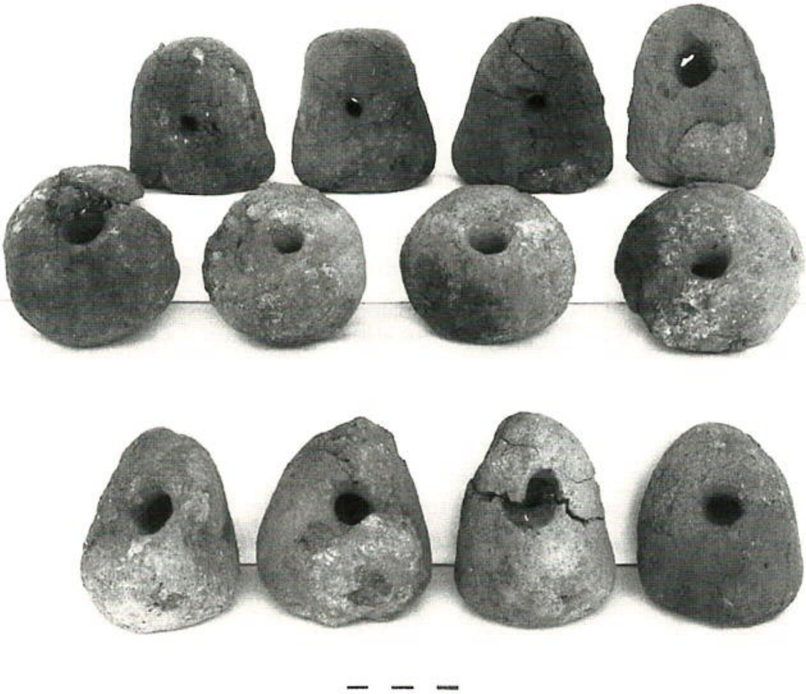

Figure 2. Loom weights from Iron Age Deir 'Alla.

Typology of clay loom weights

Typologies of loom weights are usually based on the well-known morphological typology designed for beads: *A Classification and Nomenclature of Beads and Pendants*, published by Beck in 1928.[2] Until now, no classification based on technical criteria has been published. Inspired by archaeological-technological pottery studies, I decided to make a study of the manufacturing technique of a number of Iron Age clay loom weights of Tell Deir 'Alla in Jordan (Boertien 2004). So, I tried to find an answer on the question whether there is a relationship between the form and weight of the loom weights and the way in which they were manufactured and used (Figure 2). In this context a simulation experiment was carried out.

The simulation experiment

The simulation experiment was based on the study of 588 Iron Age clay loom weights from Tell Deir 'Alla in Jordan. The experiment with local clay was carried out in 1999 when the temperature was 18-25° C. Twenty-two loom weights were made. The following description of the experiment pays attention to the clay that was used and the production sequence.

The clay

Information about local pottery fabrics was gathered because it seemed logical that local clay was used to make the loom weights. The clay from Deir 'Alla has been described by Franken and Kalsbeek (1975), Franken (1992) and by Groot (2007). The fabric is characterized by the presence of clay particles, which are a form of mudstone. These mudstone-particles, generally a reddish/brownish color, do not fall apart completely when soaked or when mixing was insufficient (Franken 1992: 106–107; Groot and Dik 2008: 106). This typical clay is referred to as *banded clay* (Franken 1992: 106–107). Groot (2007: 100) describes the local clay source as a part of the Damya/ Lisan formation, consisting of a sequence of differently colored clay layers. He distinguishes three types of fabrics:

Type 1 characterized by a high percentage of non-plastics, such as quartz sand, mudstone and a high amount of fiber.
Type 2 characterized by mudstone and lime.
Type 3 characterized by small elements of lime and some mudstone; this might indicate a better levigation or deliberate choice of Damya clay.

The Damiya/Lisan formation is easily accessible, due to the presence on one of the natural outcrops at Tell Deir 'Alla. (van der Kooij and Ibrahim 1989: 76). A thick layer of this clay is still accessible about 1,5 km east of Tell Deir 'Alla along the river Zerka. The 588 loom weights of Tell Deir 'Alla show the typical Damya/Lisan clay. The fabric as studied by Groot (2007) shows interesting similarities to the fabric of the loom weights. Type 1 is the most common type for loom weights (n = 321; 54.7%), followed by type 3 (n = 132; 22.4%) and a fabric with (lime) stone inclusions varying between 4 and 15 mm (see Figure 5) (n = 117; 19.9%). Next is type 3 (n = 132; 2.2%) followed by grog temper (n = 5: 0.8%).

The loom weights often include organic material and sand together with small and large stones. The clay was probably not specially cleaned or selected before it was used for the manufacture of the loom weights. Most of the loom weights (77.6%) are made of unselected clay from the Damya/Lisan formation, while a smaller group (22.4%) is made of selected (levigated) yellow clay. The simulation experiment was carried out with local unselected banded Damya/Lisan clay: both a well kneaded and a not so well kneaded. No extra mineral tempering material was added to the clay.

The production sequence

Collecting the clay

The clay used for the experiments is the local banded Damya/Lisan clay found in the close vicinity of Tell Deir 'Alla. The clay was not specially selected. Stones, sand and organic materials were left in the clay.

Crushing the lumps of hard clay
Because of the presence of un-dissolved clay particles in the clay, crushing was needed to make a workable mixture.

Adding water to make a workable clay mixture
The ancient loom weights show signs of being made of a dry clay mixture. Therefore, in the experiment the clay was kept rather dry. For some models, however, more water had to be added during the forming process.

Kneading the clay
A small number of smooth structured loom weights were made of nicely selected and thoroughly kneaded fine clay. Most loom weights, however, were made of clay including various amounts of big stones and sand or organic material. In the experiments two series of loom weights were made: (1) with the use of slightly kneaded clay (9 loom weights) and (2) with the use of well and thoroughly kneaded clay (13 loom weights).

Preparing the clay balls
Each piece of clay weighed about 350 grams. This is the average weight of the Iron Age loom weights (Shamir 1996: 140).

Shaping the loom weights
In the experiment different forms were made.

Conical form – A piece of clay on the left palm of the hand was pressed together with the fingers and thumb of the other hand into a conical form with a rounded bottom (Figure 3). The conical loom weights with a flat bottom were made on a flat underground (Figure 2 upper row).

Beehive form – The beehive form was made like the conical form. The bottom and upper part, however, were flattened. This type always has a very small perforation half way the loom weight (Figure 2; upper row second from left). An intrusive was attached to the weight such as a stick or a rod to fasten the warp threads to the loom weight (Davidson and Thompson 1943: 68 fig.30; McLauchlin 1981: 74; Shamir 1996: 147).

Donut form – The donut form loom weight was easily made by winding a coil of clay around a finger. This gives a donut form with a diameter of max. 6-9 cm. (Figure 4 and Fig. 2 middle row) A coil of about 15-18 cm and 3 cm high could still be worked around the finger, but longer or thicker coils were impossible to be used in this way. Big loom weights of this type, (with a diameter over 9 cm) were made in a different way. In this case a spherical piece of clay was perforated with a stick. The donut was smoothed with wet hands to make a regular form. If clay was pressed out of the hole at one side, this clay was pressed away on the surface donut.

Figure 3. Forming the conical loom weight.

Figure 4. Don't-shaped loom weights.

Spherical form – Although Friend (1998: 9) suggests that "the ball shape was easier to make", it appeared to be rather difficult to form a clay ball of 350 gram into a real good and smooth spherical shape (Figure 5). In addition, perforation with a stick deformed the spherical clay form. During the drying process the spherical forms easily developed deep cracks. Later, these cracks could be repaired as soon as the clay became leather-hard.

Cylindrical form – Working on a hard surface a spherical form could quickly be rolled into a cylindrical form (Figure 6). It was not easy to perforate the cylindrical-shaped clay.

Wheel form – In order to form a wheel-shaped clay weight (Figure 7) first a clay ball with a stick in the centre was placed on a hard surface. Next, the clay was pressed in the direction of the stick and made flat around the stick (Figure 8a). Then, the stick was tilted. By rolling the wheel over the surface (Figure 8b) the weight was nicely smoothed. At the same time, the perforation widened into a conical form. By pulling out the stick the loom weight got its typical truncated top. The form often became asymmetrical. The wheel form appeared to be a quick way of making a loom weight. Since the wheel-shaped clay weights are thinner than the spherical and cylindrical weights there were not many problems during the drying process.

Mixed forms – Of the 588 studied loom weights 30 ones (5.1%) show mixed forms (Figure 9). These weights are 5 to 7.5 cm in diameter; the hole is 2 cm in diameter. Experimentally, a mixed form appeared to be a form that can be explained as the result of a combination of two basic forming techniques or a basic forming technique and a final finishing technique. One huge loom weight has also a mixed form.
The following combinations of techniques can be distinguished (see Table 1).

Spherical worked out as a cylinder	n = 9
Spherical worked out as a wheel	n = 2
Donut worked out as a cylinder	n = 6
Donut/ wheel	n = 5
Donut/spherical	n = 2
Donut/conical	n = 2
Wheel/cylinder	n = 1
Donut/cylinder/wheel (three in one)	n = 1
Donut/cylinder/spherical (three in one)	n = 1
Donut/triangle (huge weight)	n = 1

Table 1. Thirty loom weights with a mixed form indicating various combinations of techniques.

Figure 5. Spherical loom weight.

Figure 6. Cylindrical loom weight.

Figure 7. Wheel-shaped loom weights.

Figure 8a. Shaping the wheel-shaped loom weight.

Figure 8b. Making the wheel.

Figure 9. Mixed forms.

Perforating the loom weights
The hole in the loom weight can be made in two ways. While making the object a coil of clay is wrapped around a stick or a finger, or the hole is made afterwards by perforating the weight with a stick. We can distinguish between a horizontal perforation above the middle of the weight, and a vertical perforation in the middle of the weight seen in most donut-, spherical-, cylindrical- and wheel-shaped weights. The horizontal perforation results in the pendant form, as seen in the conical and beehive shaped weights. The use of a stick from one side often gives characteristic traces (Figure 10). The size of the perforation depends on the way the hole is made. Before the stick is taken out of the weight it can be turned around (Figure 11). This often results in a hole with a conical form at one side. The perforation from two sides leaves typical traces inside the loom weight. Perforations wider than 2.5 cm in diameter are always made from two sides in all types of loom weights made with a stick or formed around a finger.

Smoothing the surface
When leather-hard, the clay weights can easily be smoothed with wet hands. This way, small cracks can be mended.

Drying the loom weights
To prevent drying cracks the thick clay loom weights have to dry slowly. Therefore, drying in the sun as described by Macalister (1912: 73), Shamir (1994a: 37, 1994b:

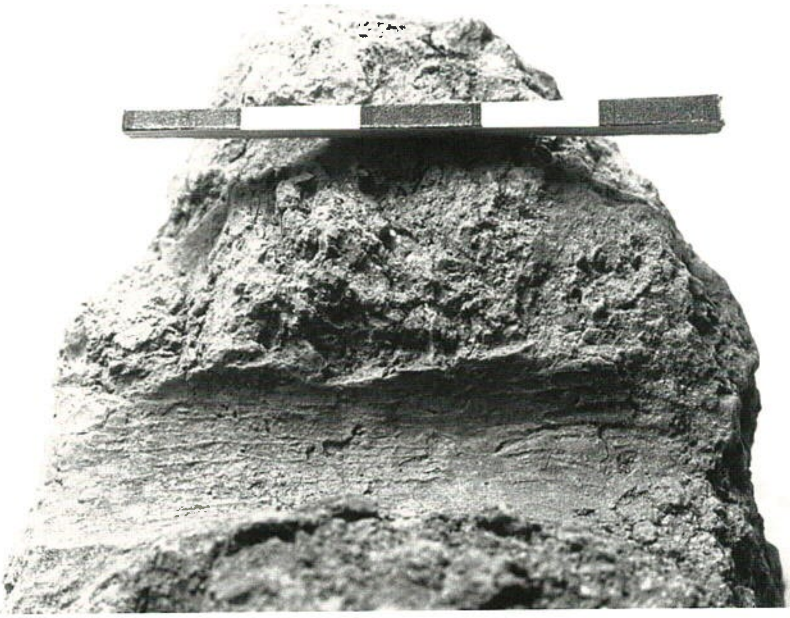

Figure 10. Conical loom weight showing traces of a stick.

Figure 11. Donut-shaped loom weight showing traces of turning a stick.

270[3], 1996: 136) and suggested by Bienkowski (1995: 89) is impossible. Drying has to be done in the shade as potters do with their pots. The loom weights in the experiment were dried in the shadow. After two days they were turned over. At a temperature of 18-25 °C it took 8 days for the weights to dry thoroughly. Even during the slow drying process in the shade, the thick loom weights cracked. Very deep cracks appeared, especially in or around the perforation in the spherical and cylindrical weights. The form of the drying cracks match with drying cracks in pottery cracks in pottery (Rye 1981: 66 and figure 46). The edges of the cracks tend to be irregular, frayed, and rough. Unfired loom weights disintegrate when getting wet (see also Shamir 1996: 136; Hoffmann 1974: 314).[4]

The use

The next part of the simulation experiment concerned the use of loom weights. During several hours threads of wool and linen were pulled through the different types of loom weights. Like in the experiment of Orit Shamir (1996: 143) no clear traces were visible under a magnifying glass. Because loom weights do not move that much on a loom it will take a very long time to produce grooves of usage, even in unbaked weights. The traces found in the loom weights of Tell Deir ʻAlla show that they have been used very intensively and for a very long period. Usage gives a smooth broad curve at one side of the weight. Here, the weight pulls the bunch of threads due to gravitational pull (Figure 12).

Figure 12. Loom weight with wear.

Clay loom weights under fire

Many of the clay loom weights from Tell Deir 'Alla were fired after an earthquake (van der Kooij and Ibrahim 1989: 82). In this context, an experiment was carried out. Eight loom weights were fired in an open fire for 1.5 hour at max. 1000° C. Afterwards, the loom weights were kept in the hot ashes for another half hour. In the firing process the organic material burned out and resulted in mottled colors typical for an open fire, varying from red, brown to black. Most of the weights did not collapse in the fire, even the ones made of slightly kneaded clay. Like in the controlled firing experiment at 970° C of Albright (1943: 118), some weights became brittle due to the high peaks in temperature of the open fire.

Conclusion

From a technological point of view we may conclude that the unfired Iron Age loom weights of Tell Deir 'Alla were made of local banded Damya/Lisan clay. It is difficult to say whether tempering material was added to the natural clay. As appeared from the simulation experiment, the various shapes of the loom weights can be explained by the forming techniques that were applied. The various classes of loom weights in the morphological classification of a 'splitter' can be reduced in a technological classification.

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Notes

1. Shamir (Mazar 2006: 480) mentions the beginning of Middle Bronze Age II as the starting point of this weaving tradition in Israel, but Friend (1998: 9) dates some loom weights from Tell Taannek to the Early Bronze Age III. Cecchini (2000: 213) studying the material from Syria concludes the Bronze Age being the period in which the entire Levant started to use the warp-weighted loom.

2. In the literature about this subject most authors base their typology on Beck 1928: Orit Shamir 1996: 136 mentions Beck as her typological source, resulting in 14 different types. Glenda Friend does not mention Beck but she based her typology on the work of Shamir (Friend 1998: 1) she describes 19 different types of loom weights (Friend 1998:71).

3. Shamir performed an experiment and concludes that "35 loom weights were formed from terra rossa clay, and laid in the sun. An average temperature of 25–30 degrees Celsius was sufficient to rapidly dry loom weights of adequate quality."

4. This experiment was based on personal communication (1996) with Loes Dumas, object registrar Tell Deir 'Alla project. She told that when a bucket with unfired loom weights was by accident left in the rain, after a day this bucket turned into a bucket filled with clay.

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TIMELESS POTTERY TRADITIONS AND ORGANIZATION OF THE CERAMICS INDUSTRY IN ANCIENT JORDAN AND ISRAEL: A CASE STUDY FROM TALL HISBAN AND TEL JEZREEL

Gloria A. London and Robert D. Shuster

Abstract

Grog and limestone inclusions characterize certain painted pottery in Israel and Jordan throughout antiquity. A study of Iron Age through medieval period sherds from Tall Hisban (Jordan) shows a preference for grog in painted pottery. Specific temper types and differences, within a single assemblage of ancient pots, can clarify organization of the ceramic industry. Temper type also informs on pot usage. The purposeful use of grog and limestone tempering materials presents a long-standing solution to problems potters faced throughout history in the region.

Introduction

Pottery excavated at an individual site inhabited for millennia offers opportunities to examine ceramic change and continuity through time at a specific location. In addition to diachronic changes in vessel shape and surface treatment, other questions of interest concentrate on how and where pots were made, how they were used, and why they look as they do. Two separate studies of Neolithic – Iron Age pottery excavated at Tel Jezreel in Israel and Tall Hisban in Jordan (Figure 1) include pottery that spans 12,000 years. The study of ceramic technology examines the single most abundant ancient container and their makers. Both are central to learn about ancient society.

Raw materials and clay preparation in the Levant

Clays found in the coastal and interior eastern Mediterranean lands tend to contain a variety of rocks and minerals. Wind and water contribute to the dispersal of clay particles such that ancient potters would mine clay deposits together with rocks and minerals. These secondary clay deposits, found at some distance from their parent rock, differ substantially from primary clay deposits which can be pure, clean clay as found throughout the central Mediterranean, including Crete, Cyprus, and Greece. Primary and secondary clay deposits each present challenges as well as certain advantages. Painted and otherwise decorated wheel thrown pottery from Mycenae, Crete, and Cyprus surpassed eastern Mediterranean pottery in terms of aesthetic appearance. In

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Figure 1. Location of Tall Hisban and Tel Jezreel.

contrast, the rougher clays of the Levant and interior lands were ideally suited for the coil made container storage jars which carried agricultural products west along the sea routes for wide scale distribution to Europe and Africa.

Despite inherent limitations of secondary clays, potters in ancient Jordan and Israel at times successfully manufactured carefully painted pottery, with strong bright hues and crisp lines aesthetically pleasing to our modern eye. Other decorated products, however, show dripping paint and blurred, muted colours under a milky film layer, as in the late second millennium B.C.E. (Franken and London 1995). In order to create well-painted wares using secondary clays, potters were obliged to manually clean the clay by removing some or all native rocks, minerals, and extraneous organic material mined together with the clay. Removal of the unwanted and largest inclusions was only the initial stage of a lengthy cleaning process. Wet or dry clay would then be pushed through a basket or other sieve to remove smaller rocks. Unless small undesirable rocks were eliminated they posed risks during all stages of manufacture and especially during firing painted pottery. Paint cannot adhere to stone inclusions. In particular large non-absorbent surfaces hamper paint adhesion more so than smaller stones. In contrast, slipped surfaces offer an absorbent undercoating to help paint adhere. As a result many painted pots have a slip layer.

Clay preparation is not only a laborious task, more importantly, it redirects the potter to perform chores not requiring the skill of a potter. Nor does it immediately lead to shaping a finished pot. Potters prefer to use their skill to make a pot rather than engage in another aspect of the work, such as clay mining, preparation, firing, and sales. In order to focus directly on making pottery, craft specialists engage non-potters to mine and prepare clay. They might be family members, such as husbands or sons of a female craft specialist, as at Paradijon, in southeastern Luzon, The Philippines (London 1991). In Cyprus, the remaining traditional potters worked with their husbands or alone to gather and prepare clay until early in the 21st century (London 2000, 2008). Male craft specialists might employ younger men or work with apprentices to fulfill the unskilled tasks, as at Zizia in Jordan based on observations made between 1987 to 2008 (London and Sinclair 1991).[1]

Initial clay preparation involves removal of rocks, minerals, and organics from clay completely or partially. Sometimes it suffices to eliminate only some inclusions to create a workable clay body. After removing some native inclusions, potters will add intentionally prepared inclusions. Another method requires complete removal, as much as possible, of native inclusions to be replaced by a more advantageous tempering material that will suit the needs of the potter and the containers. Such a step requires extra expenditures of time and effort to create the preferred additive, for example crushed quartz, calcite, limestone, grog or any other inclusion. After removing the native inclusions mined with the clay, potters or their assistants can add organic, rock, mineral, or other materials. To prepare inclusions usually involves collecting, crushing, and sifting specific minerals or other additives. Another such inclusion is grog, made by crushing fired pottery. A primary source of grog is misfired pots, which can be broken and ground. All intentionally added inclusions would ideally then be carefully and evenly distributed throughout the clay body.

Traditional potters today, who work without electrical devises to make utilitarian pots for local and possibly regional distribution, normally use local clay with minimal alternation. Water alone is added to make the clay pliable for use. Two clays might be combined to create a workable raw material as in Paradijon in The Philippines, where the husbands and sons of women craft specialists prepare clay (London 1991). None of the traditional Cypriot potters add inclusions. A survey of traditional potters worldwide confirms that few add anything to clay beyond water. Similarly in antiquity, after removing the largest inclusions, ancient potters worked with clays of the coastal and interior Levant, to coil/slab build pots, without adding inclusions. Wheel throwing, however, was not an option for untreated local clays. Some traditional potters add specific inclusions to cooking pots as in antiquity (Rye 1976). Certain painted pottery made from the secondary clays appears to be another category for which a preferred inclusion, grog, was repeatedly added at various times throughout history.

Recent 20th century use of grog inclusions in traditional pottery in Jordan

In northern Jordan, evidence of recent 20th century work at a sherd crushing installation behind Ajlun castle, was identified by Mittmann (1970: 80-81). It consists of a flat rock outcrop with remains of crushed pottery. J. Greene found a rubbing stone on the ground nearby in 1989. No information is available on how the crushed sherds were utilized or for what purpose. There are multiple uses for crushed pottery (London 1989: 221).

A visit to a rural Ajlun potter in the Wadi Nahleh at Khirbet el-Ghubb, about five minutes drive from the sherd crushing apparatus, took place during the July 1989 harvest season. The woman potter helped her husband with the summer grain harvest and would make pottery sometime later in the summer. In her open courtyard, dung patties drying on vertical exposure of bedrock were in addition to a wooden box of sherds, modern and ancient. Apparently the sherds would be crushed into grog, which was added to the clay body along with quartz sand (London and Sinclair 1991: 421). Elsewhere in northern Jordan female potters, who persist as small-scale producers of a limited repertoire, also crush sherds into grog added to clay (Ali 2005: 122).

Modern potters everywhere today consider grog a superior tempering material with several advantageous qualities:

1. Grog allows potters to exercise less caution during kiln firing (Rhodes 1973: 39).
2. The pre-fired and pre-shrunk grog is easily re-fired without damage or further shrinkage during drying and firing.
3. Grog adheres well to clay particles in the clay body.
4. Unlike non-absorbent rocks and minerals, grog absorbs paint, as do slip layers.

There is no question that when grog is present in ancient pots, it was intentionally incorporated into the clay. Did they know that grog promotes paint adhesion? Did they prefer to use grog temper for painted pottery throughout antiquity or was it limited to different time periods? These questions are investigated for pottery excavated at two sites, one in central Jordan and another in northern Israel. The pottery at these sites spans twelve millennia and can inform on practices and habits adopted by ancient potters.

Samples of pottery from two ancient sites in Jordan and Israel

Tall Hisban

Iron Age through Medieval Era pottery samples collected by James Sauer (Lugenbeal and Sauer 1972; Sauer 2004), from the initial Tall Hisban excavation in the Madaba region of Jordan, have been examined learn how potters used local materials over a 2000 year time period. The sample included pre-Classical (38%), Classical (37%) and medieval (25%) sherds (London et al. 2007, 2008).[2] Of 230 sherds characterized mineralogically by R. Shuster, 99 Iron Age samples were subsequently examined by Instrumental Neutron Activation Analysis to define the chemical nature of the clay bodies.[3] A small number of Iron Age II burnished bowls excavated at nearby Tall al-'Umayri were examined for comparative purposes. They follow the same pattern as the Hisban samples (London et al. 2008). Most pottery proved to be chemically of local origin, although there are mineralogical differences in the inclusions within and between archaeological periods as well as the INAA groups. Post-Iron Age wheel thrown pottery tends to have crushed and intentionally added quartz temper and was not part of the INAA sample. Iron Age I and II coil built pottery contains primarily limestone, quartz, calcite, and other rocks or minerals native or possibly added to the clay. Grog appears in cookers, burnished bowls, and other Iron Age II shapes, such as the only mug sampled (PH 134). Grog temper was sparse during the Classical period samples, but reappeared in specific medieval jugs (London and Shuster in press).

Tel Jezreel

Pottery excavated at Tel Jezreel extends over the millennia from the Neolithic through the Iron Age, earlier than preliminary publications report (Gophna and Shlomi 1997; Ussishkin and Woodhead 1991/1992, 1992, 1997; Zimhoni 1997).[4] Two Neolithic Sha'ar Ha'Golan sherds, painted and incised, were discovered among diagnostic sherds examined at the Jerusalem Kenyon Institute. As a whole, the Jezreel ceramic assemblage includes the full pottery sequence known from the Yoqneam Regional Survey (Ben-Tor and Portugali 1987; London forthcoming).

Grog tempering in pottery

Grog-rich wares from Hisban: Iron Age

Pottery with abundant grog temper, (60–80% of the non-organic inclusions), was always a minor petrofabric at Hisban. Pots with predominantly grog temper account for only 5% of the total Hisban sample for all archaeological periods. Grog-rich ceramics (Figure 2) include bowls, jugs or jars of Iron and Islamic date often with paint or burnish. Additional Iron Age grog-rich forms include a cooking pot (PH 124) and a mug (PH 134). Fabrics with a blend of quartz, limestone, and 30% or less grog (e.g. bowl PH 183), represent only 20% of our entire sample of 230 sherds from all archaeological periods. Pots with intentionally prepared and added grog include a cooking pot, a burnished bowl and the sole Iron Age mug.

Cookware

Of the 22 early first millennium B.C.E. Iron Age cooking pot rims submitted for petrographic study, shapes and firing colours vary considerably. The goal was to obtain the maximum variety of rim shapes rather than multiple samples of individual rim forms. Four categories of clay bodies or petrofabrics were identified based on mineral composition. The single grog-rich cooking pot (PH 124) is unique. In contrast, most cookware displays carbonaceous inclusions until the Persian Era when quartz predominates. As the exception, it might reflect the period of experimentation with different inclusions in cooking pots prior to the shift away from carbonaceous calcite and limestone to

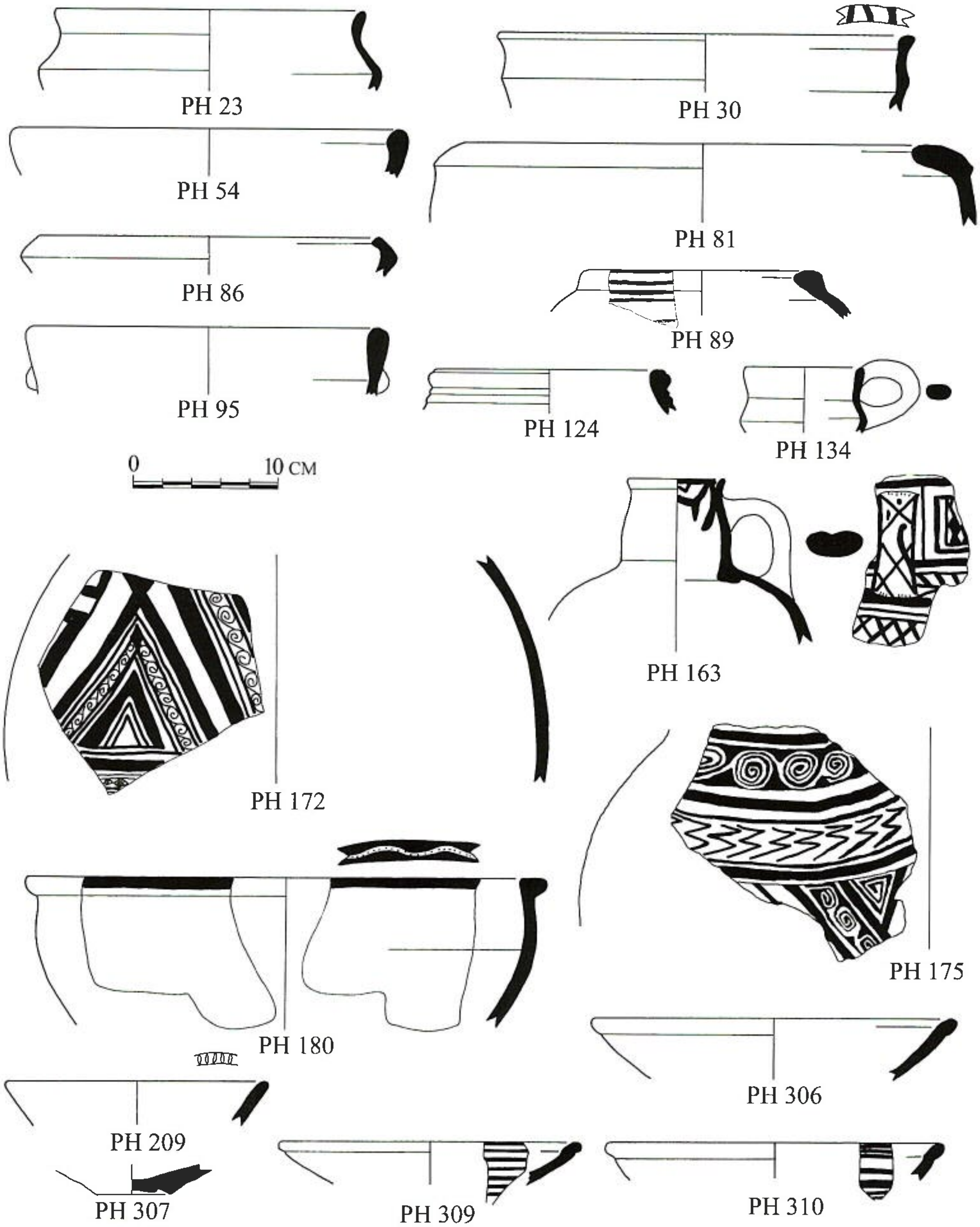

Figure 2. Grog-rich pottery mentioned in the text. Dark lines on black burnished bowls (PH 309 and 310) indicate compaction lines rather than paint.

quartz temper. Towards the end of the Iron Age, according to data from Hisban, potters used a variety of different inclusions in the clay bodies for cooking pots. Persian Period cookers, in contrast, demonstrate a decisive shift to quartz temper.

Prior to the preference for quartz, cooking pots at Hisban comprise several distinct petrofabrics. One of the nine cooking pots examined for chemical composition were made of the same clay as most Iron Age II ceramic containers. From this evidence, we infer that certain local or regional pottery workshops produced the full ceramic repertoire, including cookware. Other cooking pots, especially those with grog inclusions, were made of clays reserved expressly for kitchen wares, possibly made by potters who might have limited their output to cookers. Alternatively, cookware alone, from the workshop where grog was in use, reached Hisban.

Black and/or red burnished bowls

Burnished bowls excavated at Hisban and 'Umayri, belong to the tradition of "Ammonite" black and/or red burnished bowls (Herr 2006). With 38 samples tested petrographically and chemically, the black/red burnished Iron Age II bowls show an avoidance of quartz temper. This is a trait held in common with most Iron Age pottery at Hisban. Burnished bowls were fabricated from more than one fabric. The three petrographic ware types for burnished bowls are characterized either by grog (PH 306, 307, 309, and 310), limestone, or a blend of rocks.

Chemical analysis of bowl samples from the three mineralogical groups adds to the complexity. Three grog-tempered burnished bowls are part of the local/regional INAA Group 1 along with the bulk of Iron Age normal, undecorated jugs, jars, kraters and jars lacking any special surface treatment. However, this group represents products that could have originated in more than one workshop according to mineralogical composition. Since most burnished bowls at Hisban have primarily limestone plus a mix of quartz, grog, and other inclusions, one can infer that certain burnished bowls did not require development of a special clay body reserved exclusively for shiny, thin-walled bowls. This finding has implications for the overall organization of the ceramics industry.

Some burnished bowls, however, were fashioned from grog-rich clay. Nevertheless, chemically both the limestone and grog-rich clay bodies originated in the same region, somewhere in the Central Jordanian Plateau. The absence of a single clay body for burnished bowls, implies that more than one production location manufactured burnished bowls, possibly during the same timeframe. Perhaps within a single workshop, at a certain point during the Iron Age II, some potters made the full ceramic repertoire, including burnished bowls. Other potters simultaneously worked with a more refined version of the same or similar local clay. The clay was refined in the sense that after removing the native limestone inclusions, grog was added. Alternatively, the different clay bodies or recipes could belong to chronologically distinct and consecutive archaeological periods (London et al. 2007).

A hint of further compositional diversity within the grog-rich category results from a slightly different chemical composition for one grog-rich burnished bowl excavated at

Hisban (PH 307). It might represent an additional workshop, outside the Madaba Plains and Central Jordanian Plateau region. Non-local production is assumed since it remains chemically unassigned to any of the four INAA groupings, which included 99 samples of Iron Age vessels of all types.

INAA isolated further differences within the burnished bowl chemical composition. INAA Group 2 constitutes yet another, separate set of burnished bowls with a distinct chemical profile. As a result, we conclude that the burnished ware, traditionally known as "Ammonite" ware was manufactured in multiple workshops, with as many as four production sites concurrently and/or sequentially (London et al. 2008).

Prior to large scale compositional testing Herr (1997: 244-246) previously observed that precisely the same rims and vessel types are found with or without black burnish based on his assessment of chronologically and stylistically comparable pottery excavated at Tall al-'Umayri. Our recent testing confirms that the same workshops were capable of producing the non-burnished bowls and full repertoire, including thin and thick walled bowls of all sizes and rim types shapes. Previous petrographic analysis of a mere 22 carefully selected Early Bronze – modern sherds, from Tall al-'Umayri and the Zizia workshop, demonstrated that both red and black burnished wares were fabricated from the same clay body as for non-burnished pots (London et al. 1991: 430-437) and that there were multiple fabrics used to create 'Ammonite ware'. Expansion of the petrographic samples to include more burnished bowls from 'Umayri and Hisban reinforces that finding based on a handful of Iron Age sherds (London et al. 2007: 82). More recently, the same conclusion was reconfirmed for pottery excavated at Tell Jawa, located 11 km. south of Amman (Daviau and Graham 2009: 51).

In terms of vessel overall morphology, INAA Group I burnished bowls include a larger number and wider variety of rim shapes than those of INAA Group 2. Some Group 2 samples are body sherds selected due to their superior sheen and color, high luster, and thin walls. Bowls in INAA Group 1 can be as lustrous and well finished as those of Group 2, although more of the latter fired without a discolored core. With a larger sample of stratigraphically secure material, one can address questions related to the particular rim shapes characteristic of each petrofabric. For the present, it appears that grog temper was valued for burnished bowls.

Painted kraters

A handful of sherds in our Hisban sample contain 35 – 55% grog along with limestone and other inclusions, such as painted krater PH 30, and bowl PH 23, which does not preserve paint. In terms of clay body composition, with only 45% clay, 40% inclusions, and 15% voids, the krater would have been highly porous. It has one of the lowest clay ratios for the entire Hisban assemblage, yet this attribute is not unusual for kraters. For two additional kraters, clay content is a mere 50%. A rim without paint, PH 81 lacks paint, has 55% grog temper. Painted krater PH 89 contains 75% limestone and 10% grog. The norm for clay content Iron Age pots is 60%. Kraters might have a slightly lower clay content, and more voids of burned out organic material, in order to make them less heavy, more porous, and likely to absorb the liquid they served.

Grog-rich wares from Hisban: Medieval Era

Cookware, jugs, jars, open shapes, vats, etc. are among the 59 sherds of medieval date selected for petrographic analysis. As with Classical Period clay bodies, quartz inclusions predominate in regardless of surface treatment, including paint, plain, or glaze. Nevertheless, a slight tendency toward grog and/or limestone inclusions is discernible for painted bowls, such as PH 209. Handmade bowls, jugs, and jars, with grog or limestone inclusions, represent the counterpart to the more common quartz-rich, wheel-thrown glazed or plain pots. Middle Islamic 2B-Late Islamic painted and buff-firing bowl PH 180 is grog-rich, as is another handmade and painted bowl, PH 185, with 50% grog and 40% quartz. PH 209 has 30% grog.

Painted jugs fashioned from a petrofabric blending grog, quartz, and limestone, PH 163 and 175 lack the typical quartz-rich clay body. Instead each has grog inclusion (55 and 40%). The clay content is 60% and a mere 30% (PH 175), the lowest for any pot at Hisban for all archaeological periods. The remarkably low clay content renders painted jugs eminently suitable to keep their liquid contents cool through evaporation via the open, porous walls. Not only is clay content only 30%, but also grog could only enhance the cooling impact allowing the jug wall to sweat out its contents, which undoubtedly was water. Any other liquid would have been wasted if leaked through the walls. PH 172 was not examined for mineral content, but is the same type of jug.

Grog-rich wares from Jezreel

Painted Late Bronze Age Cypriot and Mycenean imports at Tel Jezreel were found in addition to local or regional painted products including several painted biconical jugs and a krater. A Late Bronze Age large closed pot, L. 2580, 15200.1, is painted red and black, and has grog plus red and black inclusions. It is roughly contemporaneous with grog-rich "Midianite" ware, which belongs to the local stylized imitation of imported designs painted on pottery. Midianite Ware is distributed at a small number of sites north of Timna, near Eilat in southern Israel, where it is found in relative abundance outside its origin in Saudi Arabia (Kalsbeek and London 1978). The Tel Jezreel and Midianite painted pottery again demonstrate the propensity to use grog in two distinct and different painted ceramics, a habit that continued in the chronologically later Hisban Iron Age and Medieval Era wares.

Discussion

Grog inclusions are as old as Near Eastern ceramics. Neolithic pottery excavated at Jericho has grog temper (Franken and Kalsbeek 1974: 185). Grog continued in use for painted wares during the Bronze Ages (Kalsbeek and London 1978), Iron Ages (London et al. 2008: 117, 121 and 123) and medieval times. The Wadi Nahleh traditional jars and kitchenware illustrate the persistence of grog temper late into the 20th century in Jordan.

For pottery excavated at Hisban, certain petrofabrics and/or variations span the 2000 years of habitation. Others transform or possibly disappear temporarily only to resurface later. Changes in tempering materials occur with or without changes in surface treatments. An assessment of the pot as a whole, involving the relationships among manufacture, surface treatment, temper, inclusion type, and firing reveals situations that repeatedly confronted potters and influenced their decisions. Ancient craftspeople might not have known the chemical or physical reasons why limestone has a negative impact on high-fired glazes or why they could produce serviceable unglazed pottery at relatively low temperatures. They knew what worked and what clients wanted.

Not all painted pots at Hisban have grog temper. Since limestone of various degrees of hardness, texture, and colour constitutes the bedrock and rock outcrops, ancient potters had little choice but to work with clays containing limestone inclusions. Experienced potters knew how to control the relatively low heat tolerance of limestone. Even when fired successfully at 700 degrees C., over time limestone will eventually expand and cause cracking. Limestone reacts less in a reduced kiln atmosphere. Limestone-rich black burnished pottery resulted from a reducing atmosphere designed to prevent lime spalls. Iron Age II black and red burnished "Ammonite" bowls rich in limestone temper are among the highest quality with an even, overall, lustrous sheen. The skill of firing these pots successfully marks the potters as masters of their craft.

Two coil built painted and two unpainted Iron Age II jugs excavated at Hisban exemplify the pairing of paint with limestone temper, rather than grog. A Roman period bowl demonstrates a relationship between painted pottery and limestone tempering in a time period when most pots had quartz temper. Despite our small sample for intervening periods, there appears to be a modest tendency for painted pottery with limestone or grog tempering beginning at Hisban in the Iron Age, through the Classical Period, to the Medieval Era. When considered together, these pots illustrate a co-variation between fabrication technique, temper, and surface treatment. The link between the choice of limestone inclusions and the presence of paint for coiled pottery can be related to firing, the most difficult stage of pottery manufacture. Neither paint nor limestone can endure high firing temperatures. Limestone influences the behavior of iron oxide paints at temperatures over 925 degrees C, at which point the iron content becomes unstable. The result is a dull painted pattern with minimum contrast to the earthenware color of the pot (Franken 1992: 131). One method to alleviate the problem is to cover the limestone-rich clay body with one or two thick bright, light coloured slip layers to minimize contact between inclusions and paint. Alternatively, potters chose to avoid paint, as towards the end of the second millennium B.C.E. For Iron I pottery found at Dayr 'Alla slips and painted patterns both are absent (Homès-Fredericq and Franken 1986: 161).

Iron Age II potters

Within the economic sphere of Hisban and ʻUmayri, there were minimally two burnished ware workshops. At one or more locations, potters made the full regular repertoire, including burnished "Ammonite" pieces, concurrently or not. Those same potters could have been responsible for thin and thicker walled burnished forms in addition to the normal repertoire. Perhaps bowls lacking sheen were simply over-fired which eliminated the sheen. Other workshop(s) made grog-tempered burnished and/or painted pottery. Only one of the workshops using grog was local (INAA Group I).

Painted and/or burnished Iron Age pots in our collection are likely to have grog temper. Grog and painted pottery pair together due to the ability of grog to absorb the paint in contrast to non-absorbent quartz, limestone, and other minerals. Potters using grog-rich clay bodies concentrated on small and painted shapes. Grog, although present, was never a major constituent of jars, or shapes larger than cooking pots or large bowls. Similarly grog-rich (50-80%) Iron Age clay bodies at Bethsaida include painted, slipped, and burnished small to medium size jugs and bowls rather than jars (London and Shuster 1999: 180-183; Pl. 1: 36, 40, 41, 43, and 45). This finding disassociates the potters responsible for painted pots from the manufacture of large jars and other utilitarian ceramic forms. Apparently there were workshops producing the full repertoire, including painted pieces, in addition to different workshops specializing in decorated pottery, kitchenwares, and jars. People bought painted pots made locally or from specialized producers located further afield.

Limestone- or grog-rich Iron Age petrofabrics proved inadequate for later wheel thrown plain and glazed wares. Limestone and calcite temper, so common in Iron Age ceramics and the entire Bronze Age, were finally superseded by quartz sand, although the old traditions did not vanish entirely.

Medieval Era potters

Jugs selected for diversity of form, fabric, and finish have either quite high or low clay ratios, representing the extreme values and some of the lowest percentages of clay content in the entire Hisban collection. Clay ratio refers the percentage of clay, non-plastics, and voids visible in the cross-section. Rather than a coincidence, intentionally low or high clay content relates to jug function.

Low clay ratios and abundant non-plastics, especially grog which accounts for 40% of the inclusions in PH 175, would better accommodate the ability to 'sweat' than a rock or mineral inclusion. Painted jug, PH 163, with 60% clay content, perhaps was less well suited to maintain its contents cool. Painted jugs known as the Middle Islamic 'Handmade-Made Geometrically-Painted Ware' (HMGPW) were ideally suited for short term use as water/beverage drinking jugs at meal times or at work rather than as pitchers for carrying and pouring. Apparently some jugs were better coolers. Others might have been considered to have a superior painted pattern rim for drinking, or handle for lifting. There was a market and clientele for each at Hisban. Painted designs likely represented different families, lineages, or villages.

Potters consciously manipulated the clay to create jugs for carrying, storing, or drinking liquids. Precious liquids and storage of more mundane beverages required high clay content. Potters separated by the centuries between the Iron Age and Islamic period found the same solution to problems imposed by the local raw materials. Jugs with 30% clay make ideal water coolers with the ability to sweat their contents to maintain a low temperature. Other jugs and jars with 70-90% clay served for long term water storage, serving, or to hold other liquids.

As in the Iron Age, grog was recognized as a suitable additive for painted Islamic era pots. Quartz or calcite inclusions characterize other jugs. Painted jugs and a jar have grog or limestone temper and likely originated in local, rural workshops versus those with quartz which are possibly the products of suppliers to urban centers. Medieval Hisban residents had access to portable jugs from diverse sources differing in appearance and manufacture. Certain jugs with specially prepared clay containing powdered quartz temper, display paint or fired white, suggesting manufacture in specialized workshops.

Brown (2000: 85, 93) described "functional redundancy" between handmade and wheel-thrown 13th-15th century pottery from the Kerak Plateau area. However, similarity in shape need not coincide with function or use. Rather than a significant cost differential between wheel-thrown and handmade pots (ibid. 93), another and more important distinction related to usage. While the value of some jugs was their ability to store fluids, others fulfilled the opposite purpose. A clay-poor and limestone-rich fabric produced a porous clay body able to cool its contents. The sweet taste of water stored in clay jugs results from porous walls that filter out the bitter minerals intrinsic to the water. Through time however, the pot would begin to fail as the calcareous nature of local water would cause the deposition of white minerals on the jug interior walls to form a 'natural' sealant, but no longer able to sweat and keep contents cool.

Surface treatments, paint or glaze, required a careful choice of clay body and tempering material as well as care during firing. Painted patterns have the tendency to melt if the kiln temperatures climb too high. At high firing temperatures, skillfully painted straight and intricate designs can melt into dripping blobs of muted colors. Since both painted patterns and limestone inclusions favor a fire below 800 degrees C, it was critical to control kiln temperature when firing limestone tempered and/or painted ceramics. The connections among tempering material, firing temperature, and surface treatment became clear to potters. Limestone-tempered, painted medieval bowls belong to the handmade tradition, which mostly likely did not cease entirely during the Classical Era.

Non-porous glazed pottery has many benefits. It does not exude its contents and is easier to clean than the porous open walls of unglazed wares. On the contrary, porous unglazed pottery, such as HMGPW keep liquids cool. It could have been a less costly, highly decorated hand or mouldmade product locally in rural settings beyond the reach of tax collectors and political authorities. As such, it is a visual statement of family heritage and identity comparable to the symbols embroidered on clothes. Walker (1999: 220) describes the medieval custom of serving food covered with an embroidered cloth in a pot painted with a matching pattern. Some decorated pottery, large jars, vats, and other containers used in rural settings and at ancient Hisban were still fashioned in the time-tested tradition of coiling local clays. In order to successfully paint a pot, either limestone or grog temper was preferred. Each required a relatively lower firing temperature to preserve the integrity of the painted pattern as well as the mineralogical structure of the limestone.

Potters paired grog temper with painted surfaces. A Hisban medieval buff-firing, painted bowl mineralogically is identical to an Iron Age II bowl. Potters millennia apart in time encountered similar problems and found the same solution to limitations imposed by local raw materials. In particular smaller containers, kraters, jugs, and bowls with paint show a predilection for grog temper and suggest manufacture by specialized potters.

Conclusion

Pottery collections from sites excavated decades throughout the 20th century provide material to investigate the craft of pottery making. In terms of clay manipulation and preparation, from earliest times, some potters used grog in painted pots. Throughout the ages, potters matched grog with painted pottery, as in the Neolithic, Bronze, Iron, and medieval time periods.

Grog inclusions hint at jug usage for water, especially when clay body content is low. It is less likely that beer or wine was allowed to leak. Medieval jugs with grog and painted geometric decorations were suited to sweat and maintain a cool temperature. Medieval pottery with grog-temper and paint coincides with hand or mould made and coiled manufacturing techniques. Rather than a 'return' of grog use, the post-Iron Age rural economy and household preserved pottery traditions that are unrelated to a specific time, space, or people.

Iron Age II pottery workshops included those capable of producing the full repertoire and others producing a more limited repertoire of paint, or cooking pots, or jars. In medieval times, painted mould made jugs with elaborate decoration represent products of rural craft specialists unrelated to the workshops of wheel thrown quartz-rich made by a different set of craft specialists.

Notes

1. Pierre Bikai, Director of ACOR, provided an introduction and transportation to the Zizia workshop in 1987. Without his interest and assistance, the workshop would not have been recorded over the years.

2. Petrographic analysis of 230 sherds, from the late second millennium B.C.E. through the 15th century C.E., was carried out by Robert Shuster. We thank Larry G. Herr, Douglas R. Clark, and Larry T. Geraty for permission to study and include pottery from Tall al-'Umayri in the compositional analyses. For analysis of pottery from Hisban we gratefully acknowledge the Shelby White – Leon Levy Program for Archaeological Publications. The full report in Hisban 11 awaits publication. A full manuscript can be obtained by contacting G.A. London.

3. INAA was conducted at the University of Missouri Research Reactor Center (MURR). A full report is to be published in the Andrews University Hisban Volume 11.

4. G.A. London was able to spend one month studying diagnostic sherds excavated at Tel Jezreel thanks to Charlotte Whiting, who graciously permits mention of Jezreel pottery before publication. The manuscript is currently with editors. Analysis of the ceramic assemblage stored at the Kenyon Institute in Jerusalem, part of the Council for British Research in the Levant, was carried out with the assistance of Kenyon Institute Assistant Director Chloe Manning, student intern Susannah Fishman, and artist Christopher Schofield.

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AYYUBID-MAMLUK SUGAR POTTERY FROM TELL ABU SARBUT, JORDAN

Henderikus Eduard LaGro

Abstract

During excavations at Tell Abu Sarbut in the Jordan Valley (1989–1992) a number of phases of the Ayyubid-Mamluk period with remains belonging to cane sugar production facilities were found. The sugar pottery used during the production of cane sugar consisted of many fragments of sugar moulds and syrup jars. The sugar moulds were made in three different shaping techniques, reflecting a chronological development. The syrup jars were made according to one single technique. Various techniques of finishing the rim were applied. Other evidence of cane sugar production exists of sherds with clear traces of rubbing on their surface. They were identified as implements used to clean sugar moulds after usage during the production process of the sugar. Finally, vessels were found that have been used during the production process of indigo, an agricultural product that is linked to the production of cane sugar.

Introduction

This article on the sugar pottery from Tell Abu Sarbut (Jordan Valley) (Figure 1) is a slightly adapted although not updated version of a chapter of my unpublished PhD dissertation entitled "*An Insight into Ayyubid-Mamluk Pottery. Description and Analysis of a Corpus of Mediaeval Pottery from the Cane Sugar Production and Village Occupation at Tell Abu Sarbut in Jordan*" (LaGro 2002). The aim of this study was the construction of a typo-chronological framework of the pottery at the site from the Ayyubid-Mamluk period to serve as tool for later research. Such a study would fit into the framework of the pottery studies at Leiden University and could benefit from previous work of Franken on Tell Abu Gourdan (Franken and Kalsbeek 1975; see also LaGro and de Haas 1988). For this purpose four excavation seasons took place in the period 1989–1992 (de Haas et al. 1989, 1992).[1] During the excavations a number of phases of village habitation and remains belonging to cane sugar production were found. The sugar pottery (Figure 3), which was used during the production of sugar cane, consisted of sugar moulds and syrup jars.[2]

This article is focused on the production techniques of the sugar pottery of Tell Abu Sarbut. Preliminary reports on the technological study of this pottery were previously published (Lagro and de Haas 1989/1990, 1991/1992). Attention is paid to Tell Abu

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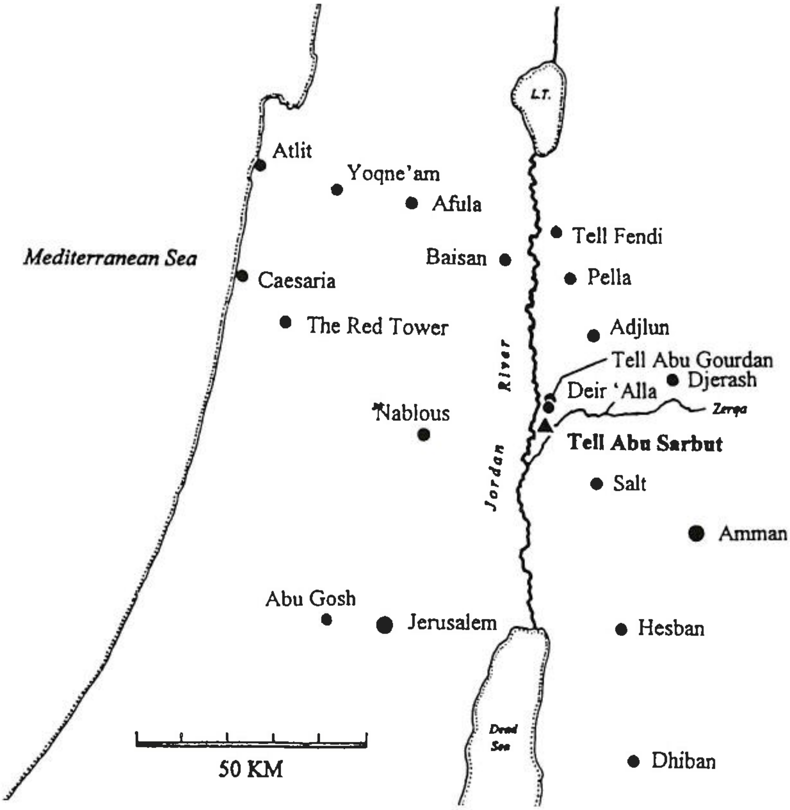

Figure 1. Location of Tell Abu Sarbut in the Jordan Valley, Jordan.

Sarbut and the context in which the sugar pottery was found. Since the cane sugar production complex was the first to be (partially) excavated in the area, it was also considered important to include some background information about the history of the sugar-cane and cane sugar production in the Jordan Valley (see LaGro 2002: 24–36).

The site

Tell Abu Sarbut, a usually uninhabited site and, apart from a number of robber trenches and a few other disturbances like tank-positions, looking pretty much intact is located on the eastern bank of the river Jordan in the central part of the valley, in the vicinity of Deir 'Alla (Figure 1).[3] It lays amidst agricultural fields, which are presently irrigated by canals branching off from the main Ghor-canal, but in former days by small streams coming from the mountains and some springs. Directly to the south of the Tell, running approximately east-west, flows a normally shallow, perennial stream through a small canal dug along the edge of the Tell. At the north side is a road that leads from the main north-south road in the valley into the direction of the river Jordan. Along the eastern side a small canal was dug in 1990 as part of a drainage system of the surrounding fields.

When Glueck visited the site in 1942, the stream presently running in the canal south of it was then flowing through a small wadi along the northern side, called 'Wadi al-Khor' (Glueck 1951: 311). On the eastern side of the Tell he observed a fig and pomegranate orchard and a small vineyard, an area now used for vegetables like tomatoes and cucumbers. According to him "numerous Byzantine and mediaeval Arabic sherds were found on this mound".

The visible site measures about 250 m east-west and 125 m north-south, but continues to some extent under the surface level. From its highest point, which is approximately -248 m, it slopes to -252 m on the east and south sides and to -255 m at the north and west sides. No previous regular excavations on the site are known, although Steuernagel, who visited the place in the beginning of the twentieth century, reported that Europeans allegedly had dug on the site and had found gold (Steuernagel 1925: 354).[4]

The pottery on the surface of the site indicated that the Ayyubid-Mamluk period, which would be the subject of the intended study, was predominantly present. In addition, the results of the East Jordan Valley Survey in 1976 had indicated the possibility of Early Roman and the presence, however slight, of the Byzantine, Umayyad and Abbasid periods. Although the presence of the early Islamic periods could not be concluded anymore with certainty during a study of surface material in 1987, this information was still considered valid. The presence of these periods would maybe provide an opportunity to shed at least some light on two other pottery related problems. The first being the reflection on the pottery of the transition from the Byzantine period to the Umayyad period, a hardly understood aspect. The second concerns the material from the Abbasid period in that area, a period, which is hardly attested in the Jordan Valley and the pottery as such badly known. The site was recommended by M. Ibrahim, who participated in the East Jordan Valley Survey of 1976, as an important site for future excavations, because it was in direct danger of destruction due to agricultural development. This turned out to be more immediate than expected, because the intention of the (private) owners of the site was to level it and turn the area into profitable agricultural land after the military status which the site then would have been ended. This prospect was an important aspect of the decision to excavate this particular site.

The excavations

In 1988, a preliminary season was held to verify the extent of the deposits and study the nature of them via a trial trench on the eastern part of the site and soundings on the western part. The trial trench revealed deposits of about half a meter thick which on basis of the pottery could be ascribed to the Ayyubid-Mamluk period. They were severely disturbed by repeated leveling of the ground in former times in order to prepare a flat surface for new constructions. These deposits were situated directly on top of deposits ascribed to the Byzantine period. Preceding the Byzantine period there was some occupation in the Roman period, this based on two fragments of terra sigillata. The extent of the presence of these latter periods and their duration have not been investigated as yet. The soundings on the western part of the site indicated rather undisturbed deposits of at least two meters thick which date to the Ayyubid-Mamluk period. On basis of the results of this preliminary season, three subsequent seasons of excavations (in 1989, 1990 and 1992 respectively) were held in five squares with a total surface of 400 square meters on the western part of the Tell. Additional soundings and trenches were made at other places on the tell proper and in the surrounding fields to obtain further information about the extent of the site (de Haas et al. 1992).

Soundings

The soundings were made as well to study the presence and extent of possible phases belonging to the early Islamic periods and to see if material from any other period than the Ayyubid-Mamluk was still present in situ. In general it could be concluded from these soundings that from the Islamic periods only deposits ascribed to the Ayyubid-Mamluk period were present in situ and that these were increasing in thickness from about half a meter, pretty much disturbed, on the eastern side to about three meters on the western side. The deposits ascribed to the Byzantine period, on the contrary decreased in western direction to about one meter thick. Two soundings on the central part of the Tell revealed the existence of a building, ascribed to the Byzantine period, which had collapsed due to a fire. After this event that area remained unoccupied for a time and the pottery from later phases there only indicated the Ayyubid-Mamluk period. Soundings on the western side revealed a large leveled surface of a phase ascribed to the Byzantine period under meters of alternating, sloping yellow and ashy layers. Such layers are associated with cane sugar production and constitute the dump of residues from the fires used during the production process.[5] On top of these ashy layers some occupational remnants of the Ayyubid-Mamluk period were found. On the eastern part only material from the same period had been found in 1988 that could be ascribed to the Islamic periods.

It seems then that possible early Islamic occupation would not have been on the central part of the Tell because of the debris of the collapsed building, but elsewhere. If this habitation would have been on the western side of the Tell, all remnants of it would have been removed during the leveling of that area. This would explain an odd sherd found on the surface during the survey in 1976 and ascribed to that period, but no remains in situ. Another possibility would be a location further away from the site, one which would now be under the present surface of the agricultural land. To the north of the site a sounding did not reveal the presence of any occupational phases, but to the south, remnants of a small bread oven were found, approximately one meter under the present surface, without, however, sherds or other material that could point to an early Islamic occupation there. To the east remnants of a recent garden wall were found, maybe belonging to the orchard observed by Glueck. To the west of the site as well no traces of early Islamic occupation were found. Walking the fields directly surrounding the site did not result either in finding pottery scatters or other indications for habitation in that period.

If people indeed had been living at the site during the early Islamic periods, the following could be a possible explanation for their whereabouts. People having their houses on the site in the Umayyad period would live somewhere away from the ruins of the Byzantine building, maybe adjacent to it. They would probably have had their houses severely damaged or even destroyed during the disastrous earthquake of the 18th of January 749, estimated to have had a magnitude of 7.1-7.6, which resulted in widespread destruction in the Jordan Valley and severe loss of life (Amiranand Arieh 1994: 266; Tsafrir and Foerster 1992). Survivors or others who wanted to continue to live on that location had to move away from the rubble and live somewhere in the vicinity. It is therefore probable that if people lived there in the Abbasid period, it would probably be nearby the present site and not directly on it, as was also the case at Pella.[6] Later, after the rubble would have weathered, people could move to the original site if that location was considered preferable and would level the surface for new buildings. Another possibility, as described above, is that remains from the Umayyad and Abbasid periods, if located on the western side of the ruined Byzantine building, were removed in order to build the first cane sugar producing facility.

Another reason to make soundings was to trace a possible habitation of the site by a supervisor and workers at the time of the functioning of the cane sugar production outside the location of the factory proper. No habitation could be linked to that period on the western part and the eastern part was too disturbed to establish that. It is possible that the supervisor lived inside the factory while the workers might have lived elsewhere, a preferable option considering the smell during the production process and the inevitable swarms of flies.

Excavations of the squares and phases

The three seasons of excavations in the squares eventually revealed the top of layers of heavily packed clay ascribed to the Byzantine period which, apart from a sounding, remained unexcavated. On top of these, a number of phases were found which on basis of the excavated material have been ascribed to the Ayyubid-Mamluk period. Of these phases a stratigraphy was made, which is mainly based on square L, the only square excavated completely until the Byzantine phase (Figure 2) (For detailed information on the phases see Appendix 1).[7]

Dating

The relative chronology of the phases is difficult to link to an absolute chronology due the lack of readable coins and the rather widespread dates of the C14 dates available. From phase 50, a sample has a calibrated date of 1292-1448, which would imply that

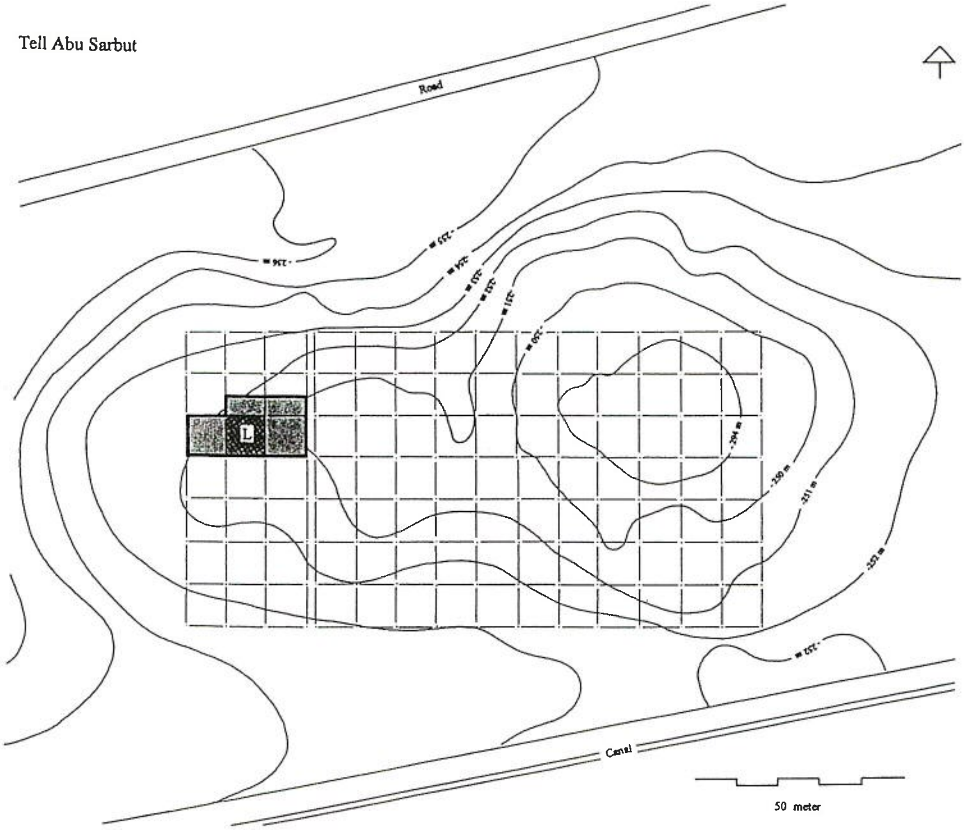

Figure 2. Tell Abu Sarbut: excavation squares.

at least the earlier phases of village occupation date to the Mamluk period.[8] This leaves the possibility that (parts of) the phases of the sugar production are earlier than the Mamluk period. For a sample associated with phase 100 the calibrated dates are 1434-1510 or 1598 – 1620, indicating either late Mamluk or the Ottoman period. A geographical study based on archives of the late sixteenth century, however, does not mention a village occupation in that area, which can be considered to have been Tell Abu Sarbut (Hütteroth and Abdulfattah 1977). In the same study no cane sugar production is mentioned anymore for the Jordan Valley, while it becomes clear from the pottery from phase 100 that the inhabitants of this phase were directly or indirectly still involved with this industry. The presence in phase 100 of white slipped green glazed ware, which was in use in the Ottoman period can not be considered an indication per se, since this material also occurred in the Mamluk period. Tobacco pipes, which could be an indication of the early 17th century, were not found at Tell Abu Sarbut nor were coins from the Ottoman period. It is more probable then that the age of phase 100 is late Mamluk.

Sugarcane and cane sugar

Cane sugar was grown in the Jordan Valley at least at the end of the tenth century and maybe earlier. Its importance increased in the successive centuries and it became a foremost cash crop, which yielded cane sugar of a high quality. Later, its importance declined, due to i.a. interference in the market mechanism by sultans and emirs, and at the end of the fifteenth century its economical production had ceased.

Some locations in the Jordan Valley still have names, which reflect former cane sugar production like *ma'sarah* (press) or *tahun/tawahin* (mills). Sugar factories in the cities have a different name, *matbakh* (boiling place), reflecting a different function in the production process. From historical sources, details about the general structure of the organization of the industry became clear. Basically a raw product was produced in factories in the direct vicinity of the area where the sugarcane was grown, not only because it is a bulky crop but also because its sugar content decreases quickly after cutting. This product, called *qand*, was then transported to factories normally located in cities like Cairo/Fustat or Damascus for further refining, resulting in various qualities of sugar. At times the owners of the factories producing the *qand* could be the owners as well of a sugar factory in a city, pointing to a developed organizational system. Although in smaller towns some sugar undoubtedly was produced for local consumption, the basic structure is as described above.

It became also clear from these sources that differences existed between Egypt and Bilad al-Sham in details of the production process, differences, which need careful attention because they result in different archaeological remains at production sites. Comparing various sources about the production process, it could be suggested that, apart from crushing with a millstone, also the combination of mortar and pestle was used, a possible translation of the word *siham*. Secondly it is suggested that also bag sugar was produced, a process in which no pottery is used. This opens the possibility that cane sugar was produced at more sites than is at present known, since these are primarily identified via sugar pottery.

Sugar moulds and syrup jars

The pottery described in this article is often called 'sugar pottery', which refers to the fact that this pottery was used during the cane sugar production process. It, however, does not take into account the different shapes and quite different functions these pots had in this process. Two main shapes of pottery were used during the manufacturing of the cane sugar (Figure 3). One is a conical shaped vessel in which the boiled sugarcane juice could solidify and is called a sugar mould. The second one, which was used to receive the leftover syrup is called syrup jar. Nor does the indication 'sugar

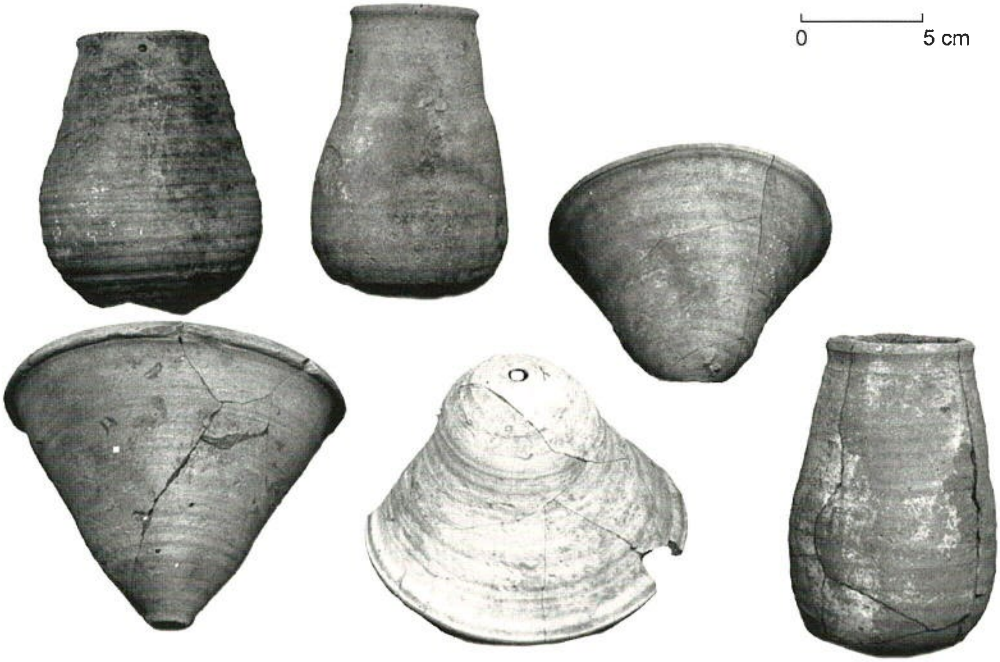

Figure 3. Sugar moulds and syrup jars from Tell Abu Sarbut.

pottery' reflect the use of such pottery in the household, as was attested in phases belonging to the village occupation at Tell Abu Sarbut. This latter reflects a probably unintended multipurpose usage of readily available, mass-produced ubiquitous pottery.

This pottery was often produced in the direct vicinity of the sugar factories, as is the case with the installations described from Marocco (Berthier 1966). Although at Tell Abu Sarbut no pottery kilns were attested, some wasters belonging to conical shaped moulds were found, which indicates that local production of the ware took place during at least a certain period, in which the factory was functioning. In Egypt, according to al-Maqrizi, the kilns were prepared in November to make moulds and two kinds of jars, which were called *qadus* and *amtar* (plural) respectively.[9] He does not mention who produced the pottery and it is therefore not clear whether this was done by a professional potter or by people working in the factory as part of their seasonal activities.

Sugar moulds

The sugar mould called *abludj* by al-Nuwayri and is described by him as wide at the top and narrow at the base, in which three holes had been pierced.[10] The word is probably derived from the Persian language and as such maybe an indication for the origin of the shape and the production method of sugar associated with this particular shape. In Arabic the word not only indicates the mould itself, but also the sugar loaf proper, which was formed in it and weighed around one *qintar*.[11]

This pottery has some features, which are directly linked to their usage in the sugar factories during the production process. A sphero-conical shape together with a smooth inside gives this pottery a 'self discharging' quality, implying that in theory it should be possible to remove the sugar as a lump from the mould after solidifying. This was not always successful and extensive deposits of sherds of moulds are often found in the direct vicinity of the sugar factories indicating a substantial breakage during the production process of the sugar. At the same time, the adapted shape of the sugar mould and the efforts to obtain a smooth surface on the inside indicate that these were meant to be reused.

Usually they were provided with a solid rim, which would not only protect it and its precious contents if it hit something, but would also serve as a sort of grip when handling, since these moulds do not have handles. According to Berthier in Marocco, a rope was fastened under the rim to prevent the mould from breaking down under the thermo shock when the boiling juice was poured into it. It is doubtful, however, if a rope would remain in place on the strongly conical shaped moulds which are described below, and this was probably done on the oblong forms Berthier described and which are a later development (Berhtier 1966: 197).

In the base one or more holes were made through which the syrup could be tapped. The moulds described by al-Nuwayri had three holes, and also from Susa moulds with three holes were published (Boucharlat and Labrousse 1979: 156; Kervran 1979: 209). The ones published from Jordan, Cyprus and Morocco have invariably one hole.

General shape of the moulds

The moulds from Tell Abu Sarbut and Tell Abu Gourdan have a shape, which can be called conical with a diameter, which roughly equals the height and these can be ascribed to the twelfth-fifteenth centuries. Also those published from Susa, and ascribed to the twelfth or thirteenth century have these characteristics. The moulds from Morocco published by Berthier and others from e.g. France and Spain are, in fact, oblong with a diameter, which is half its height. This development can probably be ascribed to the fifteenth or sixteenth century. In the following centuries this ratio changed even further and the height of the mould could become four times that of the diameter of the rim.[12] It seems then that through the ages the general shape of the mould changed from conical to oblong, a development, which will be treated further below. To what extent this development is a general one or one limited to certain areas like Western Europe and the Americas has yet to be established, because a mould published from Egypt and dated to the end of the eighteenth century still had a specific conical shape.[13]

Syrup jars

The syrup jar was called *qadus* by al-Nuwayri, but he also used this term for a vessel that could contain some tar mixed with water, which would slowly drip from tight holes in the base into the irrigation channels of the sugarcane fields to fight off the worms. The word was used as well to indicate a jar tied to a water wheel. Syrup jars usually have a rim under which a rope could be fastened, and the base is either flat or concave.

Sugar moulds and syrup jars in combination

The obvious combination of mould and jar during the production process is usually thought to have been the former on top of the latter, like it is depicted on engravings from the seventeenth century and later. Also Reisig described this combination and added that they would be stacked against each other whereby a rope around the neck of the jar would prevent it from cracking under the weight of the mould (Reisig 1793: pl. VII, fig. 35). On the other hand, it becomes clear from the description of al-Nuwayri that in this time benches were used to position the moulds and that jars were put under them. If we take in consideration the general shape of the moulds and jars, which were in use in the factories at Tell Abu Sarbut, this latter way of combining makes sense. The conical mould with a diameter nearly equal to its height on top of a jar is not very stable, unless inserted into the neck of the jar for a considerable part. Taking into account, however, the limited diameter of the opening of the neck of the jars and the width and shape of the base of the moulds, this could hardly be the case. It could also have been expected that the jar would have a rim with an inside sloping edge, which could closely fit the base of the mould to provide more stability. This is not the case with the material studies from Tell Abu Sarbut, nor is it visible on drawings of jar rims published from other, approximately contemporary sites. Also the positioning of the combinations next to each other would not provide, for much stability since the diameter of the mould exceeds that of the jar, implying that only the rims of the moulds would touch each other. It is hard to imagine then that this combination was stable enough and not full of risks that its precious contents would be spilled and it seems more likely that the moulds from Tell Abu Sarbut were suspended above a jar, as was described by al-Nuwayri.

In Figure 4 an impression of such a combination of a mould with a jar from Tell Abu Sarbut is given next to one, which is based on an engraving from the beginning of the nineteenth century, which shows the difference in dimensions between the two combinations.[14] The oblong shapes are much better suited for such a direct combination, which is often depicted on engravings where the moulds can be seen positioned directly on the jars. The bases of the oblong moulds are slim and adapted to fit partially into the jars, which have necks that are ample with a rim shape that would suit the base of the mould. The diameter of the jar corresponds toughly to that of the mould, enabling the stacking next to each other as described by Reisig (1793).

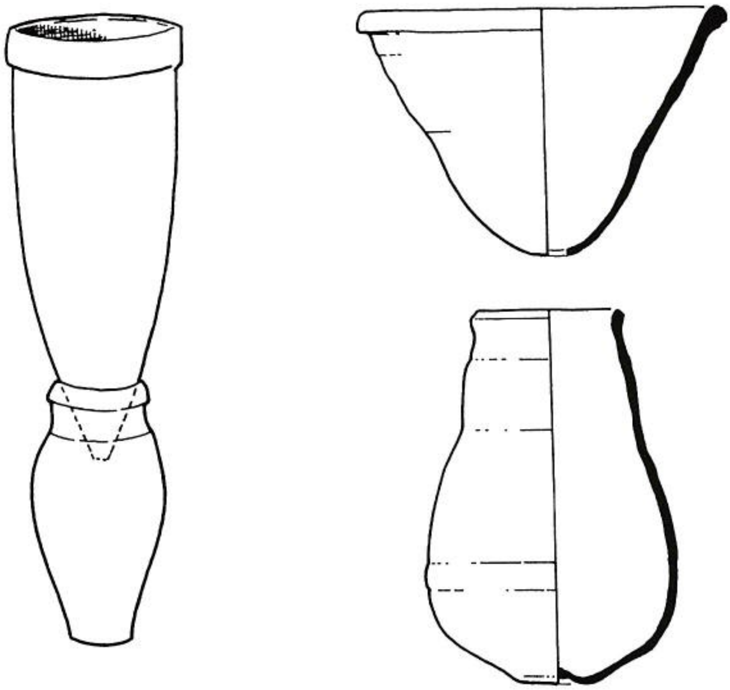

Figure 4. Left: a combination of a mould with a jar which is based on an engraving from the beginning of the nineteenth century (not to scale). Right: an impression of such a combination of a mould and a jar from Tell Abu Sarbut (not to scale).

From the description above it can be deduced that the conical shape precedes the oblong one, which could have been introduced around the fifteenth or sixteenth century. This change in basic shape reflects new exigencies of the sugar industry as a result of developments within the production process itself. At least from the seventeenth century onwards, the method to extract the remaining molasses, which are formed around the sugar crystals, is no longer described only as a process of repeated boiling, like it was done by al-Nuwayri. Another way is described by which clay of a special quality or plants were soaked in water and then spread on top of the sugar loaf inside the mould.[15] The water contained in the clay or in the plants would slowly descend through the sugar cone without dissolving it because it had a high degree of sucrose in it. It would, however, take the remaining impurities downwards to the point of the mould, which would get stained with a brownish color. It is a process, which can be repeated, with an occasional inspection of the loaf to study the progress. For this method, which uses a constant flow of moisture, a mould in permanent combination with a jar would be much more suited, because part of the impurities could flow out immediately instead of remaining concentrated in the base and staining the point more then needed. Also the oblong form would facilitate the stream of impurities more directly downwards instead of staining the sides of the cone as well. This way of purifying was probably the reason for an adaptation and change of the general shape of the mould from conical to oblong, and the use of smaller syrup jars for this goal. This development, in which the basic shape of mould and jar were adapted to this change in the production process was not followed everywhere. The conical shaped mould illustrated in the 'Description de l'Egypte' was used in a similar process to clean the sugar, but the shape had not been adapted. During the process it was placed on a support and the syrup was let out of the opening every now and then, like al Nuwayri described.[16]

Sugar moulds from Tell Abu Sarbut (SPI)[17]

Introduction

The importance of the cane sugar in the Jordan Valley can be deduced from the large number of possible sites involved in its production. When these places became operational and how long they functioned is hard to establish, and therefore, the number of sites producing at the same time is unknown. The cultivation of the cane sugar, however, extended over a long period of time and possibly certain characteristics of the pottery involved in the production process changed in the course of time, which could be due to the introduction of new methods in this process. Therefore, it was opted for a rather extensive analysis of the pottery material hoping that some recognizable traits had developed, which as such could provide a tool in the periodization of other production centers

As stated before, this pottery was an industrial product and time was probably an essential element in the production implying that any time-consuming way would be avoided as long as the result was in accordance with the specifications and requirements of the sugar production. The rough finish of the sugar pottery implies that especially in this case a study based on the shape of the rim alone would result in many groups, which do not have clear delineations. The variety in the shapes of rims published from other sites is extensive and Franken, who published a corpus of such rims, could only conclude, that "Since every variation is found in every phase, the shape of the rim has no diagnostic value" (Franken and Kalsbeek 1975: 144, 147).[18] The number of reconstructable profiles from Tell Abu Sarbut is limited and not sufficient for an extensive description, which therefore had to be based on the way the pottery was made and varieties within rims and bases. Even like this the variety in rims remained extensive and, as it turned out to be, the implications for a chronological distinction remain limited as yet.[19] Three main ways of constructing these moulds were discerned at Tell Abu Sarbut, which were named A, B and C and are described below.

Diameters of the rims

For some more general remarks about these moulds the rims have sometimes been lumped together so that SPI/A/0 indicates rims from moulds SPI/A/00–09 etc. Moulds SPI/A and SPI/B described below can sometimes have a somewhat oval opening and irregular shape due to the way they were constructed. This can result in different diameters of rim fragments, which belong in fact to the same vessel. The diameters of the rims (n = 1202) described below vary mainly between 28 and 36 cm (see histogram Figure 5).

Contents

From fragments with a measurable diameter also the angle of the rim was recorded, if the size of the sherd permitted this. This was done in order to obtain an indication of the contents of these conical shaped moulds, taking into account that both measurements which are needed for this, i.e. the diameter and the angle, can at times be inaccurate due to the material and can as such affect the outcome and result in outliers. In Figure 6 the contents vary between 4 and 22 liters (n = 1119) and it shows that they are mainly found between 8–16 liters, with a possibility that there existed two main sizes of moulds, one between 8–12 liters and one around 16 liters. The means of contents vary between 10.4 liter for mould SPI/A/1 and 14.3 liter for mould SP/A/5.

Developments of the rims

Mould SPI/A was found in all phases, while mould SPI/B started in phase 30. Mould SPI/C was found only in phase 10 and, considering the small number, it either belongs to the first factory or is maybe even residual of a previous sugar production of which

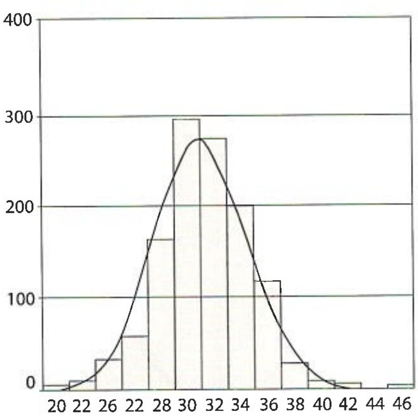

Figure 5. (SPI) Sugar moulds: diameters of rims.

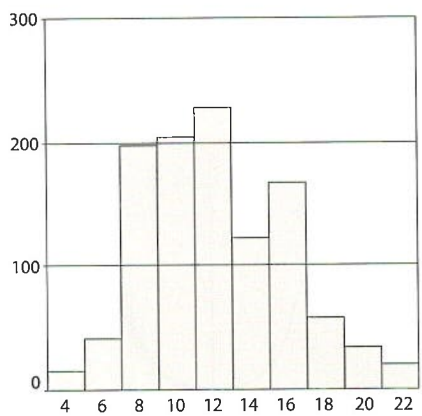

Figure 6. (SPI) Sugar moulds: contents in liters.

no architectural remains were found. Between phases 10 and 20, which are both associated with sugar production, a shift can be observed, whereby the share of rims of mould SPI/A/1 declines from 31% to 9% while that of mould SPI/A/3 and mould SPI/A/5 increases. Since these rims also represent different means of contents, a small shift can be observed at the same time to moulds with a larger content. If and to what extent this reflects changes in the production process, or is due to a different function the excavated area had in the production process in the subsequent factories or simply a different potter is at present unclear.

Sugar mould SPI/A

Construction

In Figure 7 a number of complete examples of such moulds are illustrated, which were formed with the use of coils of clay (see also Franken and Kalsbeek 1975: 143, 150). First the upper half of it was made, which was then left to dry somewhat, after which the inside was carefully scraped with a rib. Then, the form was put upside-down

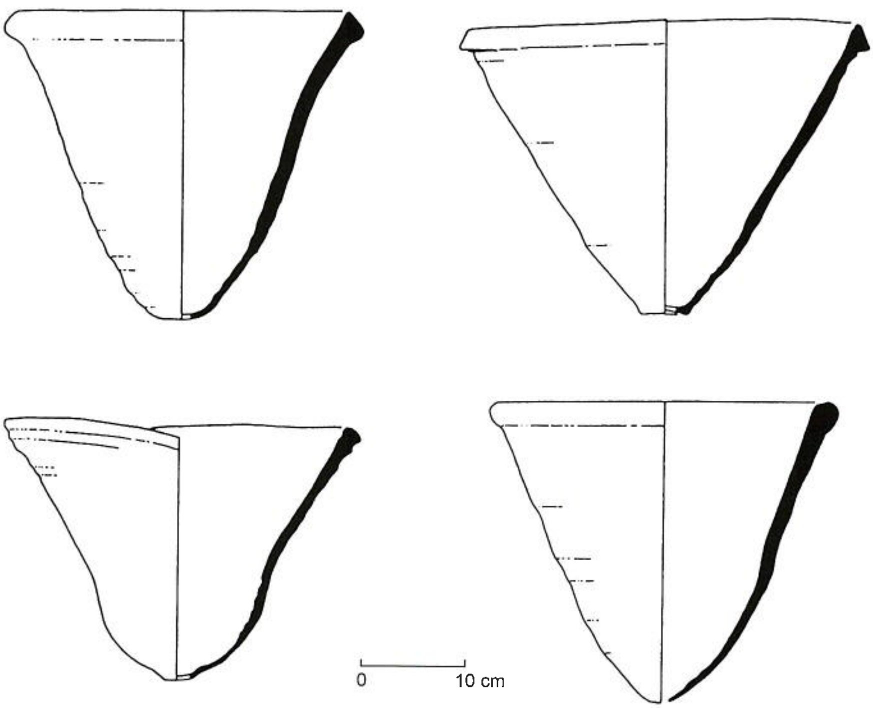

Figure 7. Sugar mould SPI/A: a number of complete examples, which were formed with the use of coils of clay.

and the lower part was constructed and closed, and a hole was pierced in the center of the base. Since the mould was upside-down and closed, the potter did not have the possibility to scrape the inside any further, leaving turning marks in the interior lower part of the mould as a result of the pressure the potter exerted to fit the coils of clay together. A second consequence of this way of making the vessel is the change in angle of the wall at the point where the potter started to form the second part, which gave the profile of the mould the shape of a 'bell'. In general, the thickness of the wall is even, although it tends to be thinner in the section that was finished upside-down.

Rims folded outwards

A fold was not made to strengthen the rim but could also be used to even up the height of the vessel if the rim was initially irregular. This could result in a rim with a large fold where it stuck out first, changing gradually into a smaller fold at places where the rim originally had been lower. Therefore, the height of the rim was not used as a criterion to differentiate. Before the fold was made, the thickness of the upper part of the wall was often reduced to facilitate the folding.

Rim SPI/A/00

The rim was folded outwards, and then, pressed against the wall leaving a shallow indention about one centimetre wide where the fingers had pressed. The fold was smoothed in such a way that visible traces of it are usually obliterated. The rim was bended slightly outwards (Figure 8.1).

Rim SPI/A/01

The rim was folded outwards but was not completely pressed against the body of the vessel and points outwards. The top of the fold was mostly rounded but could also be left somewhat sharp (Figure 8.2).

Rim SPI/A/02

The rim was folded and pressed firmly against the body and sometimes the lower part of it had been smoothed with the wall. The top of the fold is rather round and a slight indention can sometimes be observed, which was left by fingers pressing the fold downwards (Figure 8.3).

Rim SPI/A/03

The rim was folded and then the top part of the fold was pressed between two fingers, causing a groove along the outside of the rim. The lower part of it was sometimes pressed against the wall, resulting in a flattish part. Underneath the fold a small line of clay slip, which was forced out from between the fold and the wall, can at times still be seen (Figure 8.4).

Rim SPI/A/04
The top of the fold was pressed between two fingers, without leaving a distinctive groove like that of rim SPI/A/03, while the lower part of the fold was smoothed against the wall of the vessel. The transition point between the inside of the pot and the rim has a sharp edge (Figure 8.5).

Rim SPI/A/05
The rim was folded and pressed against the wall and then the outside of the fold was pressed between two fingers, hardly or not leaving a flat vertical part, but instead a sharp edge pointing outwards (Figure 8.6).

Rim SPI/A/06
The rim was folded outwards, whereby the lower part of the fold was carefully smoothed against the wall of the vessel, leaving only a slightly thickened but distinct edge along the top of the rim about 1.5 cm wide. The rim was bended slightly outwards (Figure 8.7).

Rim SPI/A/07
The outside of the fold has a round profile as if the top of the wall was rounded before the fold was made and then pressed outwards against the outside of the wall, leaving the rounded profile in tact (Figure 8.8).

Rim SPI/A/08
Before the fold was formed the wall was made thinner, amounting to about one fourth of the original thickness. This thinned part was rather short so that the fold 'rests' in fact on the wall, more than stretching over it. The upper part of the wall is usually thicker, which could be caused by downward pressure, when the fold was made on top of the wall (Figure 8.9).

Rim SPI/A/09
The rim was probably folded outwards and smoothed against the wall, nearly being incorporated with it. The visible result is a rim with a slightly thickened top part and only a small groove, which is visible at the fracture of the rim, is an indication of the possibility of a fold (Figure 8.10).

Rims folded inwards
Rim SPI/A/10
The upper part of the wall was made thinner and the top was rounded neatly, after which the rim was folded inwards. Then, the potter scraped the inside, sometimes leaving a small groove where the fold joins the inside of the wall, which was filled with clay slip. The transition of the inside wall and the rim is edgy because of the scraping (Figure 8.11).

Rims formed between two fingers
Here the potter kept and pressed the upper part of the wall between two adjoining fingers to finish the rim. These could have been the index finger and the middle finger, but a combination of other adjoining fingers is possible as well. The top of the rim can show a slight thickening, which is caused by the downward pressure and the difference in distance between the knuckles and the pattern of the fingers.

Rim SPI/A/20
The rim has been finished straight with a rounded or flattened top, which shows a small thickening (Figure 8.12).

Rim SPI/A/21
In this case a finishing touch has been given to the rim by bending the wrist downwards, causing the rim to point outwards (Figure 8.13).

Rims made with an added coil of clay on the outside
A coil of clay was put against the outside of the wall, and then, incorporated by smoothing and pressure. The coil could be put at various places against the wall: at the same level of the top of the wall, underneath this or sticking out above the top. Adding a coil of clay, which sticks out above the level of the top could be an indication that it was used to egalize the height of this. Sometimes the adhesion point of the coil is nearly on top of the wall, comparable to a complete build-up in coils. A general aspect of these moulds is an inside that had been scraped in such a way that it became slightly hollow directly underneath the rim without, however, losing the 'self-discharging' quality.

Rim SPI/A/30
A coil of clay was added nearly on the level of the top of the wall. The top of the rim is square and flattened with a small indention indicating the location where the coil joins the wall. The lower part of the coil was smoothed (Figure 8.14).

Rim SPI/A/31
A coil was put against the wall just below the level of the top and was pressed against it with a finger or rib pointing downwards and outwards. The lower part of the coil was smoothed against the wall (Figure 8.15).

Rim SPI/A/32
A coil was put against the wall sticking out above the level of the top of it. A finger or rib was pressed on the coil and the top of the wall, pointing downwards and inwards, leaving a groove where coil and rim of the vessel were joined. Sometimes this caused a sharp edge at the transition of the inside of the mould and the rim. The lip of the rim points out horizontally (Figure 8.16).

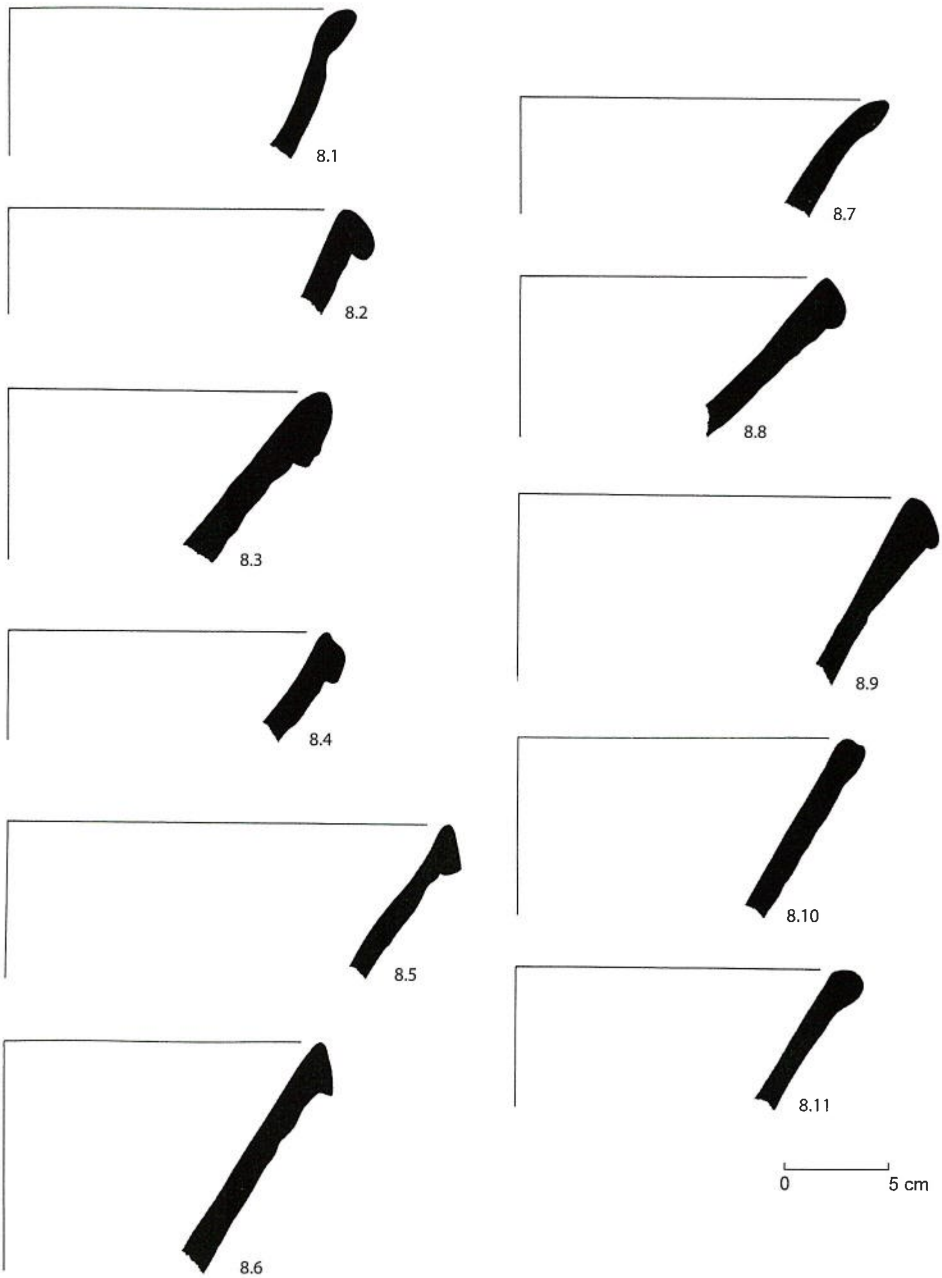

Figure 8. 8.1–8.10. Sugar mould SPI/A: rims folded outwards); 8.11. rims folded inwards; 8.12–8.13. rims folded between two fingers; 8.14–8.18. rims made with an added coil of clay on the outside; 8.19. rims with an unclear construction method; 8.20–8.21. sugar mould SPI/B: folded rims.

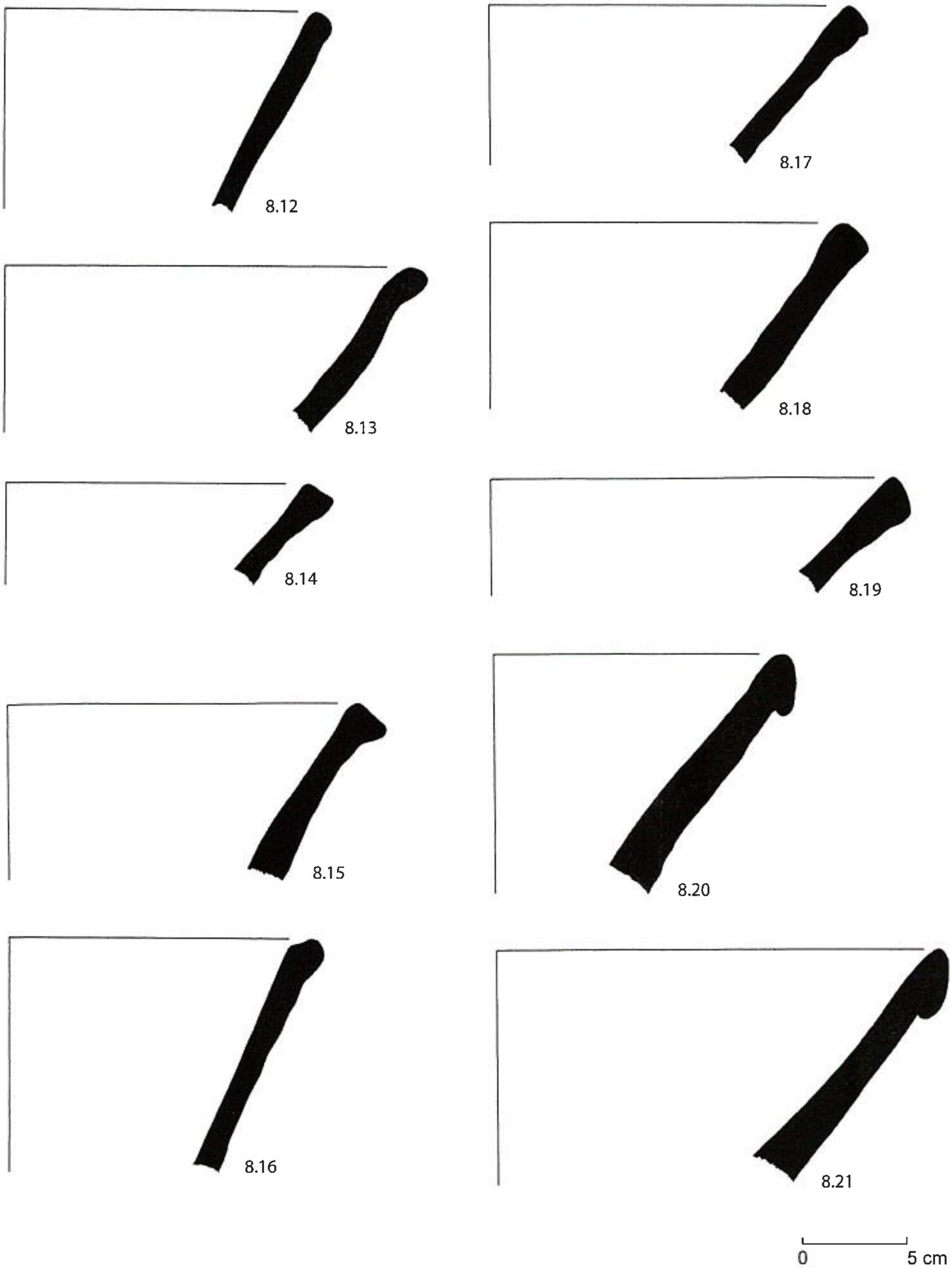

Figure 8. Continued.

Rim SPI/A/36
A coil was put against the outside of the wall above the level of its top. After smoothing the coil, the rim was pushed outside, causing the lip of the rim to point outwards (Figure 8.17).

Rims formed by pushing the clay of the top of the wall downwards
Rim SPI/A/40
The clay was pushed downwards with a finger or a rib placed on top of the wall while the outside of the rim thus formed was given a slight round edge (Figure 8.18).

Rims with an unclear construction method
Rim SPI/A/50
These rims have a shape of which the technical details are not clear. They either were made by adding a coil or the rim was folded. After either way the outside was smoothed very carefully, especially the top of the rim, obliterating traces of previous work (Figure 8.19).

Sugar mould SPI/B

Construction
In this case a lump of clay was put on a wheel and given a disk-like shape. At the edge, maybe on a low ridge on this disk, coils were placed on top of each other and fixed together. This process was continued until the desired height was achieved. Then, the top of the wall was made thinner to make a folded rim and the inside was scraped with a rib. After the clay had become leather-hard, the mould was turned upside-down and the lower part was scraped at the outside to diminish the thickness of the wall. This way of constructing resulted in a conical shape with straight walls. Sometimes the hole is not exactly in the middle because the mould had not been centered precisely during the scraping. In some cases traces of clay on or near the rim indicate the place where lumps of clay were used to support the vessel and keep it in place during the scraping. Scraping on the inside did not always completely take away the adhesion line between the coils, and horizontal indentions between them, which were filled with clay slip, are sometimes visible. The slip had a larger shrinking factor than the clay used in constructing the pot, which resulted during drying in one long and thin horizontal crack or small vertical cracks in the slip filling. On the outside of these moulds heavy ribbing is frequent. The planes of fracture of the sherds of these moulds are frequently horizontal, an indication that coils were used.

Rims
For SPI/B only one basic rim shape was discerned, i.e. an outward folded rim. Although most rims seem to have been folded like this, a small indention in some cases on top of

the rim could indicate the use of a separate coil, but it could also be a rupture of the clay resulting from the folding. The difference between SPI/B/01 and SPI/B/02 is small and is in fact more related to the width of the fold, a short fold would result in one sticking out somewhat while a longer fold could be pressed against the body of the vessel.

Rim SPI/B/01
The fold on the outside of the wall was not completely pressed against it and sticks out somewhat (Figure 8.20).

Rim SPI/B/02
The fold or coil was pressed against the wall and the rim itself is often not completely horizontal (Figure 8.21).

Bases belonging to moulds SPI/A and SPI/B

Base SPI/K
Base with a rounded shape, which was closed upside-down and belongs to mould SPI/A. Possible parallels were published from i.a. Tell Abu Gourdan (Franken and Kalsbeek 1975: 151, fig. 42, no. 15), Hirbet Sheikh 'Isa (MacDonald 1992: 235, no. 31F), and Yesud Hama'alah (Biran and Shoram 1987: 204, no. 3–4) (Figure 9.1).

Base SPI/L
The base was turned closed upside-down and an opening was made. Around this hole a small, flat surface was made by pushing the clay inwards, the surface of which is either flat or protrudes inside somewhat. The diameter of this flattish area varies between 4.5 cm and 6 cm. Although this is too small to allow the vessel to stand free, it should have provided some stability when putting it on a surface while handling it during the sugar producing process. It belongs to mould SPI/A. Possible parallels were published from Tell Abu Gourdan (Franken and Kalsbeek 1975: 152, fig. 43, no. 14 and 153: fig. 44, no 27) and the Jisr Sheikh Fendi region (Kareem 1987: 194, pl. 24; Kareem 1989: 108, fig. 5, no's 20– 21) (Figure 9.2).

Base SPI/M
This base has no signs of having been closed upside-down and traces of extensive scraping are visible on the outside on the lower half of the mould. Since the mould was not always placed perpendicularly to the center of the turntable, the scraping could result in an uneven thickness of the wall near the base. It probably can be ascribed to mould SPI/B. It is also possible that the base of mould SPI/A was sometimes scraped if the clay left near the base for closing the vessel was too much. Therefore, a distinction between bases of mould SPI/A and mould SPI/B on scraping traces alone is not sufficient (Figure 9.3).

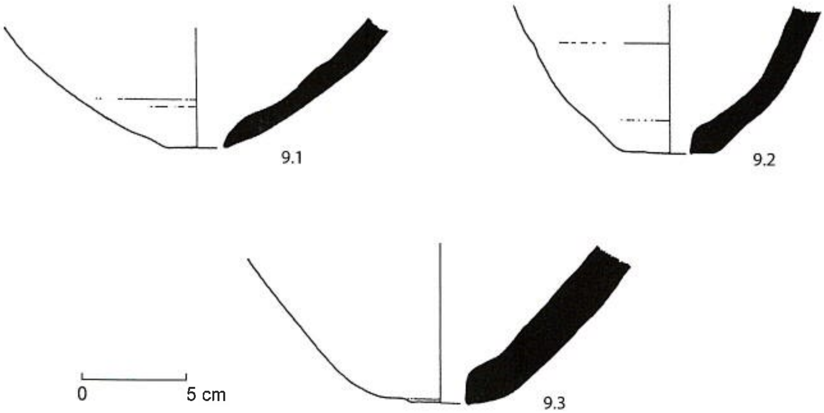

Figure 9. Bases belonging to moulds SPI/A and SPI/B.

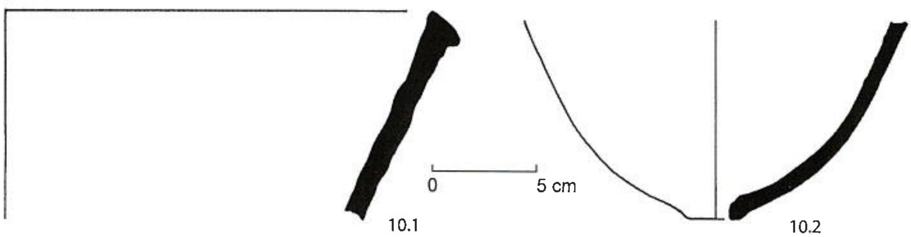

Figure 10. Sugar mould SPI/C.

Sugar mould SPI/C

These are conical shaped sugar moulds as well, but of a different clay than A and B. Only a limited number of fragments of this mould have been found, i.a. three base fragments with holes.[20] They belong to a mould, which was thrown and not built up in coils like mould SPI/A and mould SPI/B. First the upper half of the vessel was formed with an outward folded rim (Figure 10.1). This upper part was then turned upside-down and the lower part of the vessel thrown closed, leaving a small hole in the center (Figure 10.2). The lower part of the rim was sometimes smoothed against the outside of the wall, obliterating the fold. The diameter of the holes in the available base fragments was about one centimeter, considerably smaller than those of mould SPI/A and mould SPI/B. The inside of the mould was not scraped and throwing marks are still visible, but these are only slight and as such do not hamper the self-discharging capacity of the mould.

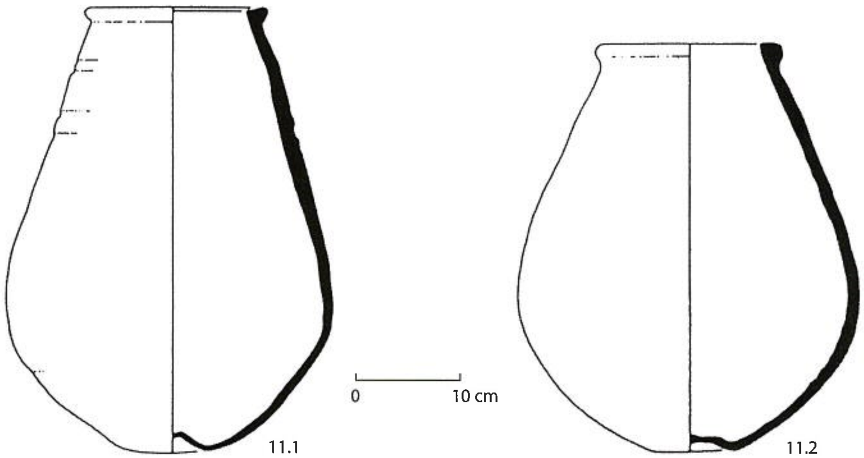

Figure 11. Syrup jars from Tell Abu Sarbut (SPII).

Syrup jars from Tell Abu Sarbut (SPII)

Construction

For these jars only one way of constructing has been identified, which runs parallel to the method described above for mould SPI/A and is identical with the one described by Franken and Kalsbeek 1975: 148-149. Some complete examples are illustrated in Figures 11.1 and 11.2. First, the upper part of the jar was made with a succession of coils in combination with turning. The pronounced turning marks indicate the pressure exerted on the coils rather than imprints of regular throwing marks. After finishing the upper part, the jar was placed upside-down, and then, the rest of the wall was finished and a concave base was formed by pressing the center inwards, which gave the jar some stability. On the outer edge near the rim, fragments of clay are often visible, which were used to support the vessel when it was placed upside-down to close the base.

Development of the rims

The rim diameters of these jars vary between 6-16 cm. A difference becomes visible between phase 10 and 20. In phase 10, rim SPII/0 forms the majority (55%), followed by rim SPII/4 (21%) and rim SPII/3 (16%). In phase 20, rim SPII/0 accounts for only 34%, rim SPII/4 remains the same, while the part of rim SPII/3 has nearly doubled to 31%. Remarkable is the actual appearance of rim SPII/2, which was represented by one fragment only in phase 10 and has ten fragments in phase 20. In phase 50, rim SPII/2 forms even the largest group, mainly consisting of rim SPII/22, and continues to be this. This increase in percentage in phases with village occupation probably indicates that these jars were still in use during those times, although the sugar producing facility did not function any more as such on the site proper.

Rims

Rims folded outwards
Rim SPII/01
The rim was folded outwards and then the top/outside of the fold was pressed between two fingers. The fold was not pressed against the wall and sticks out somewhat. The transition between rim and inside is often rather sharp due to the pressure of the fingers (Figure 12.1).

Rim SPII/02
The rim was folded outwards and the top was made round. The outside of the fold was pressed against the wall and neatly finished, which was sometimes done with the aid of an instrument like a piece of wood of which the traces can still be seen at times. The transition between the rim and the inside is roundish (Figure 12.2).

Rim SPII/03
The rim was folded outwards and the top was flattened somewhat. The transition between the inside and the rim is sharpish (Figure 12.3).

Rim SPII/04
The rim was folded and pressed against the wall, directly above the shoulder of the jar, and usually no further finishing touch was given. The transition between the inside and the rim is round (Figure 12.4).

Rim SPII/05
After the fold was made, the top of the rim was flattened and the lower part was finished carefully, obliterating the traces of the fold on the outside. The transition between rim and inside is sharp (Figure 12.5).

Rims folded inwards
Rim SPII/10
The rim was folded inwards, leaving an indention, which would be difficult for the potter to remove within the narrowness of the neck. The transition between the inside and the neck is round (Figure 12.6).

Straight rims
Rim SPII/20
A straight rim of which the top slopes inside. To make the rim slope inwards, the potter pressed the clay downwards, which could cause a slight thickening of the top of the rim. This profile in itself would be more suitable to support the moulds, but no traces of wear were found on the inside of these rims (Figure 12.7).

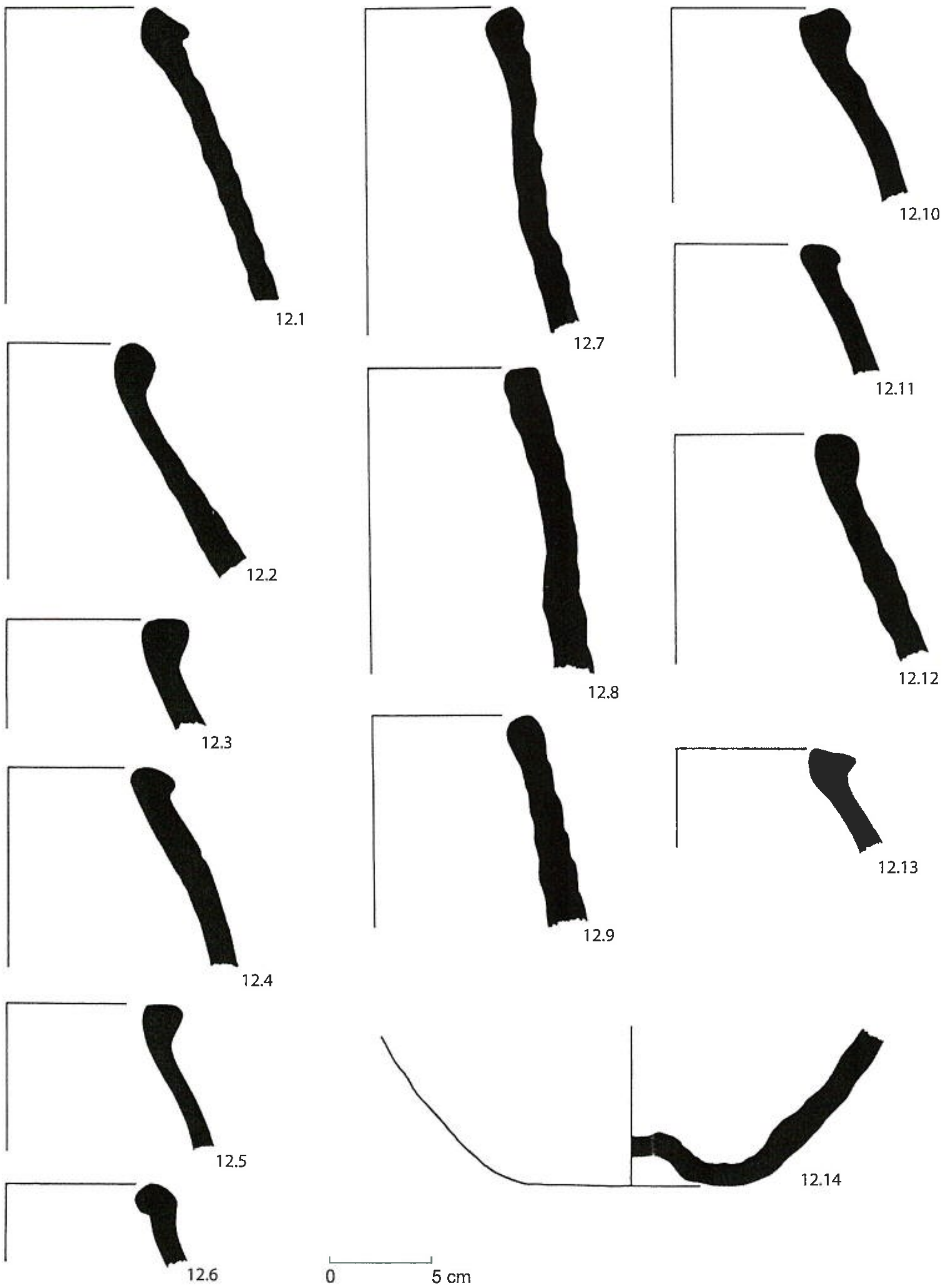

Figure 12. 12.1–12.5. Syrup jars: rims folded outwards; 12.6. rims folded inwards; 12.7–12.9. straight rims;12.10. rims with an added coil; 12.11–12.12. rims which were pushed down;12.13. rims without a clear construction method;12.14. bases.

Rim SPII/21
Straight rim with a flattened and sometimes slightly thickened top (Figure 12.8).

Rim SPII/22
Rather straight rim with a round top (Figure 12.9).

Rims with an added coil
Rim SPII/30
A coil of clay was put against the outside of the top of the wall and an indention there often indicates where the coil was attached to the wall. The transition between the inside and the rim is usually round (Figure 12.10).

Rims, which were pushed down
Rim SPII/40
The clay on top of the wall was pushed downwards and outwards. The outside of the rim is sharp and the top is usually rounded, but at times flat, while the transition between the inside and the rim is round (Figure 12.11).

Rim SPII/41
The clay was pushed downwards and outwards and then given a rounded shape (Figure 12.12).

Rims without a clear construction method
Rim SPII/50
The construction method of these rims is not clear. A coil of clay could have been put against the outside and was then smoothed in such a way that the coil is not longer visible. Another possibility is that the clay on top of the wall was just pushed downwards and outwards, and then the outside of the rim was finished between two fingers, e.g. thumb and index finger (Figure 12.13).

Bases

The bases belonging to these syrup jars are all displaying an inward pushed center with on the inside of the vessel traces of torsion around it (Figure 12.14).

Decorated pottery

Pattern in red paint

A number of fragments, 18 in total, have a pattern in red paint on the outside and, considering the thickness of the sherds and the ribs on the outside, they could all belong to mould SPI/B. Only one fragment (Figure 13.1) is large enough to show something of a pattern, which in this case consists of crosses in juxtaposition between horizontal lines. The other fragments only show straight and crossing lines, which probably belonged to a similar pattern. The paint was maybe applied as a decoration, because these sherds are also associated with the village occupation or phase 50, but it was done thoroughly and the lines are smudged, which might as well indicate that the crosses served as a sign that the vessel had another function than a mould in the production process.

In addition to those fragments, two rim fragments of SPII/22 from phase 50 had the top of the rim covered with red paint in a horizontal line.

Engraved lines

Some fragments of conical shaped vessels, but (maybe all) with a flat closed base, have a pattern of regularly engraved lines on the outside. They occur as single or double wavy lines, at least sometimes between straight, horizontal parallel lines and vary in width and depth, see Figure 13.2–13.6. The carefulness of the execution of the lines could point to a decoration although the small number of fragments involved indicates that it was not a usual one. A sherd belonging to a conical shaped vessel with a likewise engraving was found at Tell Abu Gourdan (Franken and Kalsbeek 1975: 143) and also from the Jisr Sheikh Hussein region (Kareem 1987: 191), more to the north in the Valley, a likewise fragment was reported. These fragments have been described in this article because the general shape and rims resemble those of the moulds, although they could not be used as such if they had flat bases without a hole. Although a number of fragments were found in the phases belonging to the factories and these vessels might have had a function in the production process, others were found in later occupational phases, which could point to use in the household.

'Scrubbing sherds'

A number of sherds had distinct traces of wear caused by extensive rubbing, see Figures 14.1 and 14.2. The surface with which the rubbing had taken place is always slightly curbed, indicating that the one on which the rubbing took place had a corresponding profile. The sherds, 198 in total, belong with one exception to moulds and were nearly exclusively found in phases associated with the sugar production. Many of them had been used on both sides and even the planes of fractures of the sherds occasionally show signs of rubbing. A possible use of such sherds could have been in the reservoirs where the moulds were soaked and cleaned before reuse, which was needed to remove remnants of sugar still sticking to the inside of the moulds. Rubbing with one of the omnipresent pieces of pottery would be an easy method and the slight rounding of the rubbing surface corresponds with the inside the water in the reservoirs must have contained as well quantities of fine clay, either wind-blown or just sticking to the pottery, which would have strengthened the wearing process of the sherd during the rubbing and could explain the soft and smooth surface of these sherds.

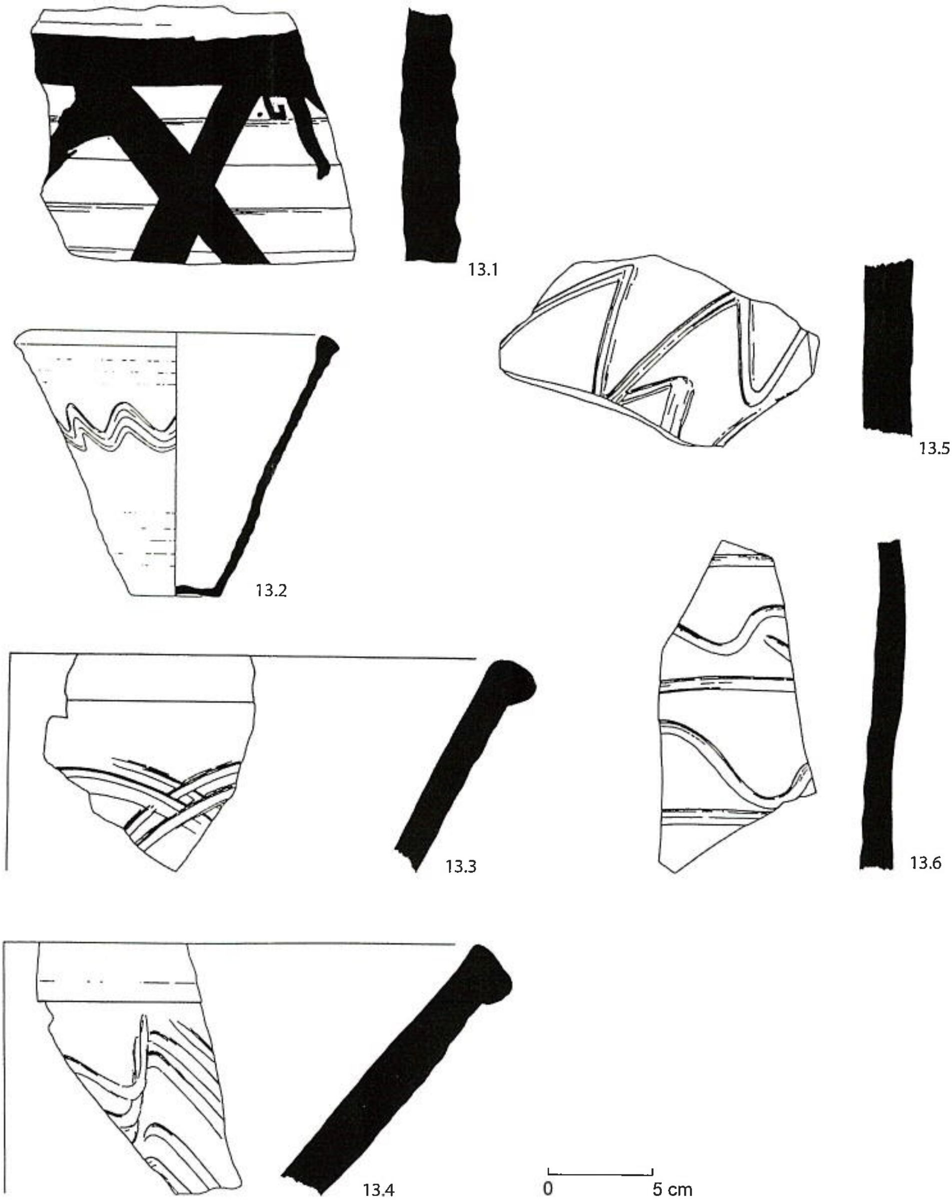

Figure 13. 13.1. Decorated pottery: pattern in red paint; 13.2–13.6. engraved lines; 13.2. not to scale.

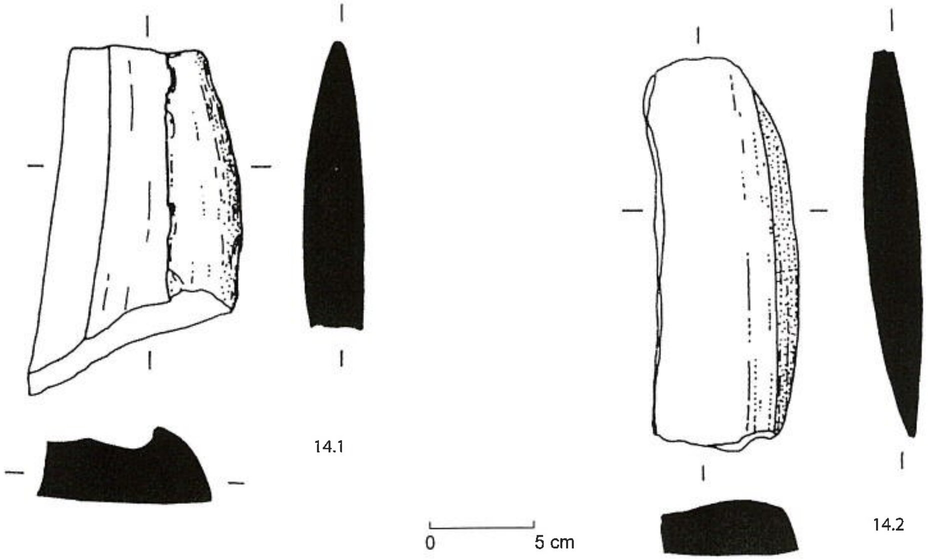

Figure 14. 'Scrubbing sherds'

Cane sugar and indigo

Body sherds with holes

A small number of sherds, 14 in total, had one or more holes of approximately one centimeter in diameter and are from vessels with the same conical shape as the moulds. The holes were made by pushing from the outside with a round instrument through the wall of the vessel when the clay was still soft, leaving parts of the clay sticking around the hole on the inside, which, therefore, was no longer smooth. One larger fragment shows that the holes numbered three and were placed in a vertical row located about half way the body (Figure 15). The function of vessels with such holes in the sugar industry is unclear, but the vessels must have been used for something in the factory, because fragments thereof were found as well in the first as in the second factory and one of the sherds had traces of rubbing as described above.

Indigo

Vessels with three holes in the wall of the vessel were used during the production of indigo in eighteenth century Egypt and other areas.[21] After being chopped up, parts of the indigo plant were soaked in water for a time to get out the blue coloring agent. The moisture with the indigo solution was then transferred to vessels, which had three holes

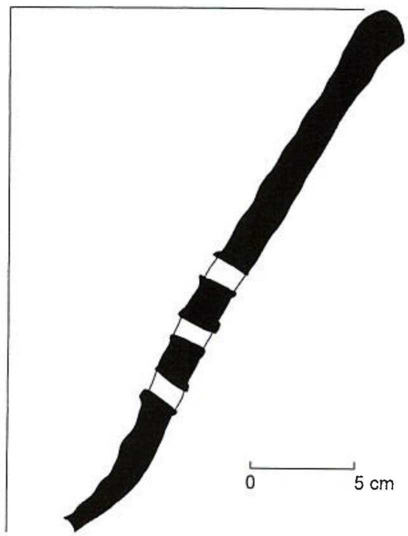

Figure 15. Body sherd with holes.

in a vertical row in the wall. After the solution had subsided partially, the clarified moisture in the upper part of the vessel was drained via one or more of the holes. The remaining paste was scraped out and left to dry before being cut up in small pieces and packed for transport. A more contemporaneous vessel used in the indigo production in Oman, with albeit one hole, also has a conical shape, which for such a production process would be a practical one because it concentrates the settled particle in the limited area of the base (Balfour-Paul 1997: 69).

Indigo was a well-known and important cash crop from the Jordan Valley and its cultivation is mentioned at places, which were also known for their sugar production, like Jericho, Baisan and in the area near the Dead Sea.[22] It was not only grown for the local market, but, like cane sugar, it was an important export product (Watson 1985: 145). Like cane sugar, it was also a newly introduced crop, which required nearly the same climatological conditions (Watson 1985: 123). In Arabic several words were used for it like *wasmah*, *nil*, or *khitr*, which might, in fact, be different varieties of indigo.[23] It was a profitable crop with a reported yield in Egypt in the thirteenth century worth 23 dinars of *faddan*, minus three dinar taxes, more than most other summer crops (Cahen 1972: 144-147). Export of indigo from Syria by Italian traders continued at least until the end of the fifteenth century, indicating the continuous economic importance of their product (Ashtor 1983: 483). In the register of the year 1596 indigo (*nila*) is still mentioned as a produce of Deir 'Alla and some other villages in the vicinity of Tell Abu Sarbut and are with exception of Baisan the only ones in the Ghor (Hütteroth and Abdulfattah 1977: 168).

It is not certain if or to what extent the cultivation of sugarcane replaced that of indigo or whether it was cultivated side by side. In a treatise on taxation written in the twelfth century both products are mentioned together in an example of a ledger to be prepared for taxes, implying that both were cultivated at the same time within the area of one administration (Frantz-Murphy 1986: 25, 41). A combination of both also occurs in a papyrus from 860, wherein the owner of a plot of land stipulated to the person renting it that all crops were permitted except indigo and sugarcane, without, however, specifying the reason (Müller-Wodarg 1957: 44). In the fourteenth century it was grown near Jericho where also sugarcane was cultivated at the same time and it is not unlikely that the possibility to change crop was used if taxes on one became high or prices got fixed or rigged by the government. Also in more recent agricultural practice sugar and indigo are mentioned together.[24] The crop itself is very suitable to serve as a rotation crop with sugarcane, or to prepare the land before sugarcane is planted, and the remnants of the plants after extraction of the coloring agent can be considered good manure for sugarcane fields (Reisig 1793: 11; Deventer 1915: 166, 445).

It is therefore, suggested that these vessels with holes in the wall were used in the indigo production and that during the time cane sugar was produced at Tell Abu Sarbut also (some) indigo was produced, either as part of a rotation crop or as a second product, maybe to compensate for possible losses in the cane sugar trade or as a private enterprise on the side by people working in the sugar factory.

Conclusions

The sugar pottery consisted of fragments of sugar moulds and syrup jars, which were used during the production of cane sugar. The study of the sugar moulds resulted in the distinction of three different techniques with which these had been constructed: one which was thrown, a second one which had been built up in slabs of clay and was finished upside-down, and a third one which was built up straight. Fragments of moulds produced according to the first one were found in small numbers only, but of moulds constructed according to the other two techniques sherds were numerous. It could be established that stratigraphically the first method was the oldest, the second one was present in all phases, while the third construction method was a later introduction. The syrup jars were constructed according to only one method, but in this case rims provided an insight into a change of these through the phases of the production facility. The combination of these elements of information is useful for the study of material from other cane sugar production sites because it can provide an understanding of the extent of contemporaneous functioning of those facilities.

The presence of some wasters within the material points to the local production of (part of) this pottery, a common procedure in those times. Whether this production solely consisted of moulds and jars is not certain. It is possible that in the pottery also, if only maybe occasionally, pottery was produced for e.g. serving food in the factory or even direct use in the household. Some sherds from phases belonging to the sugar factory point to such a production. The number of fragments was, however, limited and as such does not indicate a direct adaptation in the repertoire of the pottery produced in the factory to household demands.

Based on historical information and practical reasons it could be concluded that the sugar moulds were not placed directly on top of the syrup jars during the production process, as is usually assumed, but that at least at Tell Abu Sarbut the moulds were suspended above the jars. A study of the profile of the sugar moulds in general through the ages, when comparing shapes from various regions, showed a clear development, from conical to oblong. This change in shape could via historical sources be linked to changes in the production process, when clayed sugar replaced that of simply repeatedly boiled sugar. In this new process it was more expedient to have the moulds placed directly on top of the syrup jar, because a constant flow of moisture was used, necessitating a change in shape. The development of the sugar moulds which were used during the production process at Tell Abu Sarbut might as well not be restricted to a simple change in the way these vessels were produced. Other, additional studies might reveal that these changes could be related to developments in the sugar production process proper and explain e.g. why a difference was observed in the contents of the sugar moulds between the two main phases of the cane sugar factory.

'Decorated moulds'

In addition to the sugar moulds and syrup jars, a number of fragments of other mould-like vessels were found in phases related to the cane sugar production process. These sherds have decorations with paint or engraving, which need further explanation, because it can indicate a special function of such pottery during this process. It is also possible that the decoration was merely meant as such, maybe linked to use in the household, because similar fragments were found in later phases of village habitation.

'Scrubbing sherds'

A number of sherds had clear traces of rubbing or scrubbing on their surface. These 'scrubbing' sherds were identified as implements used to clean sugar moulds after usage during the production process of the sugar. This provides a useful tool for the identification of production sites as such, next to the presence of the pottery proper, which might in itself have been used in the household.

Indigo

Some sherds belonged to mould-like vessels with three holes in a vertical row on the side. These vessels were identified on basis of information from later historical sources as having been used during the production process of indigo. The presence of these indigo vats in phases clearly linked to the production of cane sugar provides evidence of the coexistence of these two agricultural products, confirming a link which had been surmised from the study of historical sources. Further research will eventually show

how the two products were related, not only in the technical sense of production, but also economically.

The identification of such vessels forms another indication that in the agro-industrial production in general in that period special pottery was used. This probably played a role as well in the household repertoire, like the sugar moulds and syrup jars, a factor which certainly needs further consideration and research.

Appendix 1: The phases (Figure 16)

Byzantine phase (Phase B)

This phase was attested in a sounding on the western part of the site and is there approximately one meter thick, situated on the virgin soil. It consisted of layers of clay with slightly reddish colored spots and as such could be mixed debris of the partially burned structure found on the central part of the tell to the east of the squares. On top of this were some solidly packed wash-layers of yellow colored clay with occasional fragments of mud bricks.

Phase 10

This phase is located directly on top of the Byzantine phase, which had been leveled for the construction of phase 10. The earliest deposits formed a package of irregular surfaces with ashy spots, which were covered by a layer of mud brick debris. The deposits associated with this phase form the remnants of the first cane sugar producing facility of which only a small part was excavated.

Phase 20

For the construction of this phase, the remnants of phase 10 were leveled to make a building surface. The walls associated with phase 20 consisted of foundations of stones, that were placed directly on this leveled surface of remnants of phase 10. On top of these stone foundations mud bricks were placed. The walls were part of the second sugar producing facility of which only as well a probably small part has been excavated (Figure 17). The excavated part comprised mainly a courtyard of the complex and some parts of adjacent rooms. On the eastern side of the excavation an entrance to this courtyard was found, which consisted of ashlar stones. In front of this entrance, on the outside, several rising surfaces were present that consisted of pottery sherds which were pressed in the clay of the subsequent levels. This points to the rising level of the surface on the outside in course of time and to an effort to keep the entrance, which in the winter must often have been slippery with mud, accessible by covering it with sherds. The entrance gave access to a courtyard with a number of rooms around it. In one of these an area with a carefully, and repeatedly plastered surface was found. In this surface a number of conical sugar moulds had been imbedded, which all had the lower part missing and had served as support for complete moulds when boiled cane juice was poured into these. The northern and western parts of this complex were leveled in a later stage of the occupation of the site, when walls for phase 70 were constructed. The deposits formed a package of regular fill consisting of brownish earth on top of a thin grey layer which separated this phase from phase 10. The package was covered by a layer of dark grey clay.

Phase 30

Small number of deposits consisting of debris on a surface associated with a mud brick wall, which had been built directly on top of part of phase 20. To what extent this represents a change in part of the internal layout of the factory or a (partial) rebuilding is not clear.

A possibility as well is that it concerned a readjustment of the ground level on the inside of the building due to the rising level on the outside. Most of this phase on the western side was removed in later times during the preparation of the surface for phase 70 and by more recent disturbances. The deposits consisted on the eastern side of the wall of a package of hard packed, grey-greenish clay on top of the layer of dark grey clay which separated this phase from phase 20. Above these deposits was a package of grey clay with some orange spots. On the western side of the wall, on the inside of a room, the deposits consisted of orange colored soil and an ashy layer on top of the aforementioned layer of dark grey clay. On top of the orange colored soil was a package of grey, crumbly clay with parts of hard packed clay. The top of this contained in a surface a number of small shallow dips of about twenty centimetres in diameter with some stones and a number of large chunks of burned clay.

Phase 40

Small number of deposits on a surface associated with a rebuilding of the wall of phase 30. Most of this phase was removed while building phase 70 and by more recent pits and disturbances, which were dug from what is now the surface. It is considered to be the last phase of the building that served as a cane sugar producing facility, although it is not clear whether cane sugar was still produced during this phase. The deposits consisted of a package of grey-greenish clay of debris of the wall under a package of layers of orange colored clay.

Phase 50.

This phase consisted of a package of courtyard layers, which were associated with a number of mud brick walls on top of unworked stones in the eastern part of the excavation. The deposits consisted of layers of hard packed clay, which contained many small sherds and spots of ash. The courtyard layers of this phase sloped against and over debris of phase 40 and were covered by a layer of hard packed grey colored clay. Part of this phase was removed by pits and recent disturbances.

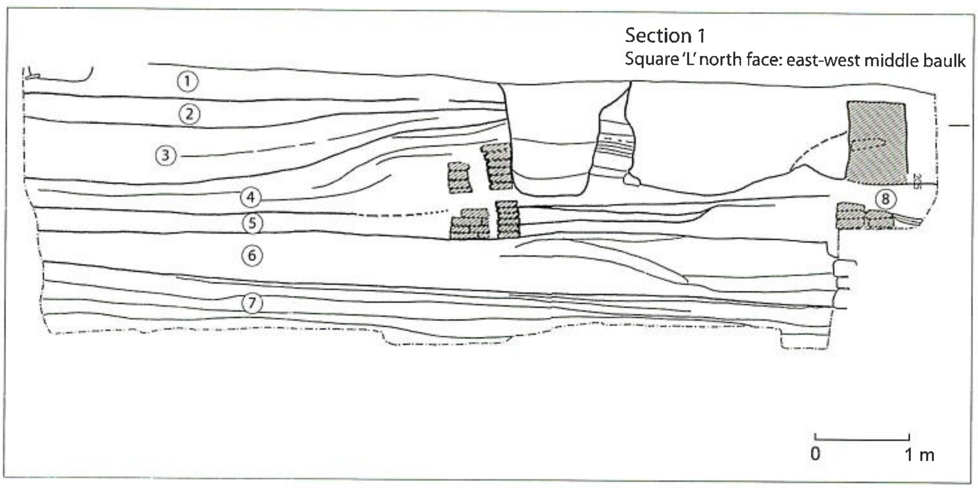

Figure 16. Phases 70–100.

Phase 60

Courtyard layers associated with mud brick walls placed on top of unworked stones in the eastern part of the excavation. The layers consisted of grey clay with small spots of charcoal and whitish specks.

Phase 70

Building phase in the western part of the excavation and extending beyond this in a westward direction. For the construction of this phase the soil was removed until the level of the second layer of mud bricks on top of the wall belonging to phase 20 and these now formed the foundation for the mud brick wall of the new building. The walls and floors of this building were covered with several layers of a yellow colored plaster.

Phase 100

Remnants of stone foundations and courtyard layers under and in the top soil of the present surface of the tell. The deposits associated with these remnants of walls consisted of layers of hard grey and yellowish clay under a layer of lose soil which constitutes the top soil.

From surfaces which could not be traced anymore due to the disturbed top soil or which have now eroded a number of rather regular shaped pits was dug, which might be associated with phase 100 or a possible later phase, of which no other trace is left. They had a rather regular, circular shape with a diameter of around 1.25 meter and usually straight walls. These pits could have functioned as latrines or could have served for storage, but the exact function is not clear. The pottery material from these pits was taken into account for the present study, but could not be ascribed to a specific phase since these are now all starting from what is at present the surface of the Tell.

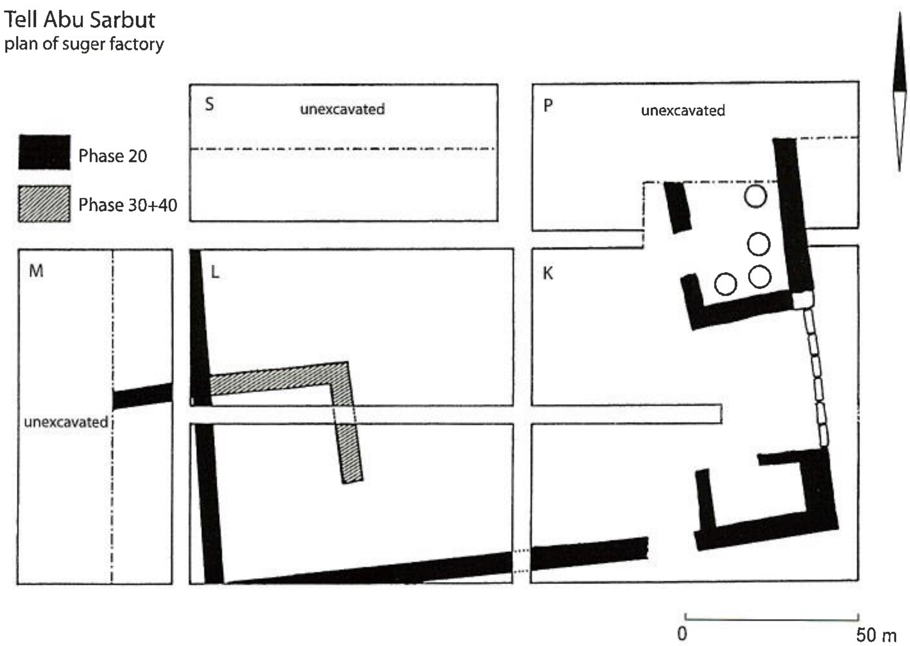

Figure 17. Plan of sugar factory.

These excavated phases did not show signs of massive fire or deliberate destruction, apart from the leveling of the surface for subsequent constructions. The complexes of the factory were probably left either after the installation had become unprofitable for the owners or as a consequence of local disturbances. The subsequent mud brick constructions were maybe as well deserted because of local circumstances or were just left after their maintenance had proven to have become too costly or too complicated and instead a new building would be constructed. This has a consequence that the material recovered from these phases consists of lost or left behind remnants, since the inhabitants would take with them everything deemed valuable when leaving their dwelling. Therefore hardly any profile or a complete piece of pottery could be recovered and since the squares did not include a dump, but were restricted to areas which were daily used, the number of larger fragments of pottery is limited as well. If the village used an area or areas as a dump, this was not encountered.

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Notes

1. The excavations were supported by the Netherlands Organization for Scientific Research (NWO).

2. The total number of excavated sugar pottery fragments from Tell Abu Sarbut is 94236. These were separated into two groups, one to be kept (12577 fragments) and one to be discarded (81659 fragments), this on basis of the presence or absence of decorations, or features which could give information about the way the pottery was made or looked like, such as rims, bases etc.

3. The location of Tell Abu Sarbut is 35° / 37' E.L. and 32° / 12' N.L. (Map of Jordan, 1: 250000 Sheet 1 Amman. Department of Lands and Surveys of Jordan, 1948).

4. Steuernagel (1925: 354). Rumors of the presence of gold treasures still persist and these should consist of coffers buried by Ottoman soldiers during their hasty retreat from the Ghor in 1918. Although no reports are known that such coffers actually have been found, it is known that a lot of golden coins were paid by the British to local farmers and tribesmen to assist in the war effort and as payment for fodder and that these often ended up in Ottoman hands (Falls 1964: 32).

5. Similar layers of ash and clay were reported from Tel Jezreel and were there associated with conical sugar pots (Grey 1994, p. 57).

6. This could have been the case on other sites as well and explain why the Abbasid period is hardly attested on many sites.

7. This phasing mainly corresponds with an earlier phasing made in the field in 1990, whereby phases 20-40 correspond with G-H and 50-100 with F-B (De Haas, 1992).

8. C14 dating was done in Groningen (The Netherlands) and are respectively GrN 17403 and GrN 17404, calibrated with a 2 sigma "confidence" level (95.4%).

9. Maqrizi 1911/23, IV, p. 253. The pottery kilns were called *qarmus* by him, a word derived from the Greek word kerameus as indicated by Dozy (1881). Probably *amtar* is the plural of *matr*, a standard measure and containing half a *qintar laithy*, i.e. 31 kg., and maybe an indication for a standard jar. Maybe it is linked to the word *matariyah*, i.e. a small jar with a high neck (Dozy 1881).

10. According to Dozy it is *ubludj* (Dozy 1881).

11. Maqrizi 1911/23, II, p. 76. The word *abludj* was also used for the contents of the mould to indicate a quantity, either in number (of *abludj*) or as a weight. According to Ibn Mammati, the *qintar djarwi* was used in the sugar trade, which weighed officially 96.7 kg. Even though the actual weight of a *qintar djarwi* might have varied, it seems hardly likely that an *abludj* would contain so many kilograms because it would be impossible to handle. It seems more likely that this *qintar djarwi* was used to weigh sugar in general either as a number of sugar loafs or parts of them.

12. See for some shapes of the fifteenth century and later e.g. Bordoy 1992: 101; Falsone 1974: 110; Régaldo-Saint-Blancard 1979-81: 172.

13. Description 1824, Etat Moderne T. II EE no. 24.

14. Figure 5.1 is based on an engraving from C. Suhr (Zucker Museum, 1989: 66).

15. The clay, which was used in this process had to be a special one. In Amsterdam, white colored clay was imported for this purpose from Rouen, which was then cleaned in the factory (Reisig 1793: 60). The sugar produced in this way is often referred to as clayed sugar. The method itself was known at least as early as the twelfth century and was described by Mattäus Platearius in a context of preparing sugar as a medicine. Chaff was put on the sugar and moistened with water. If little water was used, according to him, the sugar would remain yellow and if more would be used it would become white. He advised, however, still to boil the sugar again to clean it (Lippmann 1890: 174).

16. Description 1824, T. 17. p. 240. This probably also reflects the difference in scale of production, the factory in Egypt being a small one and the ones in Western Europe being relatively large and competing industries.

17. This section is partially an adapted version of previously published descriptions. See LaGro and de Haas 1990, 1992. The sugar moulds were then called sugar pots, but the former is a more appropriate term regarding its function and like this cannot be confused with other pottery used in the sugar production.

18. See also the variety of examples published by Whitcomb (McDonald 1992: 233-238) and Kareem (Kareem 1987: 130-187, 1989: 106-108).

19. Because of this wide variety in, mainly outward folded, rims it did not prove to be possible to compare systematically the rims from Tell Abu Sarbut with those of e.g. Tell Abu Gourdan. For the bases some tentative indications are given, but the number of these, which have been published from other sites is limited.

20. Also Franken found some rims that are ascribed here to SPI/C (Franken and Kalsbeek 1975: 151, fig. 42, no's 1–5).

21. Description 184, T. 17, p. 111. Also in Europe in the eighteenth century containers with three openings or taps were used in the indigo fabrication (Kasteleijn 1788: 22).

22. A possible combination of sugar and indigo production was considered at the beginning of the project at Tell Abu Sarbut (LaGro and de Haas 1988: 90). Whitcomb suggests a temporal precedence of indigo over sugar (Whitcomb 1992: 117).

23. The word *khitr* e.g. is described by Lane (1865) as "it looks like *wasmah*" and as "a certain plant with which one dyes .... himself...", and as such could be compared with woad, which was applied in the Occident for the same purpose.

24. In the seventeenth century indigo was formed on Barbados by newly arrived migrants and is described as a 'relatively foolproof commodity that fetched a good price". After earning enough money they could start to cultivate sugarcane (Dunn 1973: 168). In Santa Domingo indigo was grown in the seventeenth century to prepare the lands to be used later for sugarcane and eventually was replaced by this when prices fell due to overproduction and stable quality.

25. This phasing mainly corresponds with an earlier phasing made in the field in 1990, whereby phases 20-40 correspond with G-H and 50-100 with F-B (de Haas 1992).

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INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF TWO VESSELS FROM TEL YIN'AM

Harold Liebowitz and Joseph Yellin

Abstract

We report on the provenience of a Mycenaean stirrup jar (3K100566) and a Cypriot Base Ring II style jug (6M100667) from Tel Yin'am (Tell en-Na'am, map ref. 198-235) located in the eastern Lower Galilee. The regional provenience of the vessels was first determined by stylistic considerations. However, owing to the uniqueness of the finds it was decided to examine them by instrumental neutron activation analysis (INAA) in order to get a style-independent signature for the origin of these vessels. INAA confirmed that the Cypriote Base Ring II jug has a composition known from Enkomi, Cyprus. The stirrup jar has a composition that is similar to compositions observed for Mycenaean jars from the Argolid and Mycenae in particular. The attribution of these vessels to Mycenae and Cyprus respectively is important since the Mycenaean example furthers our knowledge of the size range and complex repertoire of motifs on Mycenae known heretofore, and the Cypriot BR II vessel furthers our knowledge of the chronological span of Cypriot imports into Palestine.

Introduction

Tel Yin'am (Figure 1) is a multi-occupational archaeological site, located due west of the southern tip of the Sea of Galilee, that was occupied from the Late Neolithic Period until the end of the Roman Period. The Late Bronze Age settlement has been associated with Yenoam, a site known from Egyptian New Kingdom texts, and associated with biblical Jabneel (Jos. 19: 33), a southern border town of the tribe of Naphtali, in the Iron Age.[1] The Palestine Exploration Fund surveyed the site in the nineteenth century. The site was subsequently studied by A. Saarisalo (1927) who conducted soundings at undesignated areas on the mound, and was later surveyed by Y. Aharoni, R. Amiran (Liebowitz 2003: 11,12), and then by Z. Gal (Gal 1992: 33). In 1975 the site was surveyed by H. Liebowitz, who subsequently conducted excavations at the site in 1976, 1977, 1979-1981, 1983-1989 on behalf of The University of Texas at Austin. Excavations at the site yielded evidence confirming occupation from the Late Neolithic to the Roman period, with gaps in occupation during Early Bronze I and II, Middle Bronze I and IIA, Late Bronze I, and the Hellenistic period (Liebowitz 1993, 1997).

The tell consists of a circular mound about 85 meters in diameter, rising about 12 meters above the Yavne'el Valley floor, and a larger terrace settlement that extends

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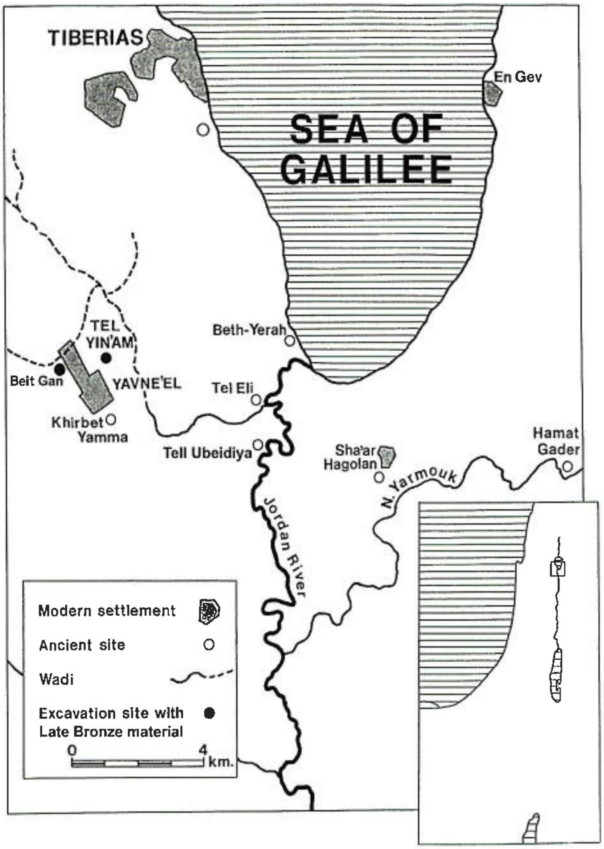

Figure 1. Location of Tel Yin'am.

approximately another 100 meters to the north and west and about another 50 meters to the south and east. The mound is eroded particularly on the west side,[2] and was evidently larger in past ages, although its size in antiquity is unknown.

Two interesting pottery finds were selected for analysis by INAA since their identification on the basis of stylistic criteria alone left identification of their ultimate provenience in some doubt: A unique, possibly "made to order,"[3] Mycenaean stirrup jar and a Cypriot Base Ring II jug. The Mycenaean stirrup jar (Figure 2), now in the Israel Museum, was unique because of its unusually large size for stirrup jars (Ht. 17.5, Diam. 22 cms.), and because of its atypical clustering of motifs. Moreover, since the sherds of the restored vessel were found in a destruction layer, and the typical Mycenaean lustre was now lacking, we initially considered the possibility that the vessel was a local imitation.[4]

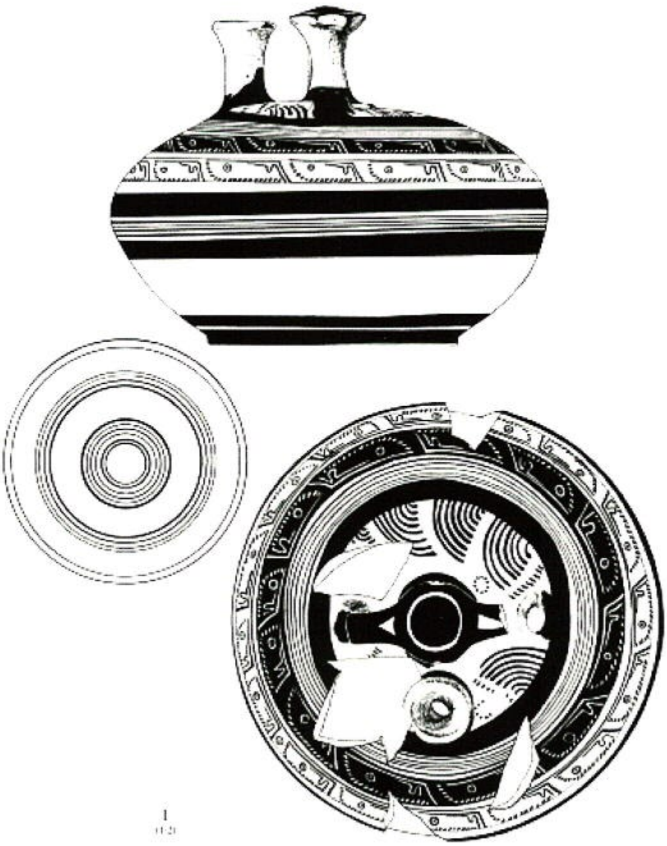

Figure 2. The Mycenaean style stirrup jar from Tel Yin'am.

Indeed it was the anomalous quality of this vessel which prompted Liebowitz to initially submit samples of this vessel to the Archaeometry Laboratory (Perlman and Yellin 1983) for testing at the The Hebrew University of Jerusalem. The vessel, reconstructed from shards was found embedded in destruction debris on the cobbled floor of a storeroom (Room 4) in Building 2 among locally-made jugs, kraters, storage jars and bowls dated to the thirteenth-century B.C.E. The Mycenaean stirrup jar was dated by Hankey along with the other Mycenaean vessels from the site, to Late Helladic IIIA2 to the end of Late Helladic IIIB1 (Hankey 2003: 155,156).

The Cypriot Base Ring II jug (Figure 3), found in a late thirteenth-century context in the smelter debris of Building 1, Room 1 belongs to a class common in Late Bronze Canaan (Liebowitz 2003: 159).[5] However, it is unusual because of the manner of treatment of the rim, with its convex pendant, and the relative rarity of Cypriot imports in the 13th century B.C.[6] Therefore, it too was subjected to INAA to ascertain that it was not a local imitation.

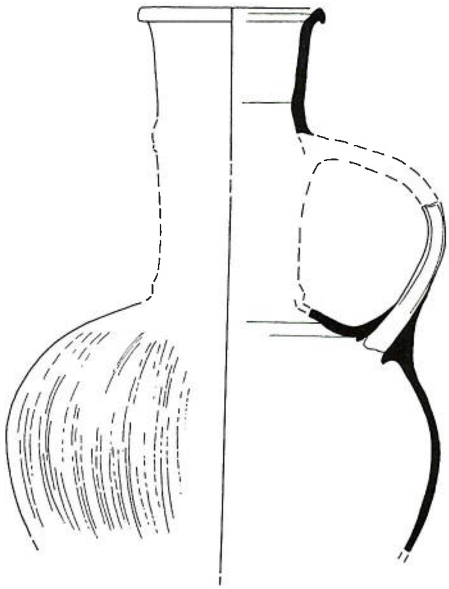

Figure 3. The Cypriot style Base Ring II jug from Tel Yin'am.

Tel Yin'am INAA data

The neutron activation procedures used for the Yin'am study are based on those described by Perlman and Asaro (1969) (see also Yellin 1984; Yellin and Cahill 2004; Yellin and Maeir 1992, 2007; Yellin et al. 1978). Table 1 gives the composition of the two vessels from Yin'am. Results of the INAA show that the chemical composition of the Mycenaean jar and the composition pattern of the jar are similar to that of known Mycenaean compositions and leave no doubt that the Mycenaean jar is from the region of Mycenae, Greece. What is meant by similarity is discussed below. The composition of the Cypriot pot matches that of a Cypriot reference group, leaving no doubt about the origin of that pot.

Reference compositions relevant to the present study are given in Tables 2 and 3. In Table 2 is a composition of a Mycenaean reference group (MYC16) reported by Karageorghis et al. (1977). This is a composition of 16 pot sherds from Mycenae, Greece. This reference was measured at the Lawrence Berkeley National Laboratory. The standard employed in these measurements was the one reported by Perlman and Asaro (1969) and that is the same standard employed in the current study. Also given in Table 2 is the composition of a group of 15 Base Ring pots from Enkomi, Cyprus, ENKBR15 (Gunneweg et al. 1983: 25). Table 3 gives the composition of a group of 138 Late Bronze Age Mycenaean vessels from sites in Northern Israel, MYBE lev reported by Zuckerman et al. (forthcoming 2010).[7] This group matches closely a reference group for Argive pottery consisting of 297 vessels reported in the same study.

Element[1]	3K100566[2] MSJ v	e	6M100667[3] BRIIj v	e
Sodium% (Na)	0.632	0.015	0.666	0.016
Potassium% (K)	2.1	0.4	3.6	0.4
Rubidium (Rb)	147	6	162	7
Cesium (Cs)	6.0	0.2	7.9	0.2
Calcium% (Ca)	11.3	0.2	4.7	0.7
Scandium (Sc)	18.97	0.04	18.45	0.04
Lanthanum (La)	28.77	0.28	43.21	0.36
Hafnium (Hf)	3.64	0.10	5.08	0.11
Tantalum (Ta)	0.765	0.015	1.333	0.072
Chromium (Cr)	265	2	130	1
Iron% (Fe)	4.73	0.04	4.90	0.04
Nickel (Ni)	202	17	95	16
Cobolt (Co)	26.31	0.24	22.8	0.22
Cerium (Ce)	57.61	0.87	87.8	0.5
Neodymium (Nd)	23.28	0.93	37.24	1.76
Samarium (Sm)	4.855	0.023	6.651	0.029
Europium (Eu)	1.079	0.020	1.493	0.048
Ytterbium (Yt)	2.48	0.06	2.99	0.12
Lutetium (Lu)	0.394	0.027	0.452	0.030
Thorium (Th)	10.1	0.08	13.98	0.09
Uranium (U)	2.40	0.08	3.00	0.10

1. Values (v) and measuring errors (e) are in parts per million except where noted otherwise.
2. MSJ is the Mycenaean style stirrup jar from Tel Yin'am whose registration is at the top of the column.
3. BRIIj is the Cypriote style Base Ring II jug whose registration is at the top of the column.

Table 1. The element composition of the Mycenaean style stirrup jar and the Cypriote Base Ring II jug from Tel Yin'am. e is the measuring error due to counting statistics.

Zuckerman et al. collected samples from 14 sites in Northern Israel including 10 non-coastal sites (Anafa, Ara, Dan, Hazor, Hula, Keisan, Megiddo, Yenoam [=Tel Yin'am], Yoqneam and Zefat). Little information on the pottery analyzed is given and only group averages are given for the compositions.

A set of mean values (M), one for each element, and a corresponding set of standard deviations (σ) characterize each of the reference groups. The σ, also called root-mean-

Element[1]	MYC16[2] M	σ	ENKBR15[3] M	σ
Na	0.615	0.139	0.84	0.06
Rb	145	14	156	10
Cs	9.19	0.76	8.0	0.5
Ca%	9.8	0.8	1.4	0.9
Sc	21.1	0.6	17.6	0.4
La	34.1	1.2	42.8	1.4
Hf	3.21	0.31	5.36	0.21
Ta	0.82	0.04	1.38	0.04
Fe%	5.16	0.18	4.82	0.17
Cr	221	14	135	10
Ni	223	19	81	15
Co	28.2	1.4	19.5	1.6
Ce	.	.	86.9	2.1
Sm	.	.	6.5	0.22
Eu	.	.	1.56	0.08
Yb	.	.	3.21	0.14
Lu	0.374	0.016	0.430	0.027
Th	10.7	0.29	14.1	0.4
U	2.28	0.09	3.34	0.80

1. Mean values (M) and standard deviations (σ) are in parts per million unless noted otherwise. A dot (.) means that the value was not measured/reported. Measured elements not reported for the reference groups are omitted for brevity.
2. Karageorghis, Asaro and Perlman 1972.
3. Gunneweg, Perlman and Yellin 1983.

Table 2. The composition of two reference groups relevant to the Yin'am pottery. Myc16 is a group of 16 Mycenaean III B ceramics representing Mycenae, Greece and Enkomi BR is a group of 15 Base Ring potteries from Enkomi, Cyprus. M is the mean value and σ is the standard deviation.

square-deviation, is the best estimate of random errors involved in the measurement of a mean (average) value of a sample of objects drawn from a population. Contributing factors to the σ are: random errors of measurement, natural homogeneity of the material (pottery), and variations in composition introduced by manufacturing. The natural homogeneity of the pottery can be determined in principal if we only know where the potter got his clay, for we could then make measurements on the raw material. In practice, we do not know what clay beds the ancient potter used. Lack of homogeneity

Element[1]	MYBE lev[2] M(138)	MYBE lev σ	3K100566 MSJ v	(M-v)/σ
Na%	0.60	0.14	0.632	0.2
K%	2.59	0.22	2.1	0.2
Rb	144	11	147	0.3
Cs	8.30	0.58	6.0	4.0
Ca%	9.52	1.43	11.3	1.2
Sc	20.1	0.8	18.97	1.4
La	30.4	0.8	28.77	2.0
Hf	3.71	0.32	3.64	0.2
Ta	0.77	0.03	0.765	0.2
Cr	227	36	265	1.0
Fe%	4.92	0.21	4.73	0.9
Ni	250	60	202	0.8
Co	26.7	1.6	26.31	0.2
Ce	62.4	1.3	57.61	3.7
Nd	25.5	0.97	23.28	2.2
Sm	4.71	0.20	4.855	0.7
Eu	1.11	0.03	1.079	1.0
Yb	2.66	0.07	2.48	2.6
Lu	0.42	0.02	0.394	1.3
Th	10.6	0.29	10.1	1.7
U	2.25	0.20	2.40	0.8

1. Values are in units of the standard deviation σ. A dot (.) means that a value for a reference group was either not measured or not reported. Measured elements not reported for the reference groups are omitted for brevity.
2. Zuckerman et al. 2010. Only elements common to the current study and Zuckerman et al. are shown.

Table 3. Comparison of the composition of the Mycenaean stirrup jar with Late Bronze Age Mycenaean vessels from Northern Israel.

introduced by pottery making practices is an unknown factor, but since provenience is almost always determined by comparing pottery to pottery, rather than pottery to clay, we take the overall homogeneity (natural plus man-made) as a single factor contributing to the σ. For many elements measuring errors are quite small in relation to the observed σ, and may usually be ignored. The measuring errors are given in Table 1 and are seen to vary from 0.2% for scandium to 19% for potassium.[8]

The significance of σ is as follows: On the basis of statistics alone and assuming that the element composition can be regarded as independent variables we can expect that 68% of the element abundances we observe could differ from the reference group mean by as much as +/- σ while only 5% could differ by as much as +/- 2σ. In Table 1 we have 21 measurements and this means that we can expect that 14 elements will differ from the reference group by up to +/- σ and only one element can be expected to differ from the reference group mean by more than +/- 2σ if the differences are due to chance alone. If the observed deviations differ significantly from the expected we conclude that the differences are real and that our potshard has a different composition than the reference group. It should be noted, however, that the element abundances measured cannot all be regarded as independent variables. There are correlations between some elements (for example, the rare earths lanthanum, cerium, neodymium, samarium, europium, ytterbium and lutetium) so that among the measurements shown in Table 1 some may be redundant because they are correlated to others and therefore add little information. But the safest rule of thumb is to include all elements measured with good precision. There are mathematical methods for dealing with correlations but these are not appropriate in the present case in which a single pot shard composition is compared to a reference group.

Results and discussion of INAA

Figure 4a, b is a plot of the Mycenaean stirrup jar (MSJ) composition given in Table 1 and that of the MYC16 reference group given in Table 2. The first thing to notice is that while many of the elements overlap in composition there are significant differences in the concentrations of Cs, Sc, La, Cr, Fe and Th. The second thing to notice is that differences are much smaller then would be expected if the pots came from regions differing in their geochemical histories. For example, in Figure 5 we show the contrast between the composition of CYP16 and the Cypriote group ENKOMI15. The differences are much larger than the differences between MSJ and MYC16 (e.g. Ca, La, Ta, Cr, Ni, Ce, Nd, Sm, Eu, Th, U).

The deviations for the Yin'am Mycenaean Stirrup jar (from the MYC16 reference group) are larger than expected for Cs, Ca, Sc, La, Cr, Fe and Th with an average deviation over all elements of about 2. Such differences may be accounted for by regional variations in the clay or by pottery making practices that introduced some minute differences in composition. Variations in composition in the region of Mycenae have been observed (cf. Zuckerman et al. 2010). The deviations for the Base Ring II jug (from the ENKBR15 group is approximately 1. Figure 6a, b shows the composition of the Base Ring II jug with the composition of the Enkomi Base Ring group. The result leaves no doubt that the Yin'am Base Ring II jug has its origin in Enkomi, Cyprus.

The result on the Yin'am Mycenaean stirrup jar should be interpreted as a variant of compositions observed in Mycenae and vicinity particularly as such compositions have

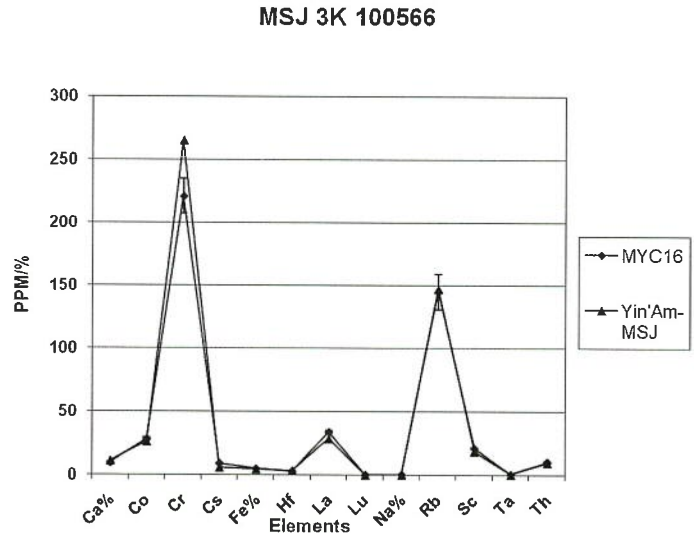

Figure 4a. Comparison between the Yin'am Mycenaean style stirrup jar elemental composition and the composition of a reference group of 16 ceramics from Mycenae, Greece.

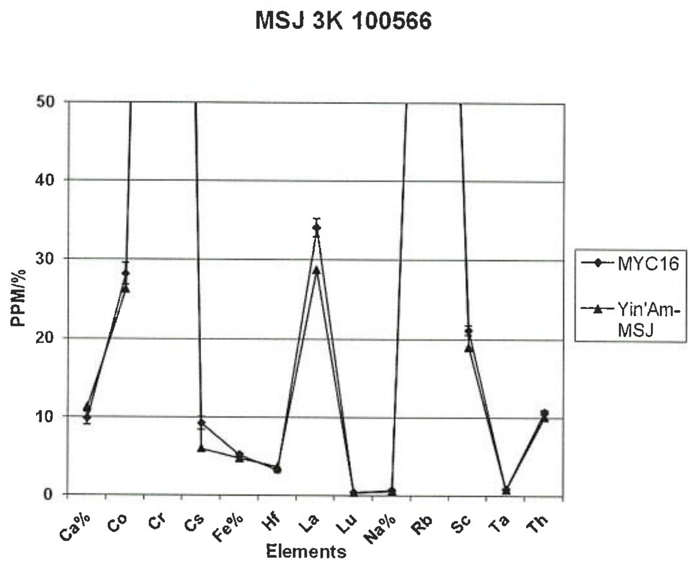

Figure 4b. An expanded view of a portion of Figure 4a.

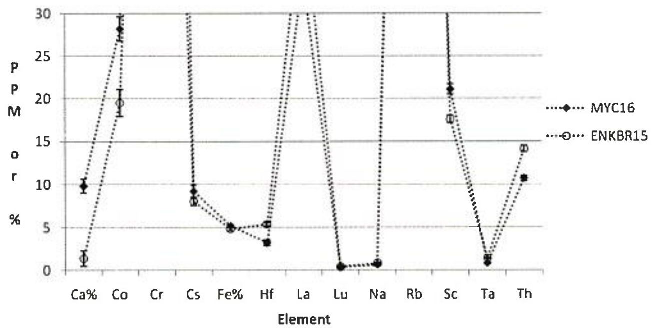

Figure 5. Mycenaean composition (MYC16) and Cypriote composition (ENKBR15).

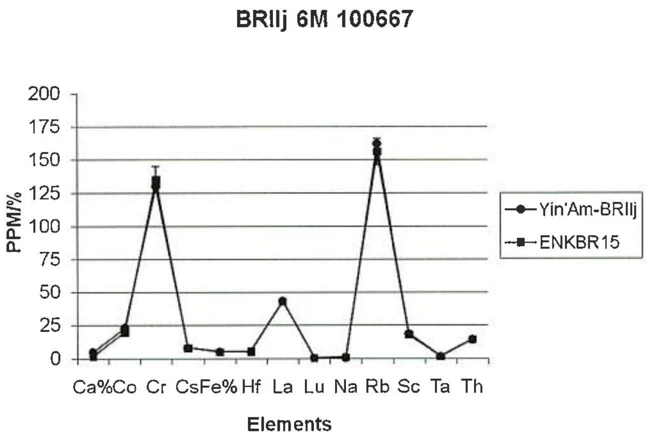

Figure 6a. Comparison between the Yin'am Base Ring II jug elemental composition and the composition of a reference group of 15 ceramics from Enkomi.

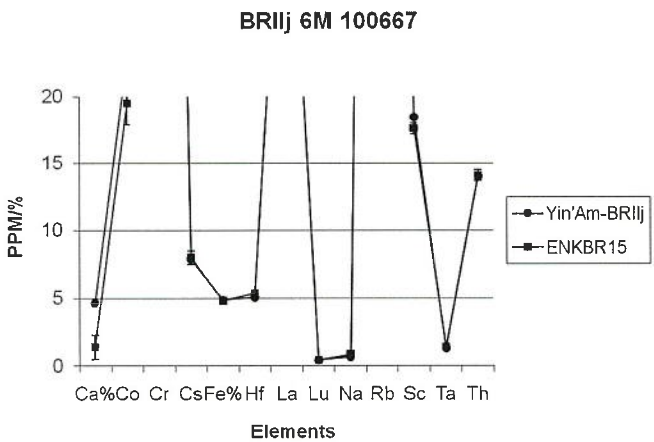

Figure 6b. An expanded view of a portion of Figure 6a.

not been observed in local Palestinian pottery. Furthermore, compositions of Mycenaean style pottery closely paralleling the composition of the Yin'am stirrup jar have been observed and shown to be from the Argolid, as for example the Pictorial (Chariot) Krater from Tel Dan (Yellin and Maeir 1992) and the Mycenaean pottery from Athienou, Cyprus (Yellin and Maeir 2007: 277–282).

Reference groups for Mycenaean pottery reported by other laboratories lead to similar conclusions. One group (Berb10) reported by Harbottle (1982) consists of 10 samples from Berbati. The other group (MycBerb39) of 39 samples from Mycenae and Berbati was reported by Mommsen, Lewandowski and Webber (1988). Harbottle (1982) and Yeh and Harbottle (1986) compared NAA results from the Brookhaven National Laboratory (BNL) and LBNL and concluded that the results are comparable while Yellin et al. (1978) showed that NAA results from Jerusalem were comparable to those of LBL. Thus, we can expect that the Jerusalem and BNL data should also be comparable.[9] Bearing in mind the limitations that there have been no direct calibration of the Jerusalem laboratory with the BNL and Bonn[10] laboratories it is nevertheless worthwhile to point out that the Yin'am stirrup jar composition compares with these two groups, Berb10 and MycBerb39 about as well as with MYC16. These results strengthen the conclusion that the Yin'am stirrup jar is from the Argolid.[11]

Figure 7a, b shows the composition of the Yin'am Mycenaean stirrup jar along with the group MYBE lev (Table 3). Small differences might be expected owing to the fact that the laboratories were not directly calibrated. we note that out of 21 elements five are in disagreement by 2 or more σ and of these four are rare earths. This may be the result of a systematic inter-laboratory error. One element only, Cs, is in very serious disagreement (4σ). The concentrations of the elements in the Yin'am Mycenaean stirrup jar are systematically lower than those in the group MYBE lev and for the few elements where this is not apparent the errors are relatively large and obscure this trend. Such a systematic difference may be due to dilution.

Results and conclusions

The composition of the Mycenaean style stirrup jar (Table 1) is close enough to the composition of the MYC16 reference group (Table 2) to suggest a common regional origin while the Cypriot Base Ring II jug (Table 1) matches a composition known from Enkomi, Cyprus (Table 2). These results are shown in Figures 4–6.

Confirmation of the foreign origin of these objects not only furthers our knowledge of the range of technique, style and decoration of these vessels, but also adds to our understanding of the widespread trade in international wares in the Late Bronze Age. Even a relatively small, rural site in the eastern Lower Galilee, such as Tel Yin'am[12], participated in international trade, even though this trade was apparently conducted by differing middle men, who brought other Mycenaean vessels and glass beads,[13] produced either in Beth Shean or in Egypt to the hinterlands, to be found at Tel Yin'am.

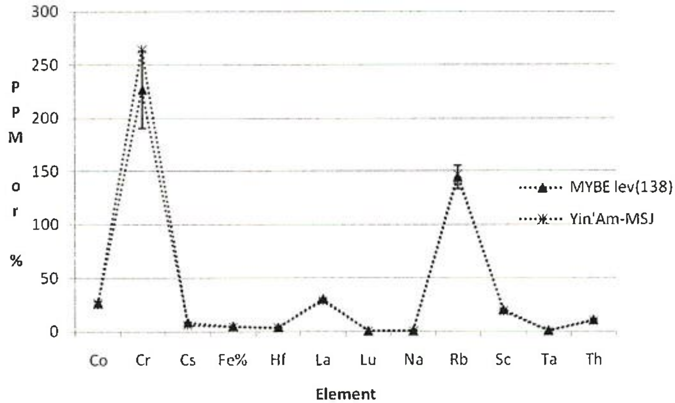

Figure 7a. Composition of the Mycenaean stirrup jar from Yin'am and a group of Mycenaean pots from sites in Northern Israel.

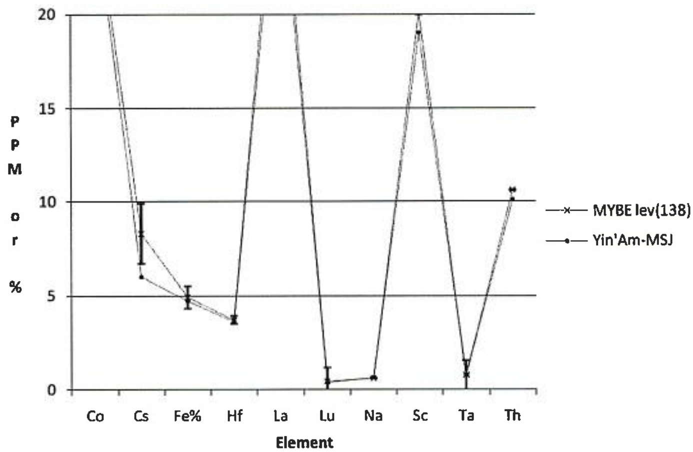

Figure 7b. Composition of the Mycenaean stirrup jar from Yin'am and a group of Mycenaean pots from sites in Northern Israel.

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Notes

1. Though identification with Yenoam has been questioned, Tel Yin'am is generally associated in the literature with the site of Yenoam as cited in New Kingdom Egyptian sources.

2. The founders of the contemporary settlement of Yavne'el in the early twentieh century took soil and rocks from the west side of the mound to use for home construction. Moreover, though Saarisalo did not identify the areas where he excavated, there is evidence that he excavated there, since an intrusive oil can was found at the base of a loose soil deposit (Liebowitz 2003: 8, 69).

3. For this suggestion, see Hankey 2003: 155, in Liebowitz 2003.

4. Indeed we found several examples of imitation Mycenaean pyxides in the destruction layers (Liebowitz 2003: 141-143).

5. Base-Ring II jugs and juglets were among the primary export pottery items from Cyprus, in that period (cf. Karageorghis and Olenik 1997: 223).

6. See Gittlen (1977) and Mazar (1990) cited in Liebowitz 2003: 159. However, Hankey elsewhere proposed that the importation of these LM (Late Mycenaean) III: B2 and LC (Late Cypriot) wares assumed to have ceased around 1225 BCE, continued to be imported until ca. 1200 or possibly later (cited in Dever 1992: 105).

7. Only elements which are common to Zuckerman et al. and the current study are shown.

8. Each element is measured with a different degree of precision depending on intrinsic properties of the element as well as on instrumental factors. INAA is not an ideal method to measure potassium. When the precision is as poor as it is here for potassium the measuring error dominates the observed spread in composition making such an element less useful as a diagnostic tool.

9. The fact that two laboratories are intercalibrated at a certain point in time does not mean that they continue to be so for all time. Instrumental changes, changes in experimental procedures and changes in standards employed could all lead to divergence of calibrations between laboratories. In the study reported here the Jerusalem and LBNL laboratories were strictly calibrated.

10. The Bonn laboratory is calibrated against the same multi-element standard (Perlman and Asaro 1969) that was used in the current study.

11. In comparing the Yin'am stirrup jar to the MycBerb39 group (not shown) we included the alkali metals Na, K and Rb. We point out that there is some evidence that these element concentrations may be altered by environmental factors that depend on the original firing temperature of the pottery (Buxeda et al. 2002) but if we eliminate these elements from the calculation it does not change the conclusion.

12. For discussions of Tel Yin'am's international trade, see: Liebowitz 2003: 2, 3, 153-163, 185, 285, 297, 298.

13. For discussion of these glass beads see Liebowitz and McGovern 2003: 181-190.

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THE NABATEAN PAINTED POTTERY IN THE DHIBAN PLATEAU, JORDAN: STATISTICAL MODELING AND ITS IMPLICATION FOR THE NABATEAN SETTLEMENT

Chang-Ho C. Ji

Abstract

The literature on Nabatean pottery and civilization has generated important information, but it has tended to center on the evidence from the regions of Petra and the Negev, rather than expand its consideration to the areas outside of this heartland and immediate vicinities. This article broadens the research scope to central Jordan by examining Nabatean painted pottery from the Dhiban Plateau. It shows that Nabatean evidence is abundant in the region and that central Jordan probably belonged to the direct sphere of Nabatean influence with many permanent Nabatean settlements. The Nabatean incursion into the Dhiban Plateau began late in the Hellenistic period and the region remained under the control of the Nabateans into the first century CE. The present paper also demonstrates that early Nabatean sherds have thick walls, walls wider than those for later forms assigned to the early Roman period. This thick-wall property of the late Hellenistic forms explains a large share of variance in sherd size and weight between early and late Nabatean painted ware found on the Dhiban Plateau.

Introduction

According to the literature of Nabatean archaeology, the discovery of Nabatean painted vessels at places outside of Petra and its immediate vicinity matters because their findings indicate that those places may have constituted part of the Nabatean kingdom or that had been at least visited by Nabatean travelers (Hammond 1973; Schmid 1997, 2004). This view is credible given that Nabatean pottery was probably not produced as trade commodity but chiefly for ordinary consumption.

Schmid (2004), in this perspective, studied the distribution of painted Nabatean pottery in Israel, Lebanon, and the Arabian peninsula. His investigation demonstrated that Nabatean painted ware were commonplace at ancient harbor or caravan sites such as Thaj, the Jawf Oasis, Hegra, Qaryat al-Faw, Marib, Gaza, Caesarea Maritima, and Antioch. Schmid contended that the so-called incense road is almost perfectly dotted by finds of Nabatean painted pottery, from its starting point at seaport sites in modern Oman and Yemen, through Saudi Arabia oases and station cities until its ending point

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at Gaza, affirming the frequent passage of Nabatean travelers along the ancient incense road. Nabatean use of other trade routes connecting Petra with the Persian Gulf is also suggested based on the common appearance of Nabatean pottery at Thaj and the Jawf Oasis.

In this article, I extend this line of discussion by presenting and analyzing Nabatean painted pottery from the Dhiban Plateau in central Jordan, roughly 200 km north of Petra. The Dhiban Plateau is critical for the understanding of Nabatean expansion to the north along the ancient King's Highway because the area is situated approximately halfway between Decapolis and the traditional Nabatean heartland at Petra. A recent review of archaeological reports from central and northern Jordan has explored the places that claim to contain Nabatean evidence (Ji 2009). The findings are mixed, showing that in northern Jordan Nabatean painted sherds are quite hard to find except for a couple of places like Madaba and Tall Jalul, notwithstanding the frequent discovery of Nabatean coins in the region of Amman. In contrast, there is rather clear architectural evidence of Nabatean activity in the Dhiban Plateau, such as remains at Aroer, Dhiban, Lehun, Mudayna ath-Thamad, and Umm ar-Rasas (Daviau, Mulder-Hijmans and Foley 2000; Homes-Fredericq 1989; Olavarri, 1965; Piccirillo 1988; Piccirillo and 'Attiyat 1986; Tushingham 1972, 1989). There are, nevertheless, reasons to be concerned about the lack of Nabatean pottery drawings in their excavation reports and the failure to analyze them according to chronology and decoration design.

My empirical data for this paper are constructed by aggregating the Nabatean painted pottery specimens from the four-year archaeological survey of the Dhiban Plateau (Ji and 'Attiyat 1997; Ji and Lee 1998, 2000). In this article, based on the Nabatean sherds from the survey, I argue that the Dhiban Plateau probably belonged to the direct sphere of Nabatean influence and was covered by Nabatean cities and villages whose dwellers engaged in trade as well as farming. Nabatean sherds also attest to their dominance over the region at least from the beginning of the first century BCE to the end of the first century CE. In addition, comparisons of early and late Nabatean sherds indicate that early forms are considerably different from late sherds in relation to their wall thickness, sherd size, and sherd weight. This finding may advance our approach to Nabatean painted vessels and their settlement history based on the pottery.

Data collection

The data for the present study was taken from the 1996-99 Dhiban Plateau Project, which surveyed the area located between the Wadi al-Mujib in the south and the Wadi al-Walla in the north (Ji and 'Attiyat 1997; Ji and Lee 1998, 2000). The survey area extended about 5 km west from Dhiban to the Sayl Haydan and about 25 km east from the same city to the Wadi Shabik. Although excursions were conducted into the eastern desert fringe and the canyons of the Wadi al-Mujib and the Wadi al-Walla, systematic survey was limited to the plateau proper, an area of approximately 250 sq. km.

For survey methodology, the survey area was divided into about 250 parcels of 1 km x 1 km. The 1 sq. km grid of a 1:50,000 scale Universal Transverse Mercator map was used to identify these 250 parcels, and each of these squares was assigned a sequence number. To take advantage of the larger 1:25,000 scale, the actual positions of the survey parcels were established on older Palestine regional topographic maps, ones produced in 1958.

Global Positioning System was used to increase the precision with which selected parcels were located. For each square, survey was conducted in an essentially east-west and south-north direction. Each 1 x 1 sq. km was surveyed in a systematic way, employing a series of 200 m spaced traverses. Put otherwise, each square was divided into five 0.2 x 1.0 km sectors, and the survey team walked or drove systematically through each sector. In this way, no part of the area was either under- or over-represented in the survey. Exceptions to this approach were the squares which contained previously-known or conspicuous archaeological sites. In such cases, the sites were examined first, and then their vicinity was explored.

The project identified 421 ancient sites in the surveyed region, covering the period from Early Bronze to Ottoman. Most germane for the present paper are the results related to the Hellenistic-early Roman sites in the region. In light of the survey, the Hellenistic era experienced a return of settlement and population following a short settlement gap in the late Persian period, an occupation intensification cycle continued to the early Roman period without any major disruptions (Ji and Lee 2007). Hellenistic sherds were found at 78 sites, and the Roman period was represented by pottery at 110 sites, corresponding to 18.53% and 26.13% of the total surveyed sites.

Painted sherds in the Dhiban Plateau

One principal intention of this paper is to offer an account of the empirical foundations using Nabatean painted sherds as to whether or not and when the Nabateans advanced to and settled in the Dhiban Plateau. I am also interested in exploring the likelihood of finding Nabatean sites in the region as well as changes in Nabatean settlement during the late Hellenistic and early Roman periods by referring to the Nabatean painted sherds.

In light of Schmid's study (1995; see also Parr 1970), Nabatean painted vessels can be divided into three broad types in terms of their chronology and drawing pattern with shallow bowls and plates as the most frequently found shape.[1] A first group (Phase I) is typical of deep bowls or plates that are rather heedlessly painted with decoration of either wavy or straight lines that cut across each other at the bottom of the vessels. A second group (Phase II) pertains to thin-walled bowls ornamented with "realistic" palm branches that radiate from the bottom of the vessels. The final group (Phase III), on the other hand, represents very fine vessels with short incurved rims whose interiors are marked with "stylized" palm leaves and rhomboid to trapezoid motifs that are connected with one another. The space between these decorative motifs is regularly furnished with dots and parallel or crisscrossed lines of the identical dark brown to nearly black colors.

Besides drawing pattern, Schmid's research (1995) at Petra demonstrates that Phase I vessels denote the earliest Nabatean painted ceramic corpus dated to the late second century BCE and the first half of the first century BCE. Phase II Nabatean pots are attributed to the period from the second half of the first century BCE to the first quarter of the first century CE. Phase III then runs from then on to roughly 100 CE. Schmid suggests that the Phase II-III transition took place during the reign of Aretas IV and that Phase III came to an end when the Nabatean kingdom was annexed as part of the Roman empire.

In addition, Schmid's survey (2004) of the Nabatean painted ware reported from Israel and the Arabian peninsular shows that the vast majority of these "distal" examples belong to Phases II and III, indicating the establishment of Nabatean control over the incense trade during the late first century BCE. Phase I vessels appear to be much sparser in these areas, however; they are reported from only two places in northern Saudi Arabia, the Jawf oasis and at-Tuwayr, a station site approximately 30 km east of Jawf.

Returning to central Jordan, the historical records suggest that by the mid third century BCE, the Nabateans already resided in the neighborhood of the Hauran in Syria and were merchants of aromatics with Ptolemaic agents in central Jordan (Graf 1983, 1992, 1994). In roughly 100 B.C., the conquest of Gaza by the Hasmonean king Alexander Jannaeus blocked Nabatean access to the Mediterranean coast. This event put a halt to Nabatean trade via the Petra-Gaza road on the one hand, but forced the Nabateans to advance northwards toward central and northern Jordan along the King's Highway (Negev 1969, 1976). This historical record leads to the expectation that the increase of Hasmonean power in the Gaza area at the end of the second century BCE set in motion a fundamental reordering of Nabatean trade priority and policy, shifting their primary focus from the Petra-Gaza road to the King's Highway region, probably including the Dhiban Plateau (Ji 2009). This advancement is likely to have reached its peak in the mid and late first century CE because textual evidence asserts that 'Abd-Maliku son of 'Obaishu, a Nabatean strategos, and his son La'muru, strategos, lived at Umm ar-Rasas in 41 CE (Graf 1994). The Nabatean strategoi were in charge of both civil and military administration of their districts, and their residence was usually associated with a sizable population and a couple of military units.

This historical remark awaits empirical scrutiny as to whether or not archaeological data join the textual evidence. In this vein, Nabatean painted sherds from the Dhiban Plateau are important because they can attest to the Nabatean presence in central Jordan. Thus, the probability of finding Nabatean painted sherds in the Dhiban Plateau is first addressed. In the data, of the 421 surveyed sites, 26 sites are found containing Nabatean painted sherds, a number equivalent to 6.18% of the total survey sites. These 26 sites, as Figure 1 illustrates, are widely spread over the Dhiban Plateau.[2] The sherds total 89, indicating that the 26 sites hold roughly three to four Nabatean

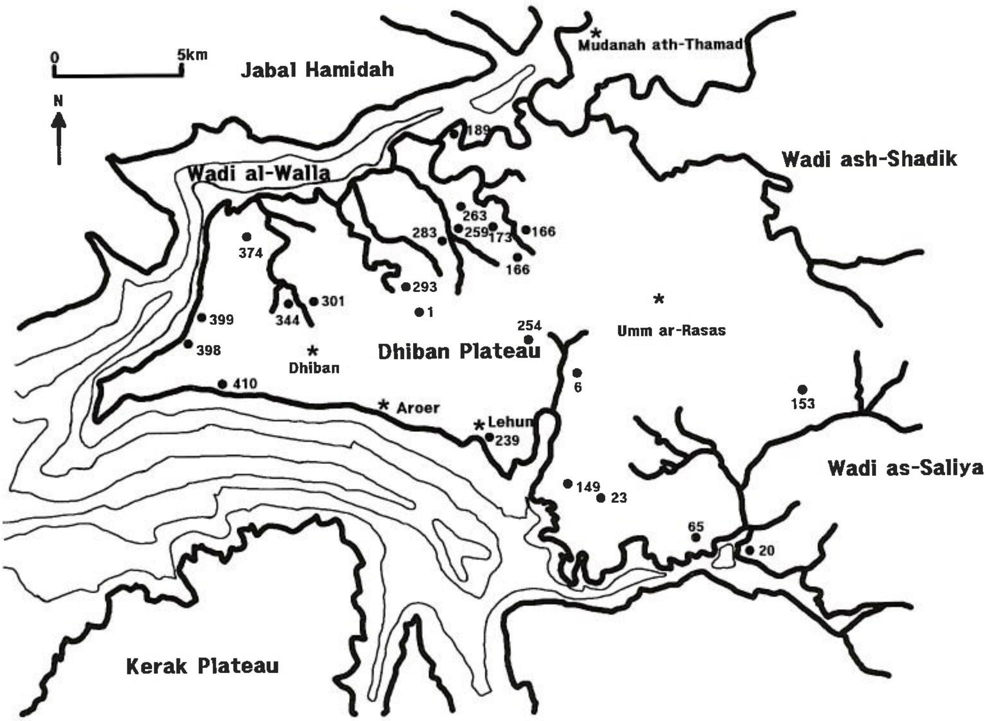


Figure 1. Dhiban Plateau Project: survey sites with Nabatean painted pottery sherds.

painted sherds on average. The count of Nabatean sherds from these 26 sites range from 1 to 28; 11 sites contain only 1 sherd, 8 sites have 2 sherds, and 6 sites have 3-10 sherds, while the survey of Khirbat Mudayna as-Saliya (Survey# 20) yielded 28 painted sherds, a count far greater than that found in other Nabatean sites (cf. Ji and ʻAttiyat 1997 for site description). This fact posits that Mudayna as-Saliya was a place of eminence during the Nabatean control of the Dhiban Plateau. On the other hand, the total number of sherds collected from the entire survey was 15,531, of which 1,906 were useful for the purpose of dating. This is to say that in the Dhiban Plateau, a chance to find a Nabatean painted sherd is roughly 1% and 5% of the entire and diagnostic surface sherd assemblage, in the order given, percentages slightly lower than the 6% for a survey site to hold at least one Nabatean painted sherd.

As a follow-up to this note, the Nabatean sherd samples are broken down into three groups in reference to their painting decoration and Schmid's division of Phases I-III. As shown in Figure 2, all three types of Nabatean painted pottery are well represented in the Dhiban Plateau. In the data, 84.27% (n = 75) of the samples belong to Phase III while Phase I is next with 11.24% (n = 10). Four sherds are linked with Phase II, which makes up 4.49% of the entire sample. The expectation taken from the textual

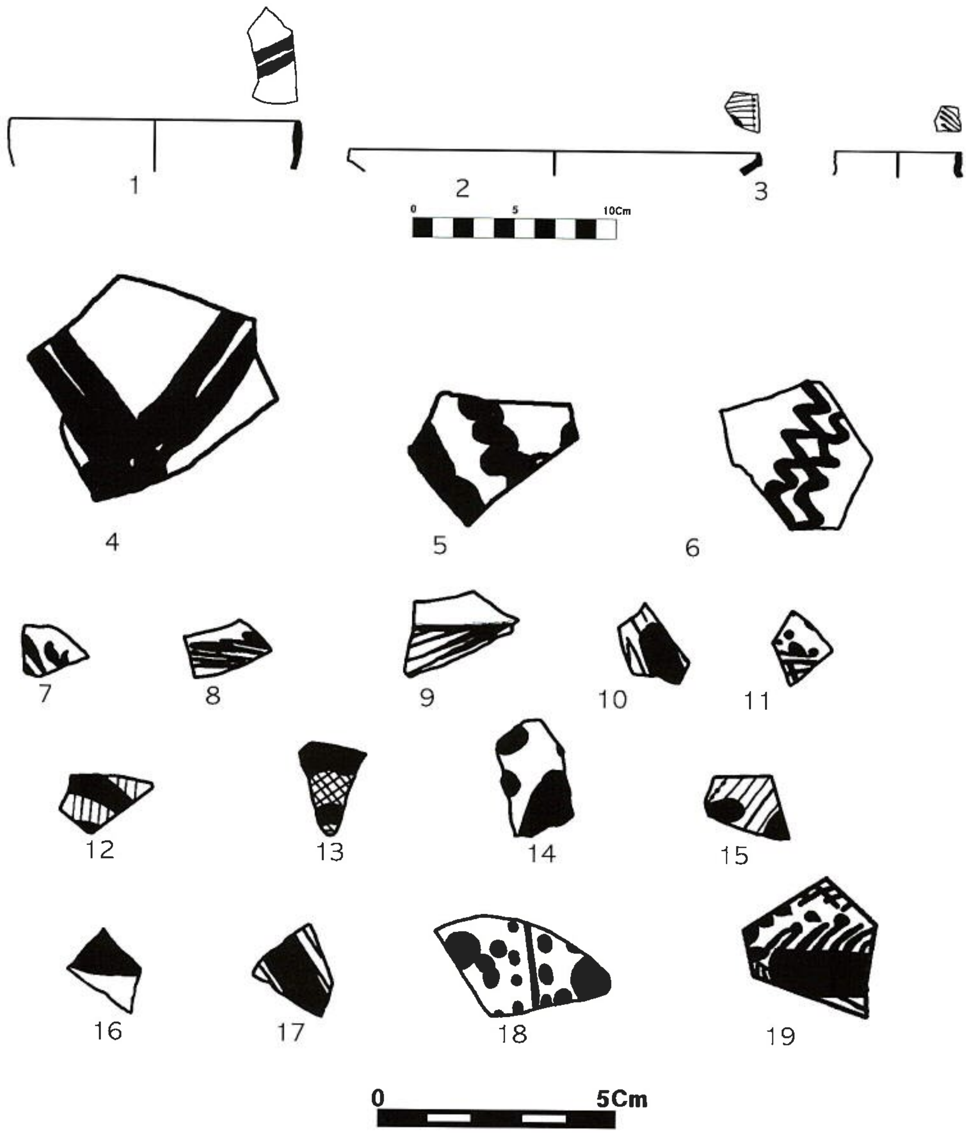


Figure 2. Nabatean painted pottery sherds from the Dhiban Plateau (Phase I: 1, 4-6; Phase II: 7-9; Phase III: 2-3, 10-19).

records was that Phase I sherds would be present in the Dhiban Plateau, but Phase III examples are more common than Phase I and II samples. As anticipated, Phase III is best represented in the Dhiban Plateau and Phase I sherds are also more or less commonplace in the region contrasting with the relative sparsity of Phase II pottery.

All this is to suggest that in view of Nabatean painted sherds, the Dhiban Plateau was first visited and occupied by the Nabateans no later than the beginning of the first century BCE and that the region subsequently witnessed rather dramatic increases of their activities in the first century CE following a short settlement abatement during the transition between the two centuries. For Mudayna as-Saliya, only one of its 28 painted sherds is classified as Phase I while Phase II examples are completely missing there. This being the case, the Nabateans probably reached Mudayna as-Saliya late in the second century BCE or at the beginning of the first century BCE but rose to eminence as a regional center much later in the first century CE.

This discussion leads to two additional observations of Phase I-III pottery. First, once the survey sites are grouped according to pottery phase, seven and four sites are found to contain Phase I and II sherds, respectively, whereas Phase III sherds come to light at 23 sites. Second, six of the seven Phase I sites include Phase III sherds as well, but only one site is identified as having a Phase II pottery sherd. Khirbat Museitiba (Site# 153) is so far the only site that bears all three types of Nabatean painted ware. This note engenders a couple of interim conclusions as to the Nabatean settlement in the Dhiban Plateau. In the region, most Phase I sites seem to have gone through a short settlement gap or interruption during the Phase II period before they were reused later in the Phase III era. Also, the Dhiban Plateau experienced a settlement intensification as demonstrated by the increase of new Nabatean settlement at the sites formerly uninhabited by the Nabateans. Finally, Phase III sherds appear to have spread over a greater area in the Dhiban Plateau than did Phase I and II pottery, exhibiting that the Phase III settlement was more dense and extensive than those of Phases I and II.

Before turning to sherd properties, I make a brief excursion to the relationships between rim type and pottery phase. The present sherd corpus includes 11 rim sherds, six belonging to the early Roman bowls with perpendicular or short-incurved rims and a carination between the body and rim (e.g., Figure 2:2; cf. Negev 1986: figs. 304-316, 368-376, 429-450). Four bowls with incurved rims constitute another dominant type of the assemblage, a form usually dated to the late Hellenistic period (e.g., Figure 2:1; cf. Guz-Zilberstein 1995). Figure 3 provides information about relationships between rim type and painting decoration in the Dhiban Plateau, showing that Phase I decoration is much higher in relation to bowls with incurved rims, contrasting with Phase III motifs tightly linked with perpendicular rims. All four incurved-rims pertain to Phase I in view of painting design; a reverse pattern applies to the ones with perpendicular or short incurved rims as Phase III motifs are found on five of the six examples. This comparison is clearly in keeping with Schmid's assertion (1995, 2001) that at Petra Phase I vessels typically have high walls and incurved rims but Phase II-III examples represent fine pottery with perpendicular or hort incurved rims. The example in Figure 2:3 is a cup or deep bowl characterized by its pinched rim and vertical collar whose shape is possibly reminiscent of Nabatean sigilata cups (Negev 1986: figs. 186-187) or the plain small jars ubiquitous at other early Roman sites (Netzer 1981: pl. 6:27).

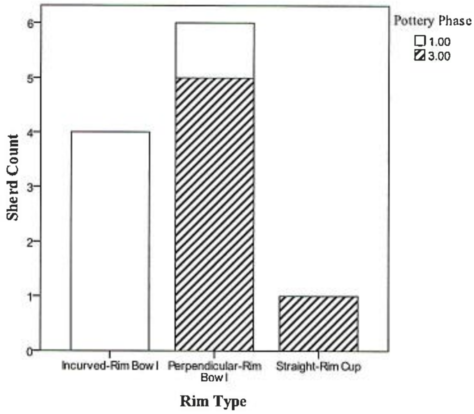


Figure 3. Relationship between Nabatean pottery phase and rim type.

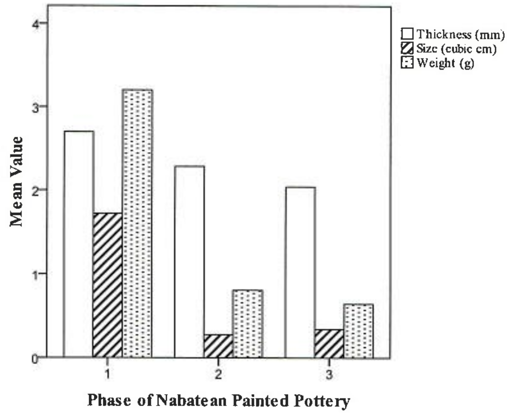


Figure 4. Mean sherd thickness, size, and weight by pottery phase.

Sherd properties

Sherd thickness

Apart from painting decoration, Schmid's study (1995) of Nabatean painted ware has offered another important observation regarding the vessels. In light of his study, a distinctive mark of the Phase I group is its "normal" wall thickness that is more or less equal to those of comparable vessels from other Hellenistic sites. That is, the body walls of early Nabatean pots tend to be greater in thickness when measured from one side to the opposite than those of the later forms. The average wall thickness reportedly decreases starting with Phase II vessels. This note has drawn scholarly attention but notably missing is the confirmation of objective and quantitative evidence.

Following Schmid's suggestion, this article attempts to examine and compare the thickness of Phase I-III sherds collected from the Dhiban Plateau. To this end, I approximated the body wall thickness by measuring four different parts of each sherd and averaging these measurements. For the selection of the four points, one edge of a body sherd was first randomly selected and then the center of the sherd was identified. Subsequently, two perpendicular lines were drawn with a pencil using the selected corner as one end of the first line, the two lines meeting at a right angle at the center of the sherd. In regards to rim sherds, the corner that was most remote from the top edge of the rim at a right angle was initially selected and then a vertical line was drawn from this corner to the top through the carination between the area from the body to the rim. I next measured the thickness of the body wall at the corner and the point where the vertical line joins the carination. A perpendicular line was then drawn to this first line at the midpoint of the first line, and I measured the thickness of the walls at the two endpoints of this second line. This approximation method was adopted because the accurate measurement of pot thickness is of great difficulty, especially in connection with those with rim or curved body surface. The estimation has yielded an average wall thickness of 2.13 mm with *SD* =.49.

To assess Schmid's theory that Phase I vessels are typical of thicker walls than the later counterpart forms, analysis of variance (ANOVA) was performed. The results show significant phase differences between Phase I and III pottery groups, F (2, 86) = 11.04, p <.0001. The Phase I group, as given in Figure 4, has the mean thickness of 2.70 mm (*SD* =.44), a value significantly greater than the 2.04 (*SD* =.43) for the Phase III group. Phase II sherds record the mean thickness of 2.29 mm (*SD* =.29); yet, this measure is not significantly different from the ones for Phase I and III groups. Put otherwise, Phase I walls are 1.2 and 1.3 times thicker than Phase II and III walls, respectively. These results are to say that Phase I vessels, as suggested by Schmid, have substantially thicker body walls than Phase III vessels and this suggestion has a 99.99% chance of being true and certain. The Phase I group is followed by Phase II vessels, but the incongruity between these two groups has failed to reach conventional levels of statistical significance at p <.05, indicating that the attenuation of Nabatean pottery walls was gradual and slow rather than abrupt, taking about one-hundred years from Phase I to Phase III.

Sherd size and weight

Besides wall thickness, a couple of additional issues are worthy of attention in relation to Nabatean painted sherds. During my fieldwork, I noticed that Phase I sherds tended to be greater in size or volume (the extent of occupied space; hereafter size) than Phase II-III sherds. Respective of this point, I estimated the size of the Nabatean sherds to see whether or not there are indeed significant differences among the three groups of Nabatean sherds. Granted their irregular shape, sherd size was measured in milliliters using graduated cylinders and then the results were converted to cubic centimeters for analysis. The entire sample shows a mean size of.55 cubic cm with *SD* = 1.16. Once classified by phase, ANOVA shows significant gaps among the three groups on sherd size, F (2, 86) = 24.01, p <.001 (see Figure 4). Phase I samples (*M* = 1.73 cubic cm, *SD* = 1.53) are of significantly greater size compared to Phase II (*M* =.28 cubic cm, *SD* =.17) and Phase III sherds (*M* =.34 cubic cm, *SD* =.35). In other words, Phase I sherds are seven to eight times larger than their Phase II-III counterparts, matching the field observation on sherd size.[3]

Another note pertains to the differences in sherd weight. Sherd weight has often been promoted as a more precise quantitative indicator for pottery studies (Rice, 1987; Solheim, 1960). The foregoing findings that Phase I sherds exceed Phase II-III ones in wall thickness and sherd size leads to the anticipation that, on the average, Phase I sherds are heavier than Phase II-III ones. Hence, each sherd sample was weighed and the ANOVA results pointed to significant differences across the sherd groups, F (2, 86) = 27.15, p <.0001 (see Figure 4). Phase I sherds are the heaviest with the mean weight of 3.20 g (*SD* = 2.92), which is much greater than the.81 (*SD* =.44) and.64 (*SD* =.44) for Phases II and III counterpart sherds, in the order specified.

Effect of thickness on size and weight

Noting that Phase I sherds differ from later Phase II-III forms, one may suspect potential linkages across wall thickness, sherd size, and sherd weight. For obvious reasons, I believe the most plausible hypothesis regarding the effects of Nabatean pottery phase on their sherd size and weight is that thin-walled Phase II-III vessels are more likely to break into small fragments (cf. Kirkby and Kirkby 1976; Solheim 1984). Phase II-III sherds in turn would weigh less than Phase I sherds due to their smaller-size fragments.

Based on this conceptual rationale, a series of regression analyses is in order in that wall thickness, sherd size, and sherd weight are incorporated as dependent variables in sequence. Specifically, I first estimate the importance of pottery phase to wall thickness, and in the second stage, sherd size is used as the dependent variable with wall thickness adopted as a covariate in estimating the effects of pottery phase on sherd size. In the final stage, sherd weight is regressed to sherd size to determine whether pottery phase counts in predicting sherd weight after taking into account the effects of sherd size. In the process, three control variables are included to tap some technical and geographical factors that might bear relationships to the dependent variables. They are the Core, Form, and Location variables. In details, I first examine whether or not a Nabatean sherd sample has the core (Core) and then whether it originates in the rim, body, or base (Form). The Core variable is considered because it can be indicative of firing atmosphere and low firing temperature; low-fired pots tend to split into more pieces than high-fired pots (Kirkby and Kirby 1976; Sinopoli 1991; Solheim 1984). Besides, the form of a sherd may matter because the base withstands a heavy superstructure and thus is made thicker and heavier than those from the rim and body areas (Rice 1987). The Location variable refers to the eastern and northern Palestinian coordinates of the survey sites that yielded Nabatean painted sherds.

The first model in Table 1 pertains to the prediction of wall thickness. Phase I sherds, as expected, have thicker walls than do Phase III sherds, uniquely accounting for 18% of the variance in wall thickness (for brevity partial correlation coefficient is not reported in the table). The gaps between Phase II and III samples are not statistically significant, however. Besides the Phase variable, the eastern and northern coordinate terms are positive and significant, each explaining 6% of total variance. This finding posits that Nabatean sherds from the eastern and northern sites have thicker walls than those found from southern and western sites. The Core and Typology variables are statistically insignificant.

The second model in Table 1 shows that sherd thickness is expectedly associated with its size, which explains 5% of the variance in sherd size. Equally important, the Phase I variable continues to be statistically significant accounting for 9% of the variance, a ratio greater than the 5% for wall thickness. Base fragments tend to be thicker compared to those from the body area with 29% of variance explained.

Finally, in the last column, three variables stand out as significant. The overall effect of sherd size is impressive as anticipated, alone explaining 75% of the variance in sherd

	Sherd Thickness			Sherd Size			Sherd Weight		
Variables	*B*	*SE*	*r*	*B*	*SE*	*r*	*B*	*SE*	*r*
Constant	–3.76	2.25		–.33	2.81	–1.01	2.17		
East Coord.	.02*	.01	.25	.00	.01	.02	.00	.01	.06
North Coord.	.02*	.01	.24	–.00	.01	–.03	.00	.01	.04
Core	.00	.11	.00	–.06	.14	–.05	.07	.11	.07
Rim Sherd	–.27	.15	–.20	.25	.19	.14	–.10	.15	–.08
Base Sherd	.33	.33	.11	2.37**	.41	.54	1.58**	.39	.42
Phase I Sherd	.71**	.17	.43	.65**	.23	.30	.35*	.18	.22
Phase II Sherd	–.03	.23	–.01	–.11	.28	–.04	.20	.22	.10
Sherd Thickness				.29*	.14	.23			
Sherd Volume							1.38**	.09	.88
R Sq./Adj. *R* Sq.	.31/.25			.58/.54			.92/.91		
F	5.24**			14.03**			112.05**		
df	7, 81			8, 80			8, 80		

*$p<.05$;**$p<.01$; categorical variable: core (0 absent,+ 1 present), sherd form (1 rim, 2 body,+ 3 base), sherd phase (1 Phase I, 2 Phase II, 3 Phase III+); + referent group.

Table 1. Ordinary-Least-Squares Regression Analysis Summary Predicting Sherd Thickness, Size, and Weight.

weight. Sherds from the base are also noticed to be heavier than those from the body with 16% of the variance explained. The Phase I variable is another determinant of sherd weight with its coefficient in the positive direction accounting for 5% of the variance, indicating that Phase I sherds are heavier than Phase III sherds even after statistically controlling the effects of sherd form and size.

Having said that, for more evidence, Figure 5 illustrates the sherds' average weight per cubic centimeter by their phase utilizing bar graphs. The figure shows that Phase I sherds have the mean weight of 4.19 g per cubic centimeter (*SD* = 6.20), a value substantively greater than the 3.12 (*SD* =.74) and 2.65 (*SD* = 1.60) for Phase II and III sherds, respectively. This finding lends further support for the preceding results showing that Nabatean painted ware became lighter in weight over the Phase I-III period with a particularly sharp decline between Phases I and II.

The present results on phase differences in sherd traits, as Rice (1987) and Solheim (1960) asserted, raise questions with respect to a common practice in archaeological research that correlates the counts of surface sherds with the degree of settlement inten-

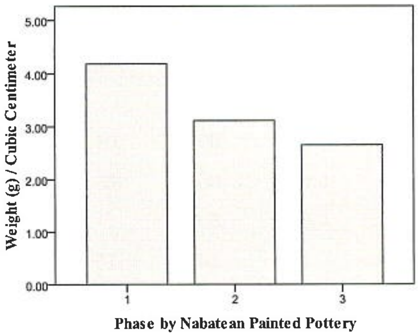
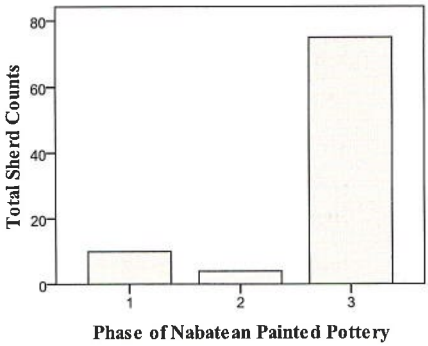


Figure 5. Mean weight per cubic centimeter by pottery phase.



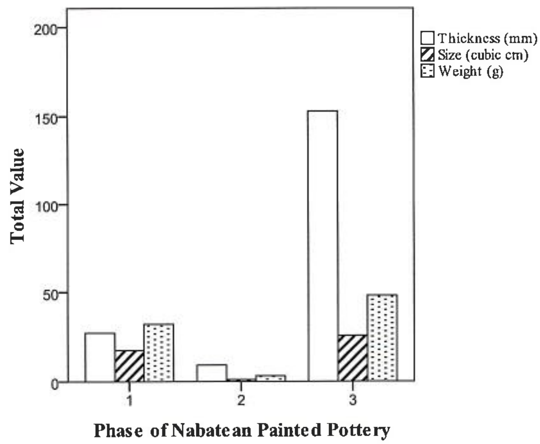


Figure 6. Total sherd count, thickness, size, and weight by pottery phase.

sity in a survey area. For example, one may argue that in the Dhiban Plateau the Phase III Nabatean settlement was seven to eight times denser or larger than the Phase I period because, as I said above, about 85% of the collected Nabatean sherds belong to Phase III whereas only about 10% is dated to Phase I. Hence, I here add up the size and weight of all sherds by phase, and Figure 6 summarizes the results with total sherd counts. The Phase I samples together have obtained the total of 17.25 cubic cm and 32.01 g for size and weight, respectively, while Phase II equals 1.10 cubic cm and 3.24 g, and Phase III, 25.67 cubic cm and 48.24 g. This comparison points to a far less pronounced disparity between Phases I and III relative to that drawn from sherd counts; the Phase III Nabatean settlement is now only 1.5 times greater than the Phase I one when measured by total sherd size and weight. In contrast, probably there was a rather dramatic settlement decline in the Phase II era granted that the totals of Phase II sherd size and weight correspond to only 4.29%-6.38% and 6.72%-10.12% of their Phase I and III counterparts, respectively.

In sum, referring to the total sherd count, size, and weight across Phases I-III helps to bolster the conclusion that the Phase III Nabatean settlement can be judged as the greatest in matters of settlement counts and population density. Phase III is followed by Phase I. The gap between these two periods is strikingly distinct if measured by sherd count. This hiatus becomes less conspicuous, however, once sherd weight and size are factored into our discussion, obscuring some blatant incongruities between the two phases based on the sherd count.

Nabatean settlements in the Dhiban Plateau

Moving from the realm of sherd properties to that of geographical and topographical attributes, I find that Nabatean painted sherds once more offer useful insights into the nature of Nabatean settlements in the Dhiban Plateau. Do specific environmental features distinguish archaeological sites with Nabatean painted sherds from those without the sherds? One way to answer this question is to examine what environmental factors relate to the presence or absence of Nabatean painted sherds at certain archaeological sites.

As to environmental factors, in my view, there are a couple of geographical and topographical factors that could have affected Nabatean decision to settle at a certain place. They are site location, site terrain, and site topography. Here, site location refers to the eastern and northern Palestinian coordinates. For terrain, survey sites are classified as located in a cultivated area or uncultivatable bedrock/rocky terrain. Topography measures whether they are situated in the plateau rim or a plain area in that the plateau rim is defined as a 2 km narrow band from the edge of the Dhiban Plateau. Site size is important because it can illustrate whether the Nabateans were urban/village dwellers or seasonal nomads who moved from one place to another simply erecting temporary buildings. The survey sites are therefore divided into small (less than 50 x 50 sq. m) and large-size sites (greater than 50 x 50 sq. m) based on the area of the archaeological remains currently visible at the sites.

Subsequently, binomial logistic regression was conducted using the presence or absence of Nabatean painted sherds as the dependent variable. The results are summarized in the first column of Table 2. The prediction model is statistically significant at $p < .0001$, explaining 18% of the total variance; the fact that 394 of 421 sites (roughly 94%) are correctly classified based on the predictors is also quite adequate. Looking at individual predictors, Nabatean sherds are found to be more closely connected with large archaeological sites representing cities or villages than small sites like watchtowers and campsites. The likelihood to find Nabatean sherds, however, has little to do with other aspects of site traits such as terrain, location, and topography.

This observation, however, may warrant further affirmation since its criterion involved two categories–presence or absence of Nabatean sherds, a criterion that is inappropriate in analyzing inter-site variances such as the counts of sherds from different sites. Hence, another way to address the issue under consideration is to model the counts of Nabatean sherds at each site instead of the dichotomous measure of presence or absence. For analysis, Poisson regression is suitable because the criterion variable now represents a count of Nabatean painted sherds by survey site.

The results in the second column of Table 2 show that Nabatean sherds are more frequently found in large sites as suggested by the preceding logistic model. Besides site size, the Poisson analysis also presents site topography and location as predictive of the counts of Nabatean sherds. Specifically, Nabatean sherds now seem to be more common at sites along the plateau rim compared to those in the central plain. Site location is significant as well. The coefficient of the eastern coordinates indicates that Nabatean

	Logistic		Poisson I+		Poisson II+	
Variables	*B*	*SE*	*B*	*SE*	*B*	*SE*
Constant	1.09	8.63	–22.90	4.71	–11.05*	5.33
East Coord.	–.02	.03	.09**	.02	.03	.02
North Coord.	–.01	.02	–.02	.01	–.01	.01
Terrain Cultivated	.65	.46	–.06	.24	.55	.27
Plateau Rim	.67	.63	1.62**	.39	1.22**	.40
Large	2.25**	.45	3.14**	.25	2.43**	.28
Pseudo *R* Sq.	.18		.32		.20	
Chi-Square	28.15**		218.20**		88.13**	
df	5		5		5	
Correct Pred. (%)	94					
N	421		420		419	

*$p<.05$;**$p<.01$; +Poisson I: entire site sample, Poission II: sample without Khirbat Mudayna as-Saliya; categorical variable: terrain (1 bedrock, 2 rocky, 3 cultivated++), site location (1 rim, 2 wadi, 3 plain++), site size (1 small++, 2 medium; 3 large); ++ referent group.

Table 2. Binomial Logistic and Poisson Regression Analysis Summary Predicting the Presence and Count of Nabatean Painted Sherds.

sherds are found in larger quantity in the eastern parts of the survey region than in the western areas.

As previously noted, however, Khirbat Mudayna as-Saliya has yielded 28 Nabatean sherds, a count four standard deviations above the mean of 3.42 for the Nabatean sites as a whole. In other words, from a statistical perspective, Mudayna as-Saliya is an outlier that substantially differs from the other survey sites because statistically only one thousandth of the total survey sites can fall into this category. This fact may signal that the finding above was possibly to some extent a function of Mudayna as-Saliya, even though it concomitantly points to its bearing for the Nabatean settlement in the Dhiban Plateau.

Accordingly, I have eliminated Mudayna as-Saliya from the data set and probed the robustness of the previous Poisson model. The results are summarized in the last column of Table 2. The results are only slightly different from those presented in the second column, with one point especially worth noting: the estimate for the eastern coordinates is no longer significant. This is almost certainly due to the location of Mudayna as-Saliya since it is at the southeastern corner of the survey area. Apart from this anomaly, all of the other estimates remain essentially the same, both the "large-size" and "rim-location" variables are once again significant in this follow-up Poisson model. That is, Nabatean painted sherds are found in greater quantities at large archaeological sites than at smaller ones. The results also provide evidence of the frequent appearance of the sherds at sites near or along the rim area of the Dhiban Plateau; they are less likely to be found in the plain area. This finding posits, reasonably enough, that the preceding analysis of Nabatean sherd counts was only partly affected by the inclusion of Mudayna as-Saliya whose effect was stronger in relation to the east-west site location than for other attributes.

For reference, I arrange the survey sites with Nabatean painted sherds by site type to further corroborate their connectivity to urban centers and villages and its implications for the nature of their settlement. During the project, all survey sites were divided for qualitative research into twelve groups based on their most distinct feature following the guidelines in the Madaba Plains Survey Manual (Herr and Christopherson 1997). The type of 26 survey sites identified as having Nabatean painted sherds is 62% city or village (n = 16), 15% isolated farmstead house (n = 4), and 23% watchtower (n = 6). It is important to note the prominence of cities and villages, as it attests to the significance of urban centers or village towns. Examples include Saliya (Site# 3), Mudayna as-Saliya (Site# 20), Ramah (Site# 23), Musheirifa (Site# 254), Umm Shujeirat Shuyab (#162), Qahqah (#166), Amuriya (#186), Qubeiba (Site# 283), Falha (Site# 293), and Dhuheiba (Site# 344), among many others, these representing some of the largest urban/village ruins in the Dhiban Plateau. In the Dhiban Plateau, the city/village residents are likely to have involved in farming activities besides animal herding granted that such sites are almost always near wadies or tributaries that are suitable for farming and horticulture. Also, because of their proximity to ancient routes, these cities and villages were well positioned to serve travelers and long-distance traders for rest and commercial transaction. The four house sites (Site# 173, 254, 259, and 410) further support a Nabatean engagement with farming and horticulture as do other several watchtower sites (Site # 167, 189, 301, and 399) located in cultivated areas. To summarize, this discussion supports the permanent-settlement thesis that the Nabateans settled in the Dhiban Plateau for permanent cause and involved in farming, animal herding, and commercial activities. The strong evidence for the urban context of the Nabatean sites is also striking and supportive of the permanent-settlement thesis.

Inter-phase analysis of Nabatean settlements

Following directly from the finding for the entire group of sherd samples, one would question whether or not the connection between the Nabatean sherds and urban/village centers would hold across the three subtypes of Nabatean sherds as well. Accordingly, in this final section, the subgroup of found sherds is linked with the geographical and topographical traits of the Nabatean sites by conducting a set of multinomial logistic regression analyses with the presence or absence of the sherd at the site as the dependent variable.[4]

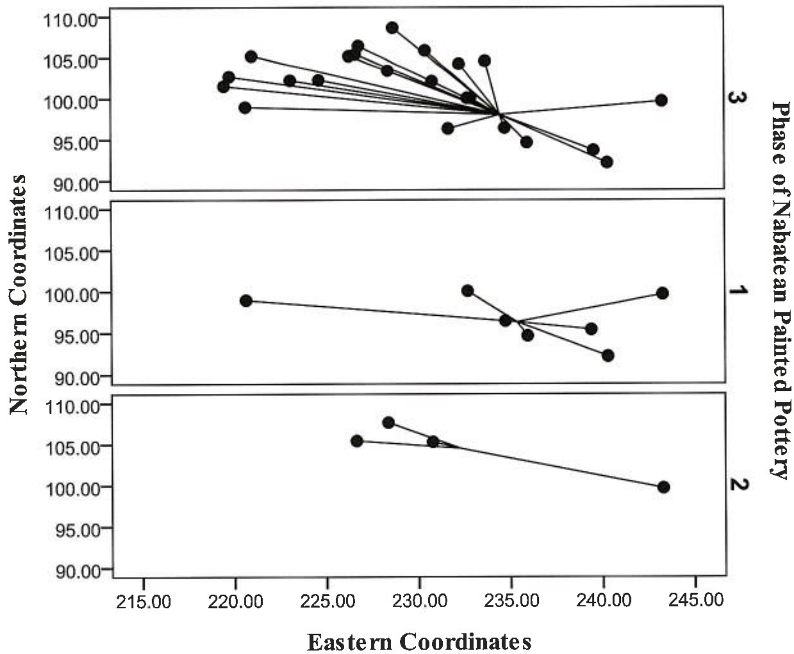


Figure 7. Scatterplots of Nabatean sites by pottery phase and Palestinian coordinates.

The results given in the left columns of Table 3 suggest that Phase I sherds, compared to Phase III sherds, are less likely to be found in the eastern and northern parts of the region. Phase I forms are also less closely associated with the sites near the plateau rim than are Phase III forms. Site size and terrain are statistically non-significant. Additionally, Phase II and III sherds are noticed to be quite similar in terms of their site location, topography, terrain, and size. The model displays good explanatory power accounting for 39% of the variance in the dependent variable.

The right columns of Table 3 determine if these findings continue to stand even after the Mudayna as-Saliya samples are taken out of the prediction equation. Removing Mudayna as-Saliya samples has changed the values of two estimated coefficients in the previous equation, most notably decreasing the size of the site topography and eastern-coordinate coefficients and making both statistically non-significant. In contrast, the northern coordinate remains salient, and its negative coefficient indicates that Phase I forms are more densely scattered in the southern part of the Dhiban Plateau compared to Phase III sherds. Once more, no substantive gaps exist between Phases II and III in conjunction with site geography and topography.

Equally telling, perhaps, to this quantitative analysis is plotting the Nabatean sites on scatterplots in that northern (on the vertical axis) and eastern coordinates (on the horizontal axis) are marked with a centroid (center of mass) for each pottery group. As

	Entire Sample				Sample without Mudayna as-Saliya			
	Phase I+		Phase II+		Phase I+		Phase II+	
Variables	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Constant	143.68*	64.93	–89.12	73.46	119.08	65.75	–92.27	74.11
East Coord.	–.25*	.13	.21	.21	–.19	.14	.23	.22
North Coord.	–.85*	.42	.41	.28	–.78*	.39	.39	.28
Cultivated Terrain	1.11	1.75	–.78	1.58	1.37	1.68	–.79	1.55
Plateau Rim	–3.83*	1.35	–.92	2.06	–2.51	1.93	–.47	2.40
Large-size Site	2.56	1.90	–.45	1.68	2.54	1.87	–.41	1.65
Pseudo *R* Sq.	.39				.40			
Chi-Square	26.39**				20.98*			
df	10				10			
N	89				61			

*$p<.05$;**$p<.01$; + the referent group for the dependent variable: Phase III; categorical variable: terrain (1 cultivate, 2 bedrock/rocky), site location (1 rim, 2 plain++), site size (1 large, 2 small++); ++ the referent group for the independent variables)

Table 3. Multinomial Logistic Regression Analysis Summary Predicting the Presence of Nabatean Painted Sherds by Phase.

can be seen in Figure 7, Phase I (the middle panel) and Phase III (the top panel) show a similar pattern of site distribution in two aspects: (1) both phases show a high density of settlement in the area of the southeastern part of the Dhiban Plateau and (2) both panels find the center of their site distribution roughly at the point of 97.00 and 235.00 for the northern and eastern coordinates, respectively. This centroid point corresponds to the location approximately 4 km southeast of Museitiba, 5 km northwest of Saliya, and 7 km northwest of Mudayna as-Saliya. Despite these similarities, however, Phases I and III markedly differ from each other in that the Phase III panel is peppered with a cluster of Nabatean sites in the northwestern quadrant where Phase I is void of any settlements. Phase II shows different patterning. In the bottom panel, the centroid of Phase II distribution is estimated to position at the location of 105.00 and 232.00 in the Wadi Amuriya area, about 1 km north of Qahqah, 1 km southwest of Umm Shujeirat Shuyab, and 7 km southeast of Amuriya. Another source of patterning for Phase II sites is their total absence in the southern part of the survey area including the Jumayl-Ramah-Mudayna as-Saliya region.

The patterns noticed on the scatterplots are largely consistent with the quantitative results above in that the first phase of Nabatean settlement started in the southeastern section of the Dhiban Plateau along the line of Museitiba-Ramah-Mudayna as-Saliya. Since the northern coordinate persists in all estimations and analyses, at this point it seems reasonable to suggest that the probability a Nabatean sherd being Phase I is clearly linked with the latitude of the site containing the sherd, as Nabatean sherds from the southern sites are more likely to belong to Phase I. Phase II experienced a shift of the axis of Nabatean sites, along with their decline in settlement intensity as a whole, northwest to the Amuriya-Qahqah region. In Phase III, the entire Dhiban Plateau may have for the first time fallen under the direct influence of the Nabateans, concurrently moving the center of their activities back to the east to the region of Umm ar-Rasas, Museitiba, and Mudayna as-Saliya. Put together, this helps us postulate that early in their settlement history, the Nabateans first began to populate the southern parts of the region and then expanded their presence and control to the north during the Phase II period, reaching a peak in the Phase III era, roughly mid first century CE.[5]

Conclusions

Referring to Nabatean painted sherds, I began this paper by asking the rather simplistic question as to whether the Dhiban Plateau belonged to the direct sphere of Nabatean influence, an area dotted by permanent Nabatean settlements, or represented a mere corridor connecting Petra in the south and the Decapolis in the north, a region every now and then traveled by Nabatean merchants and nomadic tribes. Counts of Nabatean painted sherds support the former view. As my data made clear, the research project collected a relatively large number of surface Nabatean sherds in the survey area, a quantity that might seem relevant to the suggestion that the Dhiban Plateau was in the realm of Nabatean influence rather than to simply point to the occasional passage of Nabatean travelers or caravans.

Another main story is that this Nabatean settlement started in the late Hellenistic period, no later than the late second century or the outset of the first century BCE, as the comparatively common appearance of Nabatean Phase I painted sherds indicates. The Dhiban Plateau remained under the control of the Nabateans into the first century CE when their occupation reached its zenith in population and settlement (cf. Ji 2009). Between these two periods a potential minor settlement abatement existed dated to the late first century BCE as posited by the relative sparsity of Phase II sherds in the region.

This paper also represents efforts to bring survey data to bear on research regarding the environmental aspects of Nabatean settlements in the Dhiban Plateau. My analysis of site environment reveals that Nabatean painted sherds are closely connected to major urban centers and rural villages and that they are less likely to be found at small campsites or temporary buildings, remains probably built and used by nomads for seasonal purposes. When taking into account pottery phase, site geography also emerges to offer an important insight for the historical evolution of Nabatean influence in the Dhiban Plateau. The Nabateans seem to have initially inhabited places on the southern part of the Dhiban Plateau when they arrived there in the late Hellenistic period before they spread to the north and the entire region early in the Roman period.

I neither claim to have explained definitively the history of Nabatean settlement in central Jordan nor to have drawn a final picture on variances in ceramic property between early and late Nabatean painted vessels. This is because the present paper is grounded in the surface sherds collected during an archaeological survey rather than through systematic excavations of Nabatean remains in the Dhiban Plateau. My study nevertheless reinforces variations detected by Schmid at Petra. Early Nabatean sherds (Phase I) are characteristically found to have thick walls, walls wider than those for later forms assigned to Phases II and III. This finding supports the view that in the mid first century BCE Nabatean vessels became more elegant and their walls became noticeably thinner. This fairly thick-wall disposition of Phase I accounts for a large share of variance in sherd size and weight I see between Phase I and Phase II-III forms. Phase I sherds, as compared to Phase II-III ones, are likely to be greater in weight and size due to their thick walls. This means that Phase II-III ware might break into smaller sherds than Phase I pots, suggesting that scholars should consider sherd counts as well as sherd weight and size in estimating the density of Nabatean settlements in a given region. I hope the work emanating from this paper will continue to further our understanding of Nabatean painted vessels and their utility for the study of the Nabateans beyond the kingdom's heartland at Petra.

Notes

1. Schmid proposed a further division of each pottery group into a couple of subgroups. To my judgment, however, this proposal still requires more stratigraphical corroboration to be used in relation to the chronology and dating of Nabatean settlements. Hence, the trichotomous typology is adopted for the present paper.

2. My gratitude goes to Bong-Jae Kim who drew the map and pottery in Figures 1 and 2. This paper is indebted to his interest in and contribution to the present research project.

3. Closely related to sherd volume is the extent of area. For area measurement, I initially copied the shape of each odd-shape sample by following the external facets of the sherd on a paper and imposed a series of rectangles over the drawing in order to break an otherwise odd shape into easily calculatable components such as rectangles, squares, and triangles. Finally, the areas of all individual rectangles and triangles were calculated, then summed together to estimate the total size of the sherd. Phase I sherds had a mean of 4.92 sq. cm (SD = 3.29), followed by Phases II and III with smaller means of 1.88 (SD =.87) and 1.58 sq. cm (SD =.90), respectively. That is, on average, Phase I sherds are about two-and-half and three times greater in size than Phase II and III sherds. The results are statistically significant, $F(2, 86) = 26.60$, $p < .0001$. This result is clearly in line with the analysis of sherd volume showing that Phase I sherds tend to be of greater size than Phase II-III sherds.

4. Poisson regression is inappropriate for this inter-phase comparison due to the dichotomous distribution of Phase I and II sherds: no sites yielded more than two Phase II sherds.

5. My discussion of the Phase III settlement centroid and its location may remain provisional to some extent because the Dhiban Plateau Project could not cover the northwestern quadrant of the Dhiban Plateau–the Umm ar-Rasas Historical Park and the area between Wadi ash-Shabik and Wadi ath-Thamad. Both regions belonged to two other archaeological projects during the survey period. In my view, the centroid of Phases II-III sites is likely to move slightly northward, but not much to the east, once the survey data from these areas are available, granted the reported early Roman-Nabatean (mostly Phase III) evidence at Mudayna ath-Thamad and its vicinity (cf. Daviau, Mulder-Hijmans and Foley 2000; Daviau et al. 2006). This fact accords with the present finding that the entire Dhiban Plateau came under the dominance of the Nabateans early in the Roman period. However, adding Nabatean data from these regions to the analysis is unlikely to significantly alter my note on Phases I since there is as yet no clear confirmation in regards to the discovery of Phase I Nabatean pottery at Mudayna ath-Thamad and Umm ar-Rasas.

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MIDDLE BRONZE AGE II POTTERY PRODUCTION IN THE WESTERN SHEPHELAH: COMPARING METHODS FROM TEL NAGILA, TELL ES SAFI /GATH AND TEL BURNA

Joe Uziel, David Ben-Shlomo, David Ilan, Itzhaq Shai and Aren M. Maeir

Abstract

The following paper examines stages in the châine opératoire of pottery production in the Middle Bronze Age II Shephelah (= Judean foothills, central Israel), through petrographic and macroscopic analysis of vessels from Tell es-Safi/Gath, Tel Nagila and Tel Burna. This study has led to several conclusions regarding the choice of raw materials and the techniques of forming and finishing vessels. This should be viewed as progress toward a comprehensive account of a regional tradition in Middle Bronze Age ceramic production with likely implications for pottery production further afield.

Introduction

The following study examines selected aspects of pottery production at various sites in the Shephelah (the Judean foothills in central Israel) during the Middle Bronze Age (ca. 1900-1500 BCE). Material from three sites in the Shephelah was examined – Tell es-Safi/Gath, Tel Nagila and Tel Burna (Figure 1). Thirty Middle Bronze Age samples from Tell es-Safi/Gath (Ben-Shlomo, Uziel and Maeir 2009) and 80 samples from Tel Nagila were petrographically and visually examined, while and additional 30 sherds from Tel Burna were visually examined. This study will attempt to delineate some trends in the characteristics of Middle Bronze Age pottery production in the Shephelah, including clay and temper selection, forming, finishing and firing techniques. We will try to determine whether or not there were common practices in pottery production in this region, and we will utilize the resulting conclusions in an attempt to reflect on pottery production in other regions in the Levant during the Middle Bronze Age.

A guiding principle of this study is that archaeologists – and more particularly, pottery analysts – should look beyond typology and examine production processes with equal care (cf. Franken 1971, 1974, 1991, 2005; Franken and Kalsbeek 1975; London 1985; London and Shuster 2009; Roux 2003; Roux and Miroschedji 2009). As many of these studies have done, this paper will attempt to recreate the major stages of the production process, using micro- and macroscopic evidence. However, as opposed to previous studies, which focus on a single site (e.g. Ben-Shlomo, Uziel and Maeir 2009), here we compare different sites in a specific region—the Shephelah—and during a specific time frame—the Middle Bronze Age IIB.

Tell es-Safi/Gath

Tell es-Safi/Gath is located in central Israel, approximately halfway between Jerusalem and Ashkelon, on the border between the southern coastal plain and the Shephelah (Figure 1). The site was settled virtually continuously from the Chalcolithic period until Modern times (see, e.g., Maeir 2008). Twelve seasons of survey and excavation have been conducted at the site, with eight excavation fields studied (Figure 2). A long sequence of periods are represented on the site, including strata dating to the Early Bronze Age II-III, Middle Bronze Age IIB, Late Bronze Age IIB, Iron Age I and Iron Age IIA and IIB (Maeir 2008). The Middle Bronze Age IIB has only been uncovered in Area F, near the summit, where a glacis and fortification wall/gate were revealed (Uziel 2008).

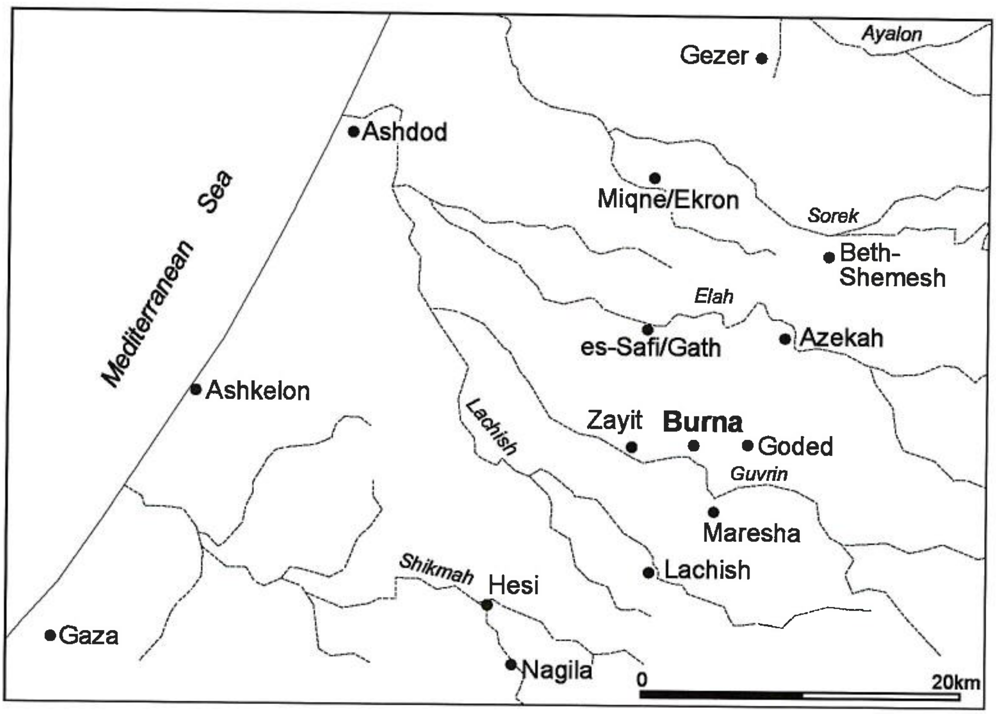

Figure 1. Map of the Shephelah (Judean Foothills), showing the location of the three sites studied in the paper and other major MB sites in the region.

Tel Nagila[1]

Tel Nagila lies approximately 32 km north of Beersheva and 28 km east of Gaza in the border zone between the southern Coastal Plain and the Shephelah (Figure 1). The tell covers a rectangular area of approximately 4 hectares (Figure 3). Two seasons of excavation were conducted at the site in 1962 and 1963, directed by Ruth Amiran and Avraham Eitan, on behalf of the (now defunct) Institute for Mediterranean Studies in Jerusalem. Four excavation areas were opened on the tell, with four more in the site's environs. From the excavations at the site, it is clear that the site was settled intermittently from the Chalcolithic to the Mamluk period (Amiran and Eitan 1966, 1993: 1066). The most intensive occupation occurred during the Middle Bronze Age IIB-C period. The excavations at the site revealed a complex fortification system, composed of a moat, rampart and wall, as well as a burial cave containing at least 55 interments and over 160 complete pottery vessels. However, probably the most important find of this excavation was the discovery of a series of four superimposed domestic strata, at the center of the mound (Area A, Str. VII-X; Uziel 2008).

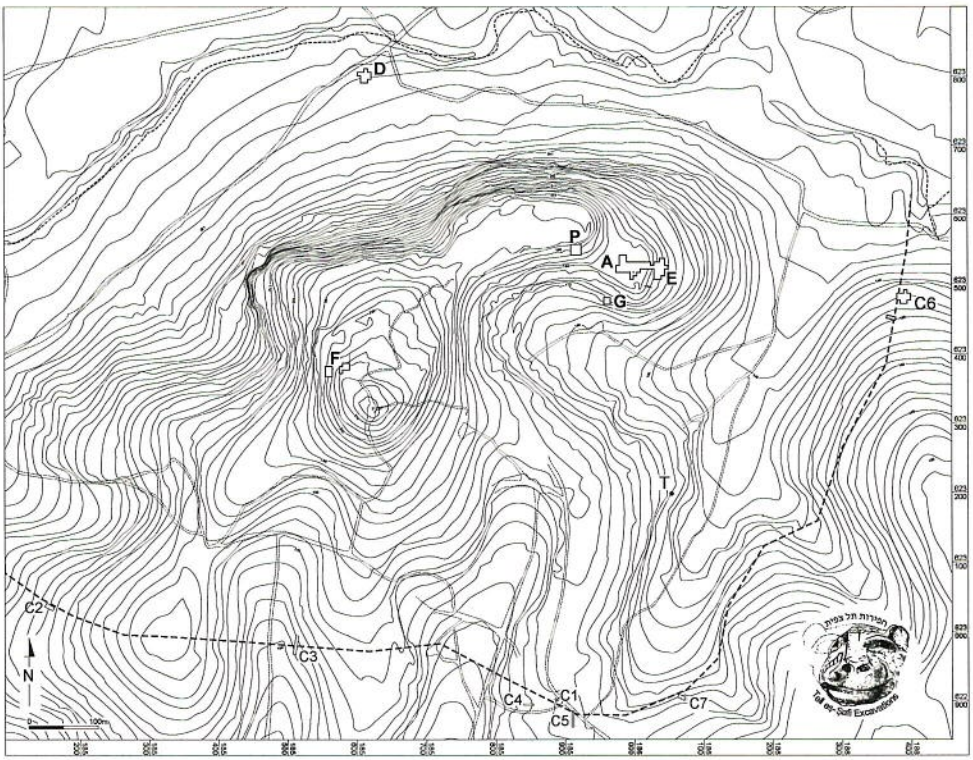

Figure 2. Map of Tell es-Safi/Gath, showing the location of excavation areas.

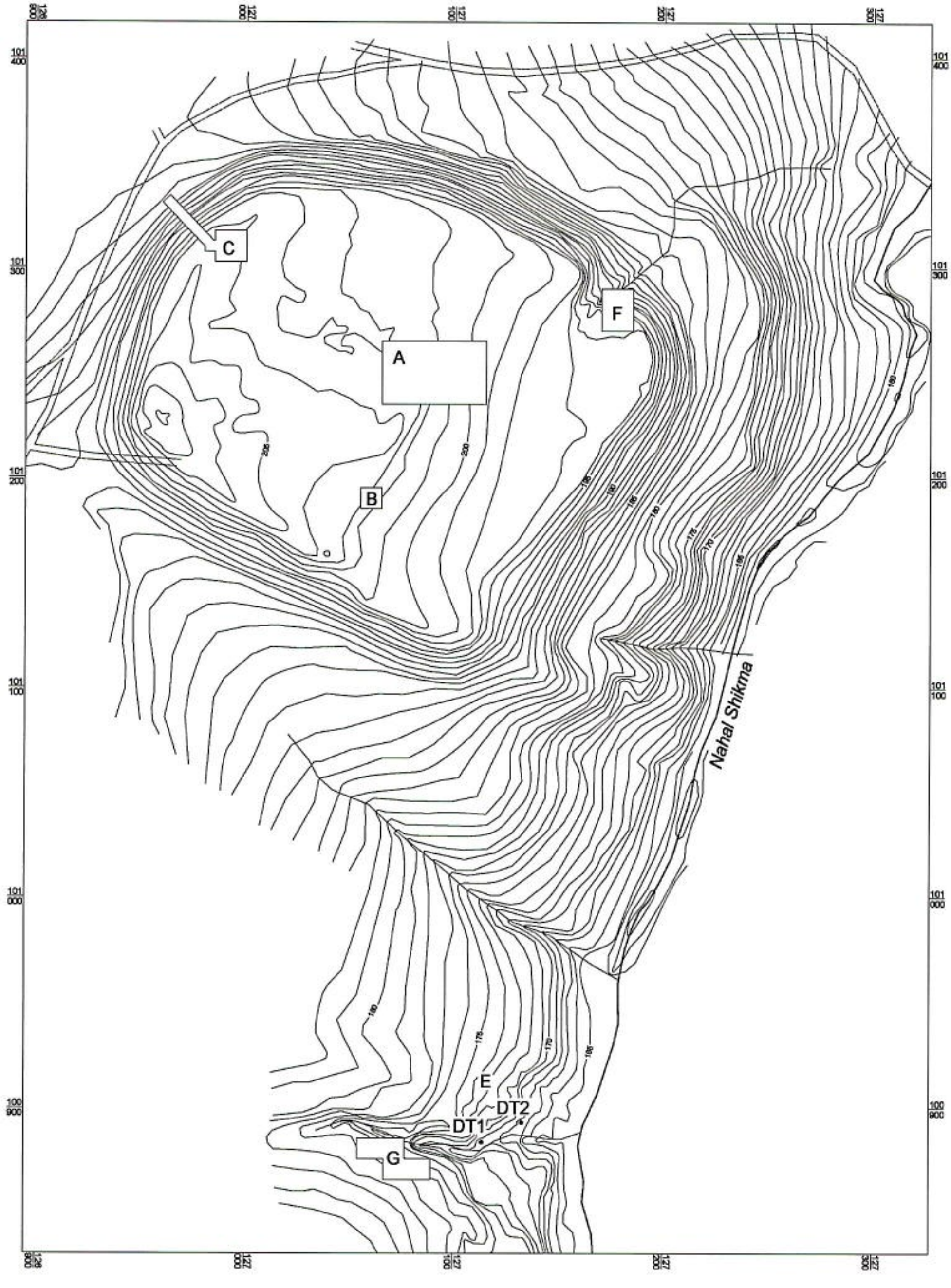

Figure 3. Map of Tel Nagila, showing the location of excavation areas.

Tel Burna

Tel Burna is located in the Judean Shephelah, along the northern banks of Wadi Guvrin, slightly north of Lachish (Figure 1). Previous surveys (e.g. Dagan 2000) conducted in the region suggest that the site was established in the Early Bronze Age II, and was settled intensively in the Late Bronze Age and Iron Age, and occupation continued in the Persian and Roman periods. Excavations have not yet been conducted at the site, despite the clear prominence of the tell and the accessibility of the remains, including apparent fortifications visible on the surface (Aharoni and Amiran 1955). The recent survey conducted at the site (Figure 4; Shai and Uziel forthcoming) revealed that the site was settled in the third millennium BCE, and continued to be settled throughout the Bronze and Iron Ages. According to the surface scatter of artifacts, it seems that the Middle Bronze Age settlement was approximately five hectares (Figure 4).

Description of the assemblages

The Middle Bronze Age pottery assemblages from the three sites (Figures 5-9) appear to date to the same general phase within this same period – Middle Bronze Age IIB/C (=MB II-III; for the different ways this period can be subdivided, see, e.g., Ilan 1995), with the material from Tell es-Safi/Gath dating to the early stages of the period, and the material from Tel Nagila covering the entire span of the period (Uziel 2008). Being a survey collection, it is not possible to closely date the material from Tel Burna to specific stages within the MB IIB/C (Shai and Uziel forthcoming). Typologically, all major vessel classes were studied: open and carinated bowls; lamps; kraters; globular and carinated cooking pots; goblets; jugs; dipper, piriform and cylindrical juglets; and storage jars (Figure 10). As will be seen below, no major differences were identified in the various stages of the *châine opératoire* of the respective pottery types. Therefore, the discussion below does not distinguish between types, unless noted otherwise.

Research methods

The two forms of analysis used in this study were Thin Section Petrographic Analysis (TSPA) and visual examination of the pottery. The visual analysis, which provided information on the forming and finishing of the pottery, was undertaken by examining each piece macroscopically. The TSPA provided information regarding the choice and preparation of raw materials, and the firing temperatures. TSPA samples were obtained by thin sectioning the pottery sherds. First a slice, several mm thick, is cut from the sherd. One side is flattened and affixed with transparent epoxy to a microscope slide. After hardening and drying, the exposed side is shaved down to a thickness of 0.03 mm (30 microns) in which most of the minerals are transparent. The slides are examined through a petrographic polarizing microscope (in this study Nikon and Zeiss [for photography] models were used, with magnifications of X25-X400).

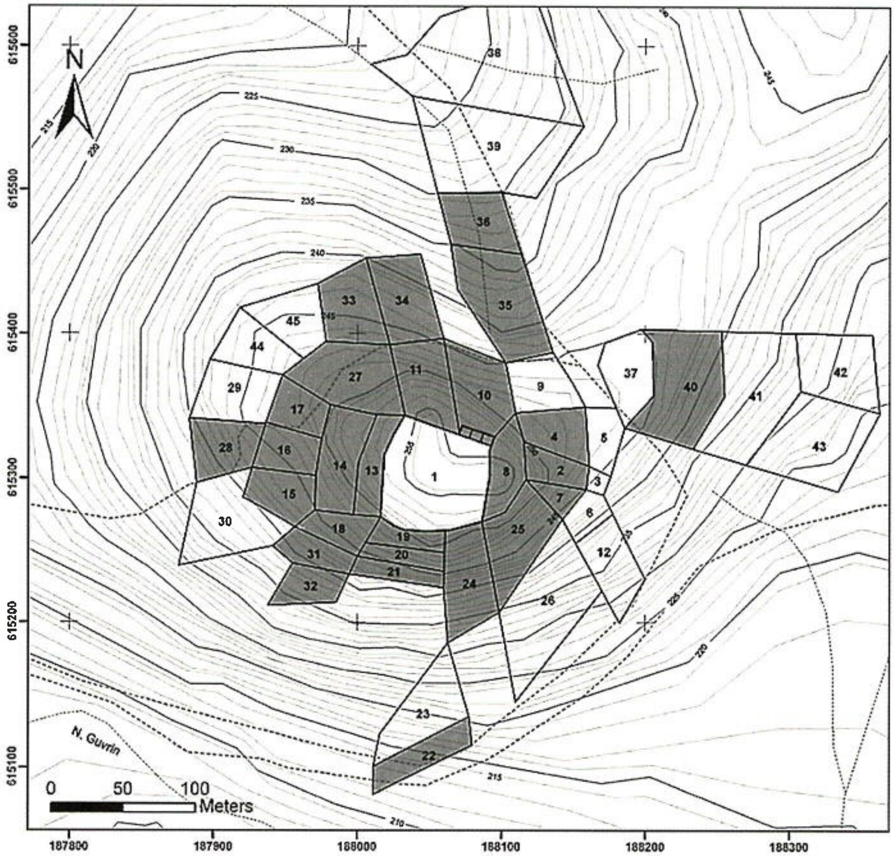

Figure 4. Map of Tel Burna, showing the surface scatter of Middle Bronze Age artifacts (based on surface survey).

The fabric description of the slides includes: general characteristics of the matrix (when identified as calcareous, ferruginous etc.), optical activity, inclusion spacing, percentage of voids and a general description of the silt component of the matrix.[2] The local soil type is defined when applicable (mostly according to Goren 1996; Goren, Finkelstein and Na'aman 2004; Goren and Halperin 2004 and according to soil maps: Dan et al. 1972; Shahar et al. 1995). Non-plastic inclusions are listed according to mineral, including percentage (of the slide area, with reference to percentage charts; e.g. Bullok et al. 1985), sorting, size ranges, texture, shape and various special features, such as cracks in crystals etc. Components under 1% of the total slide area are termed as "several", "rare" or "very rare" according to their relative frequency. Finally, other features noted are: orientation of inclusions, shape of voids[3], decomposed material and organic material.[4]

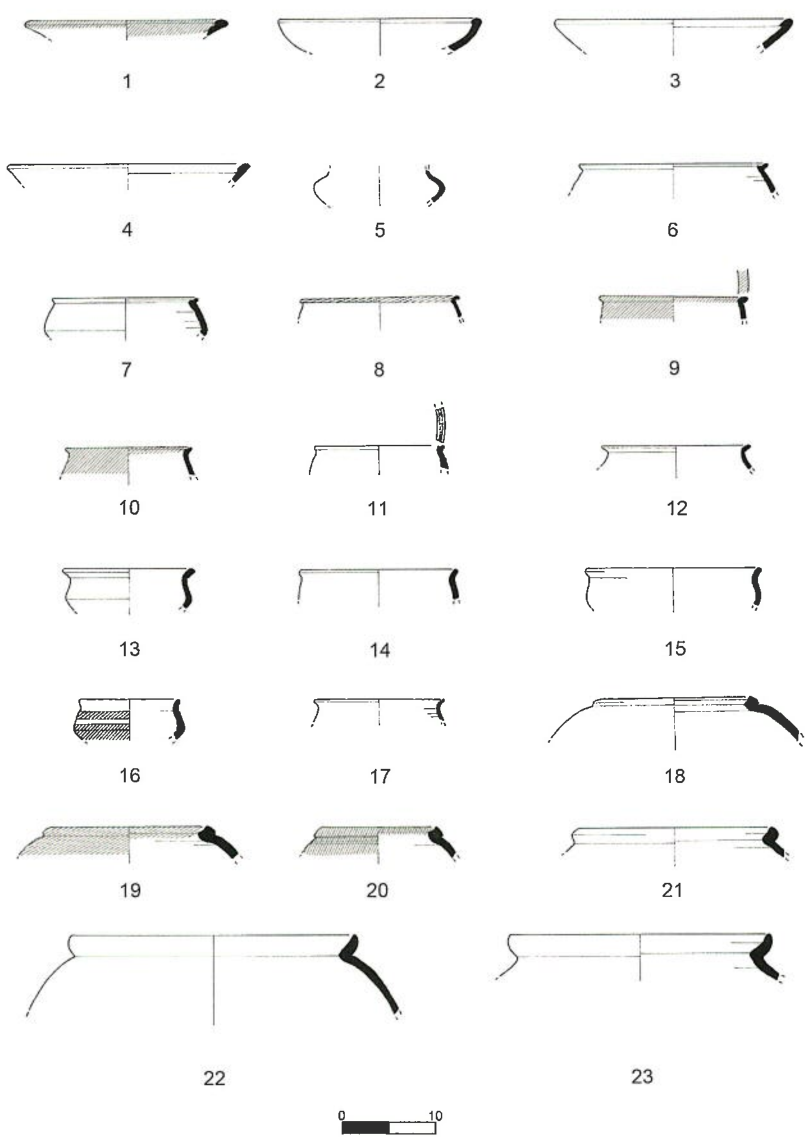

Figure 5. Selected Middle Bronze Age IIB pottery from Tell es-Safi/Gath.

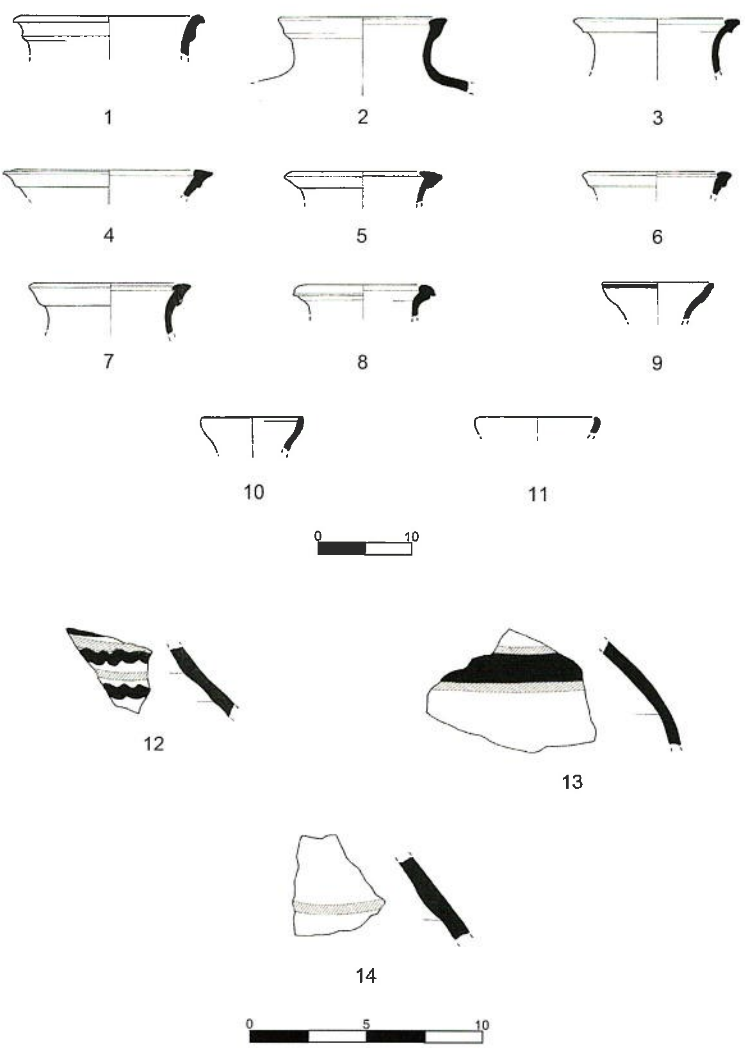

Figure 6. Selected Middle Bronze Age IIB pottery from Tell es-Safi/Gath.

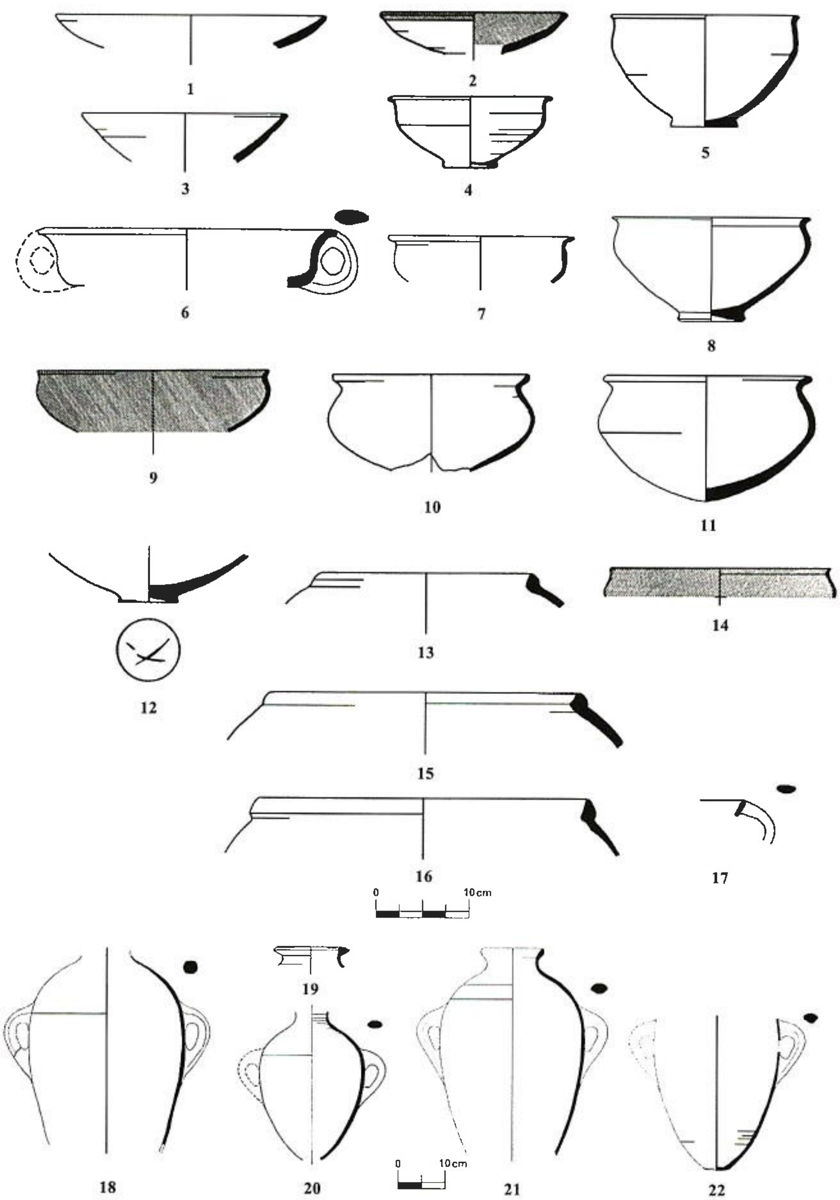

Figure 7. Selected Middle Bronze Age IIB pottery from Tel Nagila.

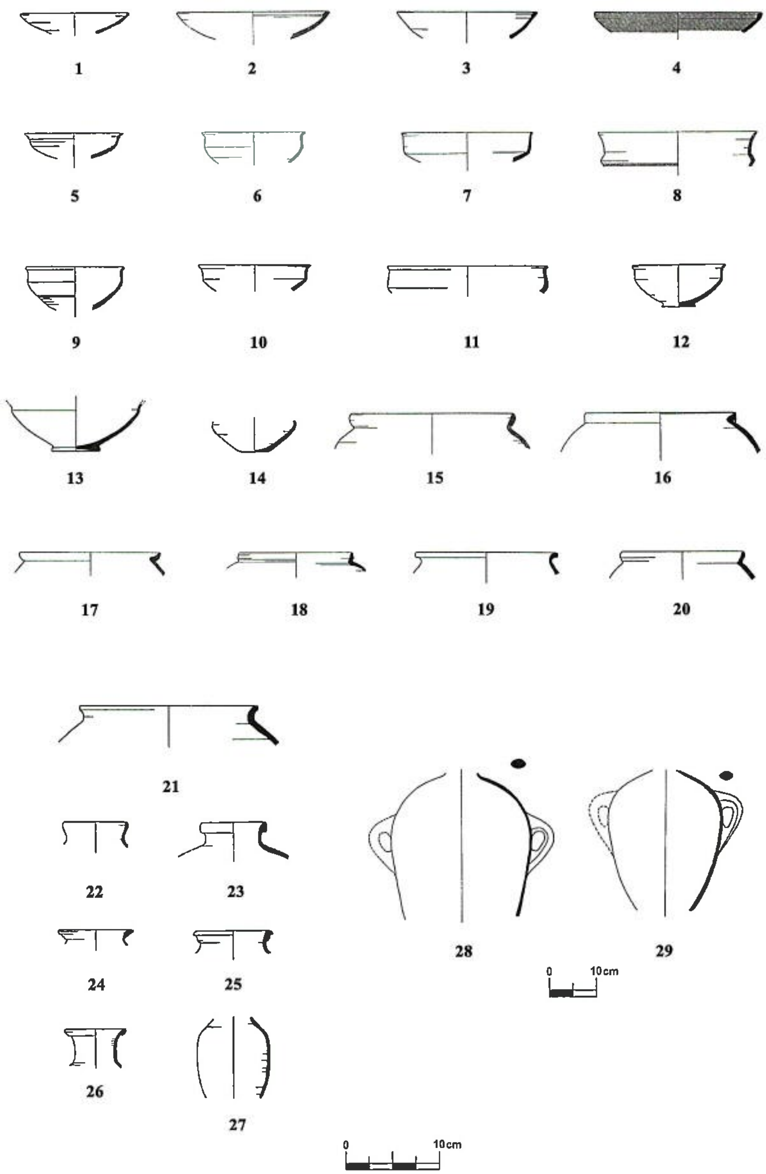

Figure 8. Selected Middle Bronze Age IIB pottery from Tel Nagila.

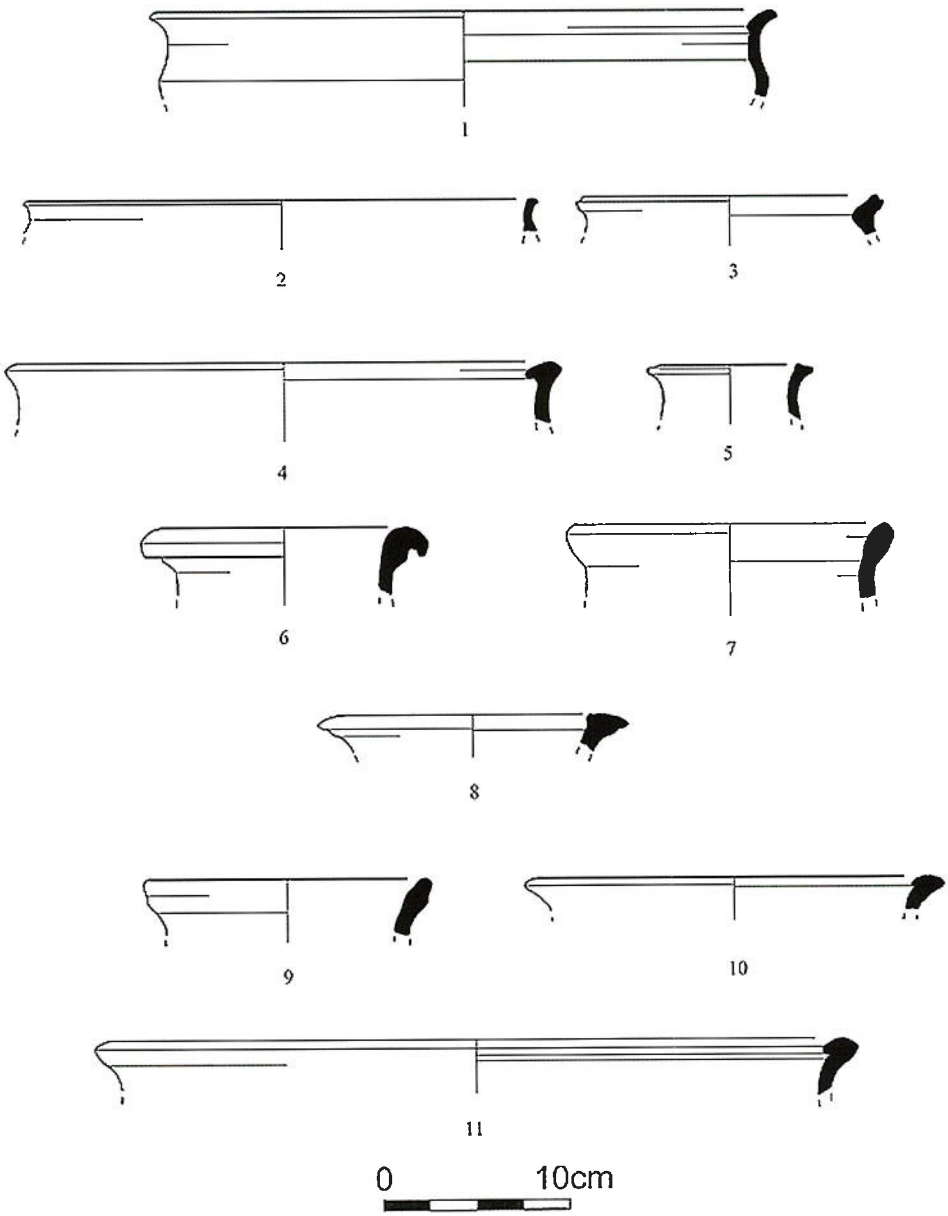

Figure 9. Selected Middle Bronze Age IIB pottery from Tel Burna.

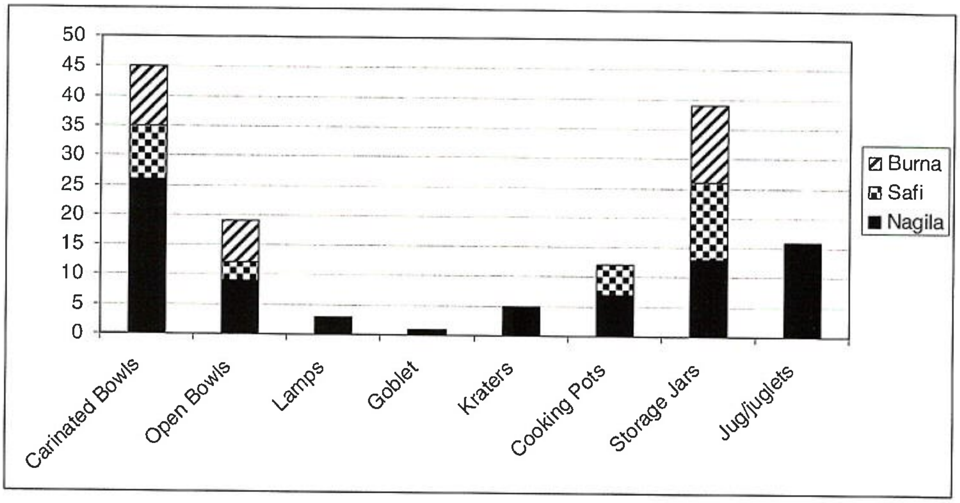

Figure 10. Typological division of sampled pottery.

Results of the analysis

Choice and preparation of raw materials

The three main petrographic groups identified reflect the clay sources available at Tell es-Safi/Gath and Tel Nagila (Figure 11):

Petrographic Group 1
This group consists of a brown, soil-derived clay and is characterized by a dark, optically inactive clay matrix. It is relatively porous, with voids covering 10–25% of the slide area, and the distribution of inclusions (non-plastic elements) is usually either single spaced or double spaced. The inclusions include a dominant component of quartz, usually 15–30% of the slide area, and in some cases as high as 40%.

Petrographic Group 2
This group is characterized by a "carbonatic"/calcareous matrix, optically slightly active to active, moderately to highly silty, with particles double to open spaced. The porosity is rather variable (5–30% voids). The inclusions are dominated by quartz, typically 15–20% of the slide area. Petrographic Group 2 probably represents various types of loess soil-derived clay (Ben-Shlomo 2006: 168–171, Group B; Cohen-Weinberger 2006: 16). Petro-fabrics derived from loess soils have been widely reported in petrographic studies of pottery from the northern Negev, southern coastal plain, inner coastal plain and the Shephelah (e.g., Goren, et al. 2004: 9, 112; Master 2003: 55).

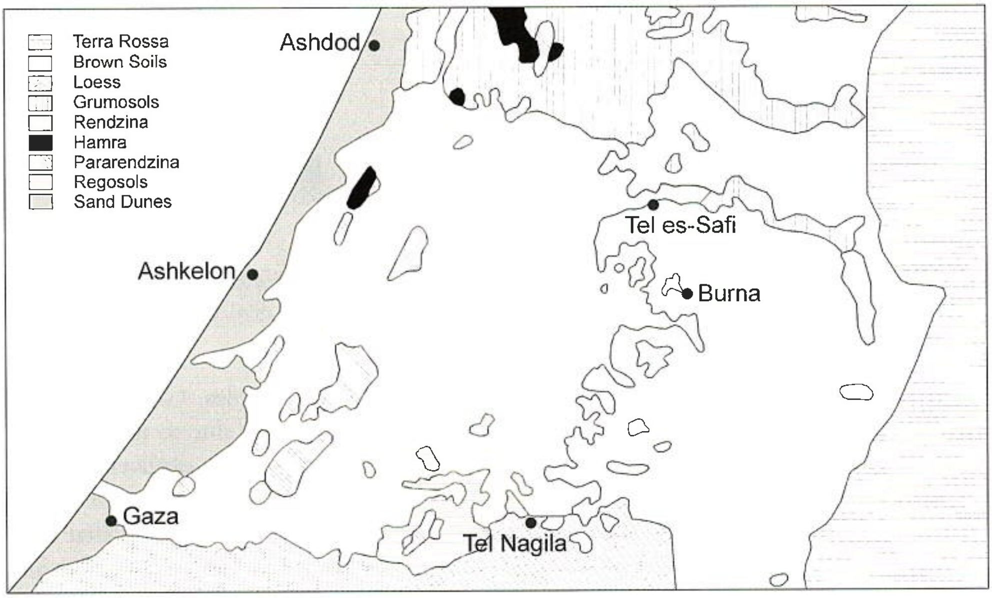

Figure 11. Soil map of the Shephelah (Judean Foothills), showing the location of soils used for pottery production.

Petrographic Group 3

This group is characterized by a calcareous silty matrix, usually quite compact (5–10% voids). Main inclusions are calcareous, mostly sand-sized chalk fragment, calcareous concentrations and foraminifers of various types (mostly planktonian). Quartz usually appears as a secondary inclusion component (0–10% of slide area), and is angular and fine silt in size. This group represents clay derived from rendzina soils or Pliocene marl (having certain similarities to Paleocene Taqiye marl clay used elsewhere in this region for pottery making, e.g., Cohen-Weinberger 2006, Group A1-A2; Goren 1996: 52–53).

Other petrographic fabrics found seem to indicate the presence of imported pottery from the hill country and northern Israel; they will be discussed elsewhere since they comprise a small minority of the fabrics and are less relevant for the questions we are asking here about the local *châine opératoire*.

All in all, a diversity of the local clay recipes was used during the MB IIB (Figures 12-13). While at Tel Nagila we observe a more frequent use of loess soils (Figure 12, Group 2), most likely due to the proximity of these soils to the site, there is a fairly balanced division between the three petrographic groups. This is even more clear at Tell es-Safi/Gath, where the use of different types of clays is divided evenly between the three groups. In contrast, in other periods a specific clay recipe was preferred (Figure 13; Ben-Shlomo, Uziel and Maeir 2009).

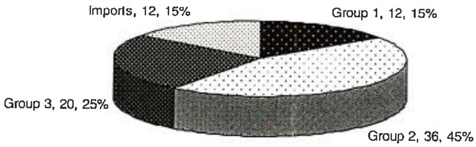

Figure 12. Division of petrographic groups at Tel Nagila.

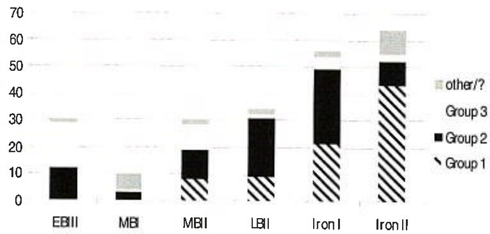

Figure 13. Division of petrographic groups at Tell es-Safi/Gath.

Particularly interesting is that while made up of only 12 samples, Group 1 at Tel Nagila consists solely of bowls.[5] While this might be a coincidence due to the relatively small sample (12 samples), the results may be of significance. One explanation that might be proffered is that the potter's workshop used a special clay recipe for bowls. Alternately, Group 1 might indicate the presence of a "specialty" workshop that only produced bowls from clay from a particular source. The data does not support the first idea, where a special clay recipe was used for bowls, since bowls were made of other clay recipes as well. Nor does it testify that only bowls could be made using this clay recipe, since at Tell es-Safi/Gath other vessels were made using this type of clay. This leaves the last explanation as the most feasible. Ethnographic studies have documented such "specialty" workshops as well (e.g. Hasaki 2005, 2007; London 1991: 222).

Aside from this last pattern, we have no unequivocal explanation at present for the three petrographic groups, which, for the most part, do not cluster or correlate with vessel types, chronological phases or geographical settings. We can offer tentative hypotheses for future testing:

- Workshops shifted their preferred clay sources over time, but a lack of observable typological change has resulted in our inability to detect these phases.
- Different workshops or different potters within a workshop utilized different clay sources and adopted signature clay recipes.

Forming, finishing, and firing of the vessels

The pottery from the three sites was macroscopically examined, in an attempt to identify various stages of pottery production that were still visible on the vessels. As the final stages of pottery production often "erase" evidence of the earlier stages of production, the entire *châine opératoire* can be difficult to reconstruct. That said, the internal portion of closed vessels and the external part of open vessels often preserve earlier stages in the chain. Therefore, evidence of forming, shaping and finishing can be discerned.

MB II pottery appears to show a stronger tendency for finer finishing than evident in the preceding and subsequent periods (see, Ben-Shlomo, et al. 2009; e.g. Franken and London 1995). While the introduction of the fast wheel (and in turn, wheel-thrown vessels) was in the past generally thought to have occurred during this period (e.g., Amiran 1969: 100), this has been challenged in a number of recent studies (e.g., Courty and Roux 1995; Roux 2003; Roux and de Miroschedji 2009; but see Duistermaat 2008: 375-378 for the suggested use of the "stick wheel"). These studies have demonstrated that it is at times difficult to distinguish between wheel-thrown and "wheel-coiled" vessels (i.e., vessels hand-built from coils and then smoothed on the wheel). We do not intend to refute the idea that the fast wheel was used during this period,[6] but it is clear that the "wheel-coiled" technique was used as well. The evidence for pottery production process in the materials from Tell es-Safi/Gath and Tel Burna is less conclusive, with less indication for coils (although there are some traces of coils on the pottery from these two sites). On the other hand, the material from Tel Nagila strongly suggests that a large number of the vessels were in fact coil-built, and then finished on the wheel (Figure 14: 1, 5, 7-10). The lack of evidence for the use of the coiling technique at Tel es-Safi/Gath and Tel Burna might be due to the fact that the pottery from these two sites is more fragmentary than the assemblage from Tel Nagila; it is difficult to discern coiling on sherds alone. While wheel-thrown vessels may have been produced in the MB II, the technique did not completely replace coil-built vessels. Moreover, there is no clear cut evidence in the entire corpus of pottery analyzed in this study for the wheel-thrown technique.

The evidence for coiling is found in all vessel classes, i.e. we cannot say that certain types were wheel-thrown and others were coil-built. The potters took great care in smoothing these vessels, both inside and out (for a similar case of smoothing the interior of jars, see Arnold 1991: 42), including the inner (and lower) part of storage jars and closed cooking pots (Figure 15: 1, 6, 12). Certain vessels were smoothed in areas that could not have possibly been reached had the entire vessel been formed in one sitting—for example, the shoulders of juglets with very small openings and the innermost parts of large storage jars (Figures 14: 8 and 15: 2).

This suggests one of the following methods:

- Vessels were made in parts, with each part smoothed and finished separately. The parts were then joined, followed by another act of finishing, which erased any evidence of the joining (see, e.g., Duistermaat 2008: 380, fig. V.33; Franken 2005: 35; Franken and Kalsbeek 1975: 116, fig. 29; Homes-Fredericq and Franken 1986: 117; van de Moortel 2001; Schreiber 1999: 20-21).
- The vessel's forming was done in stages, with part of the vessel formed, then smoothed, followed by the construction of the subsequent part of the vessel, which was then smoothed, and so on (e.g., Arnold 2003: 81; Schreiber 1999: 210-212).

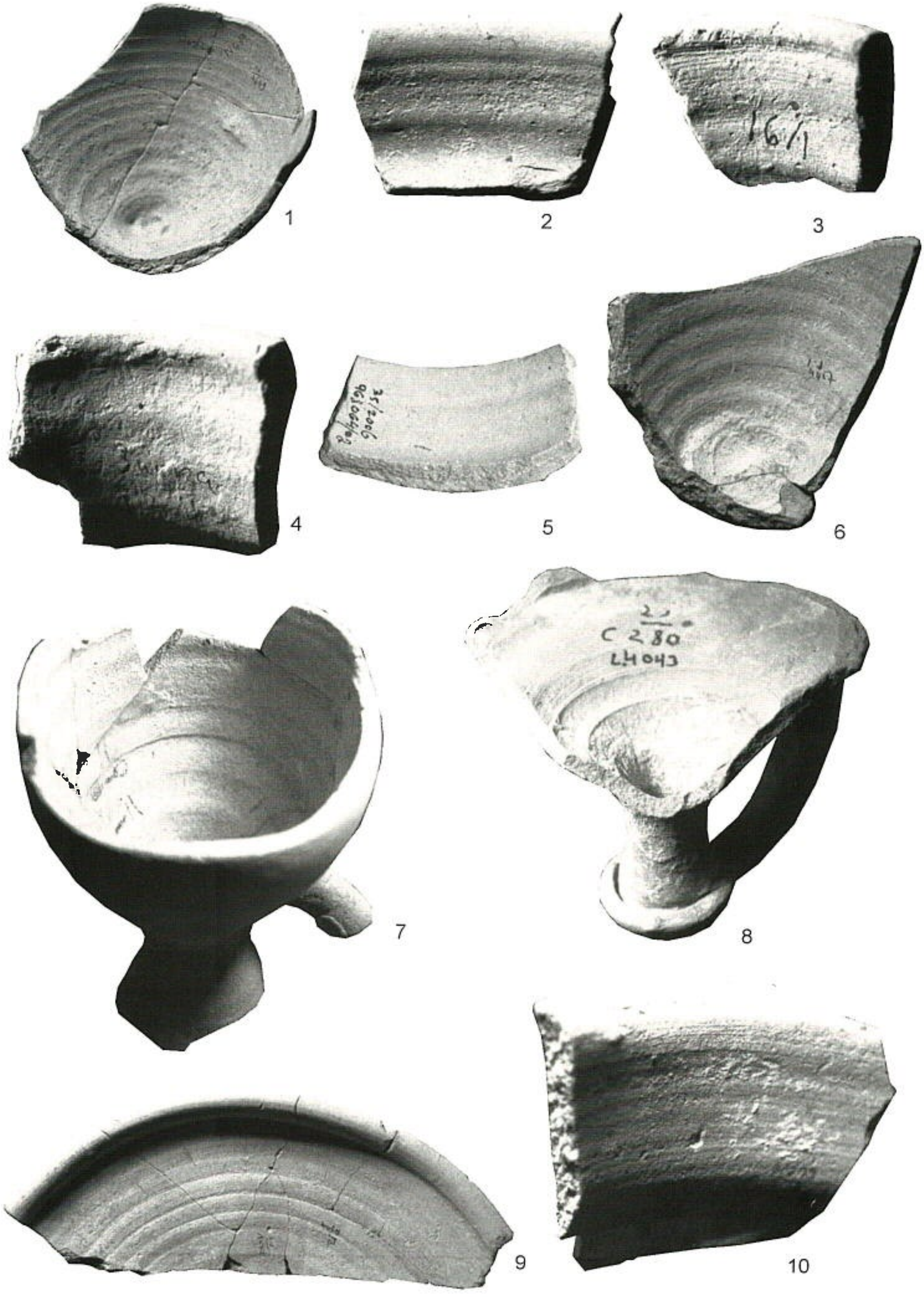

Figure 14. Evidence for coiling on Middle Bronze Age II pottery.

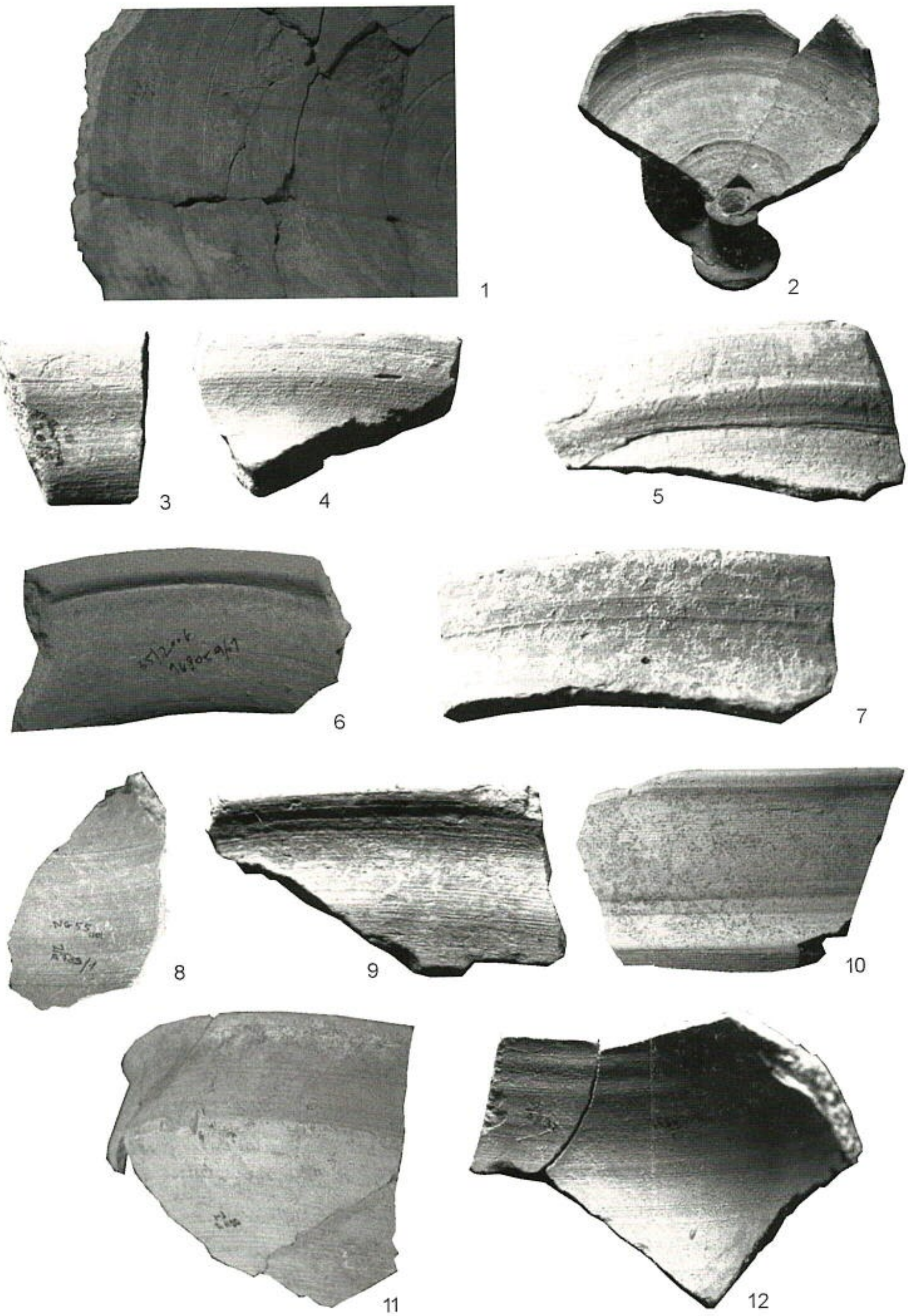

Figure 15. Evidence for finishing on Middle Bronze Age II pottery.

It seems likely that both of these methods were at work, and may have been used for different types of vessels. Both scenarios imply that the components of MB pottery production were not necessarily sequential.

In general the vessels at both Tel Nagila and Tell es-Safi/Gath seem to have been fired at a high temperature (above 800° C).[7] That said, there are several exceptions, with one vessel at Tell es-Safi/Gath apparently fired as a medium temperature (600-800° C), and two vessels (NG 15 and 16) from Tel Nagila showing signs of very high firing temperatures (900°C or higher). While the latter may indicate the pyrotechnical advancements seen towards the end of the MB II (e.g. Lilyquist 1993), the fact that they were found in different strata (X and VIII) appears to indicate that this may have been an anomalous or unintentional event, such as a post-fabrication conflagration.

Conclusions

The study of pottery from three different Middle Bronze Age sites in the Shephelah revealed a similar production process throughout the region. Three different major groups of local clay composition were utilized simultaneously, at least at Tel Nagila and Tell es-Safi/Gath. The use of different clays does not appear to have chronological or typological significance; perhaps the different types of clay represent different workshops, though this is difficult to prove. At Tell es-Safi/Gath there seems to be a less unified clay recipe than in other periods (Ben-Shlomo, Uziel and Maeir 2009). At Tel Nagila one recipe (Petrographic Group 2) represents almost 50% of the locally made assemblage, but the other two groups are also used extensively (see Figure 12).

The process of constructing vessels seems quite similar, with no chronological, typological or site-specific distinctions noted. Most (if not all) of the vessels were formed with coils and finished on the wheel. The finishing of vessel interiors suggests that preforms were not completed prior to the finishing of the vessel, rather there was a back-and-forth process, where part of the vessel was formed and finished and then other sections added, either after being formed and finished separately, or through the addition of coils (contrary to Homes-Fredericq and Franken 1986: 117). Vessels were generally fired at relatively high temperatures (above 800° C).

Petrographic analysis revealed that twelve samples from Tel Nagila were imported from other regions in Israel the hill country and the northern coast. These vessels were also macroscopically examined. It was found that the forming and finishing of these vessels is similar to the techniques identified at the Shephelah sites. The vessels are coil-built, well-finished both inside and out and fired at a high temperature. Therefore, it is possible that the techniques identified at the Shephelah sites of Tel Burna, Tel Nagila and Tell es-Safi/Gath are indicative of general trends in the production of Middle Bronze Age II pottery throughout the Southern Levant. This has been recently confirmed, for example, in the ceramics studied from Beth Shean (Roux in press).

The analysis of *châine opératoire* leads naturally to questions of the mode(s) of production—household, industrial or something in between. Roux has suggested that the spread of wheel-formed (i.e. wheel-coiled) pottery was an outcome of specialized workshops that developed in tandem with increased Canaanite urbanization, and not as the result of the diffusion of production traditions. Her reconstruction does not appear to be supported by the various clay groups identified at Tel Nagila and Tell es-Safi/Gath, which suggest the coexistence of several potter's workshops. Kletter and Gorzalczany (2001: 102), in their study of multiple workshop and kiln sites along the Yarkon River (Israel), have posited that MB pottery workshops engaged in mass production, but that this mass production was local in character, based in both towns and villages, with single or multiple families running different workshops on the outskirts of different settlements. This may be a better model, albeit in need of further elaboration, including a socioeconomic explanation for the standardization of wheel-coiled pottery. But this is a topic for future study.

Notes

1. The final analysis and publication of the finds from the site is currently in preparation by J. Uziel, D. Ilan and A.M. Maeir, and funded by the Shelby White – Leon Levy Program for Archaeological Publications.

2. Grain size is defined using the Udden-Wentworth scale (Adams, MacKenzie and Guilford 1984): sand: 2000-62 microns; silt: 62-4 microns; clay: under 4 microns.

3. For classification of voids, see Bullok et al. 1985: 43-47.

4. A major difference from Whitbread's system (1995) is that all percentages are given relative to the total area of the slide. Although it is difficult, in this system, to express accurately the relative abundances of rarer inclusion types, it has other advantages: the description is more faithful to the appearance of the slide (and in the detailed description it is important to give as much raw data as possible without interpretation); relative percentages can usually be calculated more easily by means of percentage estimation charts. The b-fabric type system was not employed in this study; however, more emphasis was given to the description of the shape (roundness and sphericity of grains) as this proved to be more crucial in the description of the petrographic groups (generally following Bullok et al. 1985: 20-38).

5. This is not true of the sample at Tell es-Safi/Gath, where a variety of Middle Bronze Age II vessels were made using this clay.

6. For evidence of the fast wheel in the Bronze Age, see e.g. Magrill and Middleton (2004: 2521–2526) based on X-radiographic study of material from the LB II Cave 4034 workshop at Lachish.

7. Firing temperatures were estimated according to characteristics of the matrix and inclusions observed in the thin sections.

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CANAANITE EB-IB 'PROTO METALLIC WARE': THE EARLIEST PRODUCTION OF CERAMIC 'METALLIC WARE' IN THE LAND OF ISRAEL

Yitzhak Paz, Shlomo Shoval and Olga Zlatkin.

Abstract

The earliest production of 'Metallic Ware' in the Land of Israel was studied due to their spatial, typological and technological traits in light of an on-going research. 'Metallic Ware' is a distinct ceramic tradition recognized by its pink/orange color, thin walls, hard fabric and distinctive metallic resounds. The typical Northern Canaanite 'Metallic Ware' (NCMW) is well known in the Early Bronze II–Early Bronze III (c. 3050-2300 BCE) and was manufactured from raw material taken from the Lower Cretaceous sediments that crop in the Northern Canaan region. A group of Early Bronze IB pottery vessels, which has material affinities of Metallic Ware was characterized using typology, petrography and material analysis by FT-IR spectroscopy. This pottery defined here as 'proto-Metallic Ware' (PMW) was excavated in four Canaanite EBIB sites in the central coastal plains of Israel: Rishpon-4, Aphek, Shoham North and Givatayim.

Recent examination of the EBIB PMW resulted with the notion that the earliest appearance of MW tradition must have occurred already during latest EBIB (c. 3150-3050 BC). The typical vessels that characterize that industry are the main issue of this study. The article describes various spatial, typological and technological implications, as well as the petrography of the pottery, the composition of the ceramic matrix, the firing temperature, and the origin of the pottery.

Keywords: Canaan, Ceramic, Early Bronze Age, FT-IR spectroscopy, Material analysis, 'Metallic Ware', Petrography, Pottery.

Introduction

The typical EBII–EBIII 'Northern Canaanite Metallic Ware'

Early Bronze Age pottery in the land of Israel is characterized, inter alia, by the appearance of 'Northern Canaanite Metallic Ware' (NCMW). The 'Metallic Ware' (MW), sometimes termed 'Abydos Ware' or 'Combed Ware', is a distinct ceramic tradition that encompassed every aspect, from raw material sources to ideological realms. This type of pottery is recognized by its highly fired material, pink/orange color, thin walls, hard fabric and distinctive metallic resounds, that is, a metallic ring when struck.

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According to Greenberg and Porat (1996), the typical NCMW exhibits a unity of typology and chronology, at its peak in EBII (3050-2700 BCE) and declining in EBIII (2700-2300 BCE). It was used for storage or serving and comprises a full range of household forms, excluding cooking pots. The raw material was fired at a high temperature which gives it the properties of MW. Petrographical analysis of the EBII – EBIII NCMW from northern Israel reveals a distinct geological source – the raw material was taken from the Lower Cretaceous sediments that crop in the foothills of Mount Hermon and in the south of Lebanon (Greenberg and Porat 1996). In view of its stylistic affinity to contemporary Canaanite pottery, Greenberg and Porat proposed that the NCMW was produced in workshops centered near the upper Jordan Valley and distributed from there, in large quantities, to sites as far as 100 km away.

Regarding the Greenberg and Porat (1996) work, the clear attribution of the phenomenon's zenith to EBII is well attested. The decrease and demise of the NCMW production during EBIII is also well documented (Greenberg 2000; Greenberg and Porat 1996: 12-13). What remained obscure to archaeological research was the earliest appearance of the phenomenon, which is the subject of this article.

The EBIB 'proto-Metallic Ware'- Some methodological remarks

In the present article, a group of EBIB pottery vessels with material affinities to MW is studied. For the EBIB pottery, we use the term 'proto-Metallic Ware' (PMW[1]); an EBIB industry that was not fully developed (technologically) compared to the typical EBII – EBIII NCMW industry, and was characterized by a very restricted repertoire of vessel types, compared to the typical repertoire. This type of PMW was discovered during the excavations of EBIB remains in sites located in the central coastal plain of Israel: Rishpon-4, Tel Aphek, Shoham North, and the cemetery of Givatayim. Their first definition as MW was done back in 2006 through a preliminary petrographic analyses on a few selected sherds from Rishpon-4 and the cemetery of Givatayim (conducted by M. Iserlis).

The current study includes a total of 45 pottery sherds that were recently analyzed by S. Shoval and O. Zlatkin. Twenty-eight of them were defined typologically as PMW. The other sherds, defined as non-PMW, served as a control group. The majority of PMW (19 sherds) were found in Rishpon-4; six sherds have been detected to date in the assemblage of Shoham North (three PMW and three non-PMW); 15 sherds came from EBIB loci at Tel Aphek (three PMW, five bowls from the 'Aphek Family' as defined by Beck (1985), and seven plain vessels); five sherds derived from the cemetery of Givatayim[2]. Following is a brief description of the sites in which PMW sherds were found and analyzed petrographically and a typological description of the vessels that were analyzed.

The present article focuses on three main issues: First – it highlights the possibility that PMW was a well-known phenomenon no later than latest EBIB. Second – it defines the spatial, typological, technological and petrographic traits of PMW EBIB pottery, and to traces its possible origin. Third – it discusses a possible relation between the coastal plain PMW pottery and pottery that seem to belong to the same phenomenon that were found at Jordan Valley sites, such as Bet Yerah, Bet Shean and Tell Abu al-Kharaz. Although this relation was already reported in a recent article (Paz 2009). The thorough research that included a larger sample from all four central Israel sites mentioned above resulted with the study conducted by the authors of the current article.

Archeological data

Following is a brief description of the general affinities of the EBIB excavated sites in which PMW sherds were found and a typological description of the vessels that were analyzed.

Rishpon-4

Rishpon-4 is located in the Ramat Aviv Gimmel neighborhood of the city of Tel Aviv. The site is located ca. 31m above sea level on the western slope of a hill known as the eastern 'Kurkar ridge'. The exact location is on the southwestern corner of Haviv and Barazani streets. The site was surveyed in 1976 and partial findings published by Gophna and others (Gophna 1978; Gophna and Ayalon 1998; Gophna and Bunimovitz 1980). The summary of excavations is based upon the brief report published by J. Kaplan and H. Ritter-Kaplan (1993: 1452-1453) and previous publications by Gophna (1978, 1980, 1998). Since it was accidentally encountered during construction works, the site was excavated on and off for about 12 years from 1978. The excavation results are being processed for final publication (Gophna and Paz in preparation). The finds at the site included much pottery, all belonging to the EBIB period. Large amounts of flint waste, as well as tools like scrapers, cores and sickle blades, were also found.

The typology of the vessels

The great majority of the sherds from Rishpon-4 are local plain pottery, which are non-metallic. Such pottery is typical of the northern regions of the EBIB, mainly of Jordan Valley sites such as Tel Shalem, Tel Bet Shean and Tell Abu al-Kharaz, (Eisenberg 1996; Fischer 2000; Fitzgerald 1935). The most common vessels were hole-mouth jars, forming no less than 41% of the whole assemblage. The most popular hole-mouth sub-type had a ribbed and ridged rim; as much as 88% of the hole-mouth vessels had this rim. The portion of PMW represents a considerable proportion of the overall assemblage, 30 sherds out of ca. 700 (4.3%). Such amounts of PMW in the EBIB site are abundant relative to the portion of MW in the EBII sites of south-central Israel. For comparison, at Tel Bareqet, a major EBII urban center in central Israel, indicative sherds of MW represent no more than 0.1% of the assemblage. Regarding the shapes, it should be noted that the PMW pottery types from Rishpon-4 represent EBIB forms (described below). The PMW of this site represents two main groups: bowls and small-medium size jars, whereas PMW platters, jugs or pithoi were not found. Indeed, pithoi were created exclusively from the local clay and were crude heavy vessels. As a rule, the EBIB PMW vessels are handmade, and that technique was used for all types of vessels and all of their components. This is in contrast to the NCMW of the EBII sites, where in many cases jar rims were finished on a potter's wheel, (Greenberg and Porat 1996: 10). In addition, there is a complete absence of combing in the EBIB PMW of Rishpon-4, while pattern-combing is common in EBII assemblages (Greenberg and Porat 1996: 10).

The typology of pottery from Rishpon-4 is presented in Figure 1. Although only the typology of sherds from Rishpon-4 are presented in the figure, this is sufficient for the purpose of the current study, since the typology of PMW from Rishpon-4 is well duplicated in the other three coastal plain sites we discuss.

Plain rim bowls

The most common type of bowls; they were either shallow or hemi-spherical, with a slight carination just below the rim (Figure 1: 1-3). Both sub-types had soot marks in many of the sherds, a hint to their usage as lamps. Most of the vessels of this type were found at Rishpon-4 in common local ware (details below).

Sinuous side bowl

Rounded bowls with sharpened rims and a slightly sinuous side (Figure 1: 4-7).

Splayed rim bowl

One specimen of this vessel was found at Rishpon-4 (Figure 1: 8). It was a large shallow vessel that had a splayed rim. It seems that this type of rim was common both in EBIB (st. V at Tel Dalit, Gophna 1996: Fig. 39: 7) at Lod (Paz et. al. 2005: Fig. 23: 2) and in EBII (a more elaborate version of the splayed rim, with a 'channel', at sites such as Leviah (Paz, 2003: Pl. 14: 4) and Tel Qashish, (Zuckerman 1996: Fig. X: 19)). The oddity lies in the fact that this type of bowl was never made of MW, neither in EBIB nor in EBII, and thus the Rishpon-4 specimen is quite uncommon.

Small-medium storage jars

The second common vessel type produced in PMW were small to medium storage jars (Figures 1: 9, 10, 12, 13, 14-16, 18). From their size, some could be jugs (the sherd fragments were not sufficient to confirm this assumption). All jars had plain averted rims, shorter or longer. In general, those shapes were well attested at the site in local ware too (mentioned above). One similar rim sherd of the same type was found in the 'Slaughterhouse of Tel Aviv' site, which was also excavated by Kaplan in 1950-1952 (Gophna and Paz forthcoming). The only PMW jar found at Tel Shalem in an EBIB context may belong to this type (Eisenberg 1996: Fig. 17: 6).

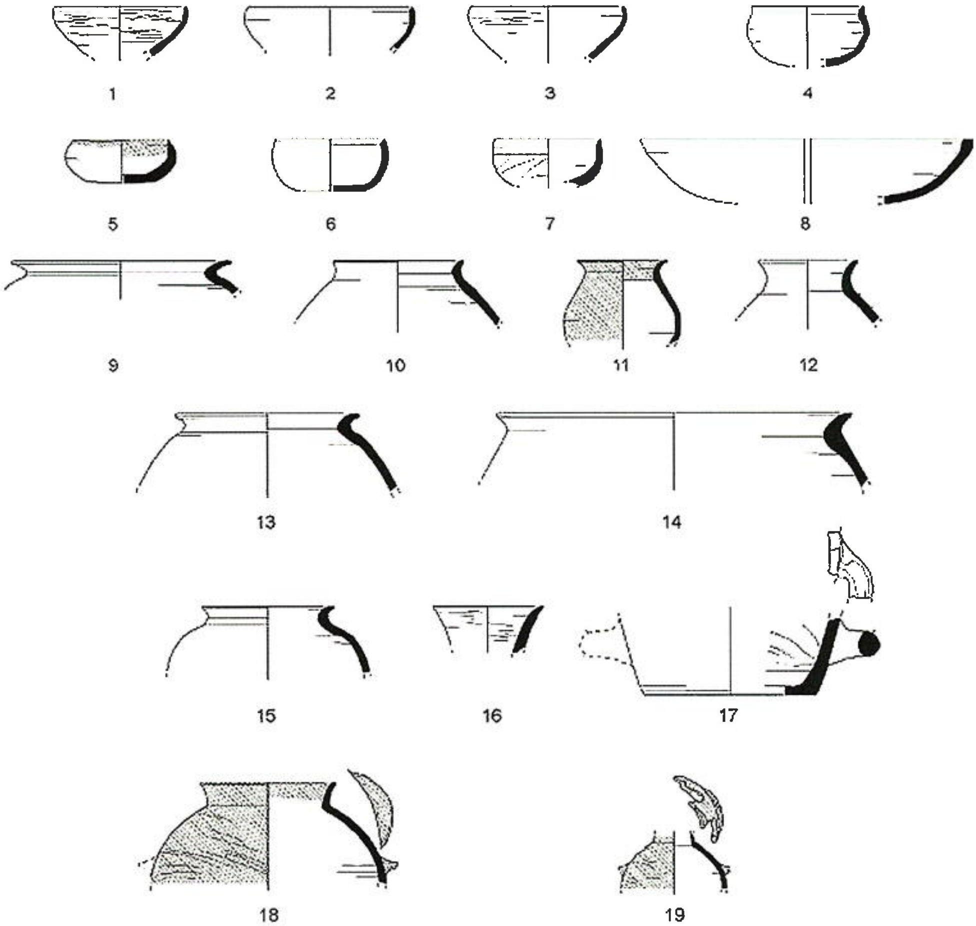

Fig. 1: The typology of EBIB pottery from Rishpon-4.

Amphoriskoi

(Figure 1: 11, 19): Two sherds of what could be amphoriskoi were also found at Rishpon-4. The small fragments are not sufficient to further relate to the vessels.

Vessel with horizontal handle

A fragment of the lower part of a unique vessel, of an as yet unknown form, was found in Rishpon-4 (Figure 1: 17). It seems to have been a large vessel, made of red clay, with a horizontal loop handle adjacent to the base. Traces of white lime wash were presented. To date, the vessel has no parallels.

Shoham North

Shoham North (Tel Khirbet Abu Hamid) is located in the northern part of the Shoham settlement, 20km southeast of Tel Aviv. The site contains burials and occupation levels from the Chalcolithic and occupation remains from the Early Bronze Age (van den Brink and Gophna 2005: 1-5). In 1992, a salvage excavation conducted by the Israel Antiquity Authority unearthed a series of two subsequent residential complexes, the earlier of which included two rounded buildings dated to the late EBIB (Nadelman 1995). The vast majority of the pottery that came from the architectural remains can be securely dated to the late EBIB, as is well attested at sites such as Tel Dalit and Tel Lod (Gophna 1996; Paz et. al. 2005). The PMW sherds that will be discussed below belong to this phase that yielded, among other things, a fragment of an Egyptian cylindrical vessel. The PMW sherds were all made from red-orange clay, very well fired, and resemble the Rishpon-4 assemblage of the same kind. They include three plain jar rims, similar to the sherds found at Rishpon-4.

Tel Aphek

Tel Aphek is located east of the city of Petach-Tiqwa. The major urban fortified center of Tel Aphek flourished during both the EBIB and EBII periods, as revealed in the excavation of Areas A and B (e.g. Gal and Kochavi 2000: 59-67; Yadin and Kochavi 2000: 134-139). Area G, located at the south-western slope of the mound, encompasses rich multi-period assemblages, amongst them Early Bronze Age remains. The latter were severely disturbed and survived very fragmentarily. Most of the remains consist of segments of walls and floors, which can seldom be connected to a coherent plan. This said, by careful analyses of the documentation made in the field, we are able today to reconstruct five EBA architectural strata. The EBIB pottery from Area G is being studied for future publication (Paz in preparation) and includes, among other finds, some PMW sherds, such as were not reported from the other areas.

Two PMW sherds from Tel Aphek were analyzed. One of them was a jar body sherd made of dark red clay, with a fragmented loop handle. It was highly slipped and burnished. The other sherd was a fragment of a jug base, made of pale orange clay with a gray core. In order to create a control group for PMW at Tel Aphek, five bowl sherds, all belonging to the 'Aphek family', known for its fine carinated bowls and its darker brown colors, as described by Beck (1985) were analyzed, as a group of highly fired vessels ('metallic' affinities ascribed to this family were already noted by Beck (1985). It turned out that this group, defined by thin walls and well levigated clay, was indeed fired at a high temperature ranging from 850-1000°C. The 'metallic' character of the vessels resulted from the complete lack of calcite in the matrix, which requires a higher firing temperature. This said, the 'Aphek Family' vessels were not 'PMW', being made of local clay (details below) and completely different in typology and technique from the Rishpon-4 assemblage.

Cemetery of Givatayim

The cemetery of Givatayim is a large Chalcolithic and EBIB cemetery located in the Giv'at Kozlovsky neighborhood of the city of Givatayim. This site is characterized by caves that are quarried into a limestone ridge and were used during the Chalcolithic and EBIB periods. Some of the burial caves were excavated during the 1960's by J. Kaplan and other excavators (Sussman and Ben-Arieh 1966). The EBIB phase of usage yielded vast amounts of complete local vessels as well as many imported Egyptian pottery vessels. Among the local 'Canaanite' vessels were dozens of red clay bowls, jars and pedestal jars of a small size that resemble those of the Rishpon-4 assemblage and seem to be PMW. Unfortunately, the examination of the complete vessels was not permitted and we examined some sherds of three bowls and a jar, which are similar to vessel types of Rishpon-4.

The Slaughterhouse Hill site

The site of the Slaughterhouse Hill is located in the city of Tel Aviv. The site was excavated by J. Kaplan in 1950-1952 (e.g. Kaplan 1993). A small rim sherd of a jar, identical to the jar type of Rishpon-4 (Figure 1: 9) was found during the study of the EBIB remains (identified by Gophna and Paz). The nature of this site during EBIB is not clear at present, and a mortuary context is plausible (Gophna and Paz in preparation).

Study of the material affinities of the PMW

Following is a description of the study on the material affinities of the PMW and their presumed origin

Experimental data

The list of the PMW investigated from the sites Rishpon-4, Tel Aphek, Shoham, and the cemetery of Givatayim is in Table 1. As references, some typical EBII–EBIII NCMW from northern Canaanite sites was also examined. For comparison, some groups of EBIB pottery defined as non-'metallic' pottery were also analyzed.

Pottery Number	Excavation number	Type	Pottery Number	Excavation number	Type
Subgroup 1a: PMW			Subgroup 1c: Ca-PMW		
R4-6	R-39,57- 78/4	Jar, Fig. 1:18	R4-8	R-83- 81/4	Bowl, Fig. 1:8
R4-7	R-59- 78/4	Jar, Fig. 1:13	R4-9	R-17- 78/4	Jar?, Fig. 1:17
R4-10	R-20- 78/4	Bowl, Fig. 1:1	R4-18	R-34-78/4	Jar, Fig. 1:10

Pottery Number	Excavation number	Type	Pottery Number	Excavation number	Type
R4-11a	R-67- 78/4	Bowl	R4-23	R-126- 82/4	Bowl, Fig. 1:5
R4-11b	R-67- 78/4	Bowl	R4-25	R-17- 78/4	Bowl, Fig. 1:6?
R4-12	R-162, 182-82/4	Bowl, Fig. 1:3	Sm-1	1869 2233/541/3	Jar
R4-13	R-39- 78/4	Jar, Fig. 1:9	Gv-1	193/G/65 k/13	Bowl
R4-14	R-48- 78/4	Jar, Fig. 1:14			
R4-15	R-197- 82/4	Jar	Group 2: NCMW		
R4-16	R-1- 78/4	Jar, Fig. 1:10	Zv-7	16-23/99/01/7	Platter
R4-17	R-51- 78/4	Jar, Fig. 1:15	Zv-12	16-23/99/01/12	Platter
R4-19	R-179- 82/4	Jar, Fig. 1:12	Lw-7	LEV 97-1066-L-937-2	Jar
R4-20	R-62-78/4	Jar, Fig. 1:16	Lw-10	TL-10	Platter
R4-21	R-13- 78/4	Amphoriskos, Fig. 1: 19	Lw-13	LEV 97-L-941-2	Platter
R4-22	R-65- 79/4	Bowl, Fig. 1:6	Lw-14	LEV 97-1064-L-937-2	Platter
R4-24	R-65- 78/4	Bowl, Fig. 1: 7	Lw-15	LEV 97-1066b-L-937-2	Platter
R4-26	R-61- 78/4	Bowl, Fig. 1:2?	Lw-18	LEV 97-1076-L-937-2	Pithoi
R4-27	R-62- 78/4	Bowl, Fig. 1: 2	Lw-23	LEV 97-1056-L-938	Platter
R4-28	R-65- 78/4	Bowl, Fig. 1:2?			
Ap-10	35	Carinated Bowl	Group 3: Non-PMW		
Ap-11	66/47	Carinated Bowl	R4-1	R-131- 82/4	Hole-mouth vessel
Ap-12	66027	Bowl	R4-2	R-231- 82/4	Storage Jar
Ap-13	12316	Storage Jar	R4-3	R-130- 82/4	Storage Jar
Ap-14	60426	Jug	R4-4	-	Bowl
Sm-2	1869 2427/584/4	Jar	R4-5	R-24- 78/4	Bowl
Sm-3	1869 2299/553/3-4	Jar	Ap-1	-	Pedestal Bowl
Sm-4	1869 2349/553/4	Body sherd	Ap-2	-	Bowl

Pottery Number	Excavation number	Type	Pottery Number	Excavation number	Type
Sm-5	1869 2233/541-5	Jug	Ap-3	-	Bowl
Sm-6	1869 2245/541-11	Jug	Ap-4	-	Bowl
Gv-2	GI 4-75	Bowl	Ap-5	65715/1	Bowl
Gv-3	263/G/65, k/13 88-212,	Bowl	Ap-6	-	Bowl
Gv-4	305/G, k/13, area 1	Bowl	Ap-7	-	Bowl
Gv-5	221	Jar	Sm-7	1869 2233/541-4	Hole-Mouth
			Sm-8	1869 2233/541-6	Cylinder, Nile clay?
Subgroup 1b: Siltic PMW		'Aphek family' sherds			
Ap-8	66152	Lamp			
Ap-9	12317	Bowl			
Ap-15	-	Lamp			

Table 1. The groups of the examined EBIB pottery. Subgroup 1a: PMW – EBIB 'proto-Metallic Ware' poor in calcite; subgroup 1b: siltic-PMW – PMW rich in quartz silt; subgroup 1c: Ca-PMW – PMW containing some calcite. Group 2: NCMW – typical EBII-EBIII 'Metallic Ware'. Group 3: non-PMW – EBIB pottery not defined as 'Metallic Ware'. Sites: R4=Rishpon-4, Ap= Tel Aphek, Sm= Shoham North, Gv= cemetery of Givatayim. Lw= Leviah and Zv= Tel Mitzpe Zevulun

Methods of analysis

Petrography

The optical microscopy characteristics of the pottery, its textures and temper composition were identified using petrography. Thin sections of the pottery were analyzed under a polarizing microscope. In several sherds the temper composition was identified using binocular microscopy.

Infrared spectroscopy (FT-IR)

The composition of the ceramic matrix of the pottery was analyzed using infrared spectroscopy. The spectra were obtained using a Jasco-4100 FT-IR spectrometer and Spectra Manager software. The spectra of powdered samples of the ceramic matrix (excluding the temper particles) were obtained. The ceramic matrix was separated from the temper under a binocular microscope. The samples were examined in pressed KBr disks. Mixtures of 1 mg of the powdered sample and 150 mg of KBr were obtained by grinding in an agate mortar and then pressing into disks. The disks were examined at room temperature and again immediately after heating to 110°C to remove absorbed water. Before measurement, the heated disks were re-pressed to improve the resolution of the spectra. Accumulations of 60 s were applied for the spectra collection.

Second derivatives of the FT-IR spectra
The fired clay composition of the ceramic matrix of the pottery was analyzed using the second derivative of the FT-IR spectra. The use of the second derivative of the spectra enables improvement of the identification of the individual phases of which the ceramic matrix of the pottery is composed. The second derivative makes it possible to determine whether kaolinitic or smectitic (montmorillonitic) raw material was used for the production of pottery. It enables determination of the exact location of the main SiO band of the meta-smectite in the spectra, which is important for the determination of the firing temperature.

Spectral subtraction of quartz: In the FT-IR spectra, the main SiO band of two components of the ceramic matrix – the fired clay and the quartz silt – are partly overlaid. In order to eliminate the quartz distortion, the spectra of quartz was subtracted before application of the second derivative to the spectra.

Results

Petrography
The examined pottery was divided by petrography into three main petrographic groups and some subgroups (Figure 2):

Group 1 – PMW: EBIB proto-'Metallic'.
Subgroup 1a – PMW poor in calcite (Figure 1b).
Subgroup 1b – Siltic-PMW: rich in quartz silt (Figure 1c).
Subgroup 1c – Ca-PMW: containing some calcite (Figure 1d).

Group 2 – NCMW: reference typical EBII-EBIII north Canaanite 'Metallic Ware' (Figure 1a).

Group 3 – non-MW: reference EBIB non-'Metallic Ware'
Subgroup 3a – Qu-non-PMW: rich in quartz temper (Figure 1e).
Subgroup 3b – Ca-non-PMW: containing monocrystalline calcite temper (Figure 1f).

Analysis of the ceramic matrix
The composition of the ceramic matrix of the pottery was analyzed by FT-IR spectroscopy. The percentages of calcite and quartz silt, the composition of the fired clay and the firing temperature were obtained (Figures 3-4). The amounts of calcite and quartz in the different groups of the examined pottery are given in Figure 5.

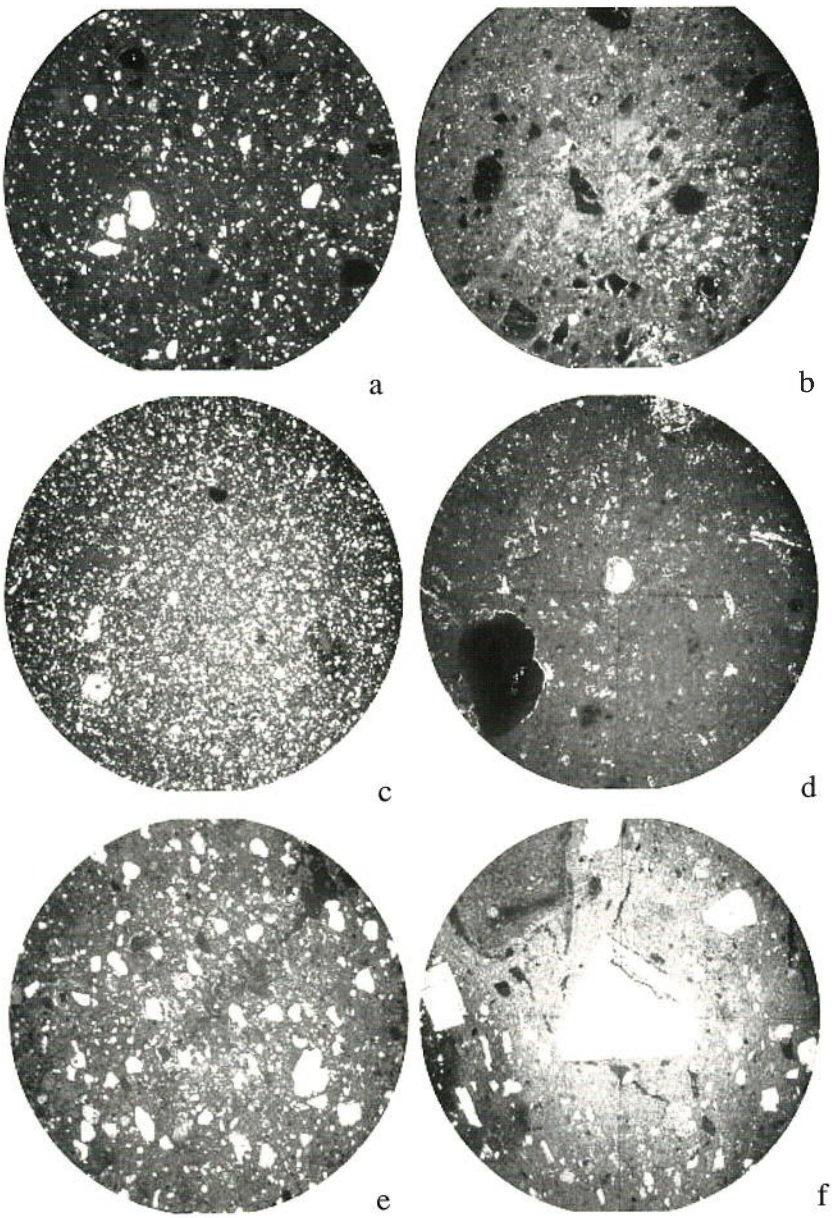

Figure 2. Petrographic groups of the pottery: (a) NCMW: reference typical EBII-EBIII north Canaanite 'Metallic Ware' (TL-5), (b) representative PMW: EBIB 'proto-Metallic Ware' poor in calcite (R4-27), (c) Siltic-PMW: rich in quartz silt (Ap-8), (d) Ca-PMW: containing some calcite (R4-23) (e) non-MW: reference EBIB non-'Metallic Ware' containing quartz temper (Ap-5), (f) non-MW: reference EB-IB non-PMW containing monocrystalline calcite temper (R4-1).

% calcite: In a calcareous pottery the ceramic matrix is composed of fired clay and microcrystalline calcite. The percentage of the microcrystalline calcite in the ceramic matrix was analyzed according to the relative intensity of the main CO_3 band (at 1430-1440 cm^{-1}) versus the main SiO band (at 1035-1085 cm^{-1}) in the spectra (Figures 3-4). Calibration curves were used for this determination. The results are depicted in Figure 5. The results demonstrate that the PMW of subgroups 1a and 1b contain small amounts of calcite in the matrix as observed by the small band of calcite (Figure 3). The low amount of calcite in the PMW is similar to the composition of the typical NCMW of group 2. Thus, for the preparation of the MW, non-calcareous or poorly calcareous raw material was used. On the other hand, the non-'Metallic Ware' of group 3 contains large amounts of calcite in the matrix as observed by the strong band of calcite (Figure 4). The latter vessels were prepared from calcareous raw material.

% quartz silt: The ceramic matrix may contain quartz silt. The percentage of the quartz silt in the ceramic matrix (after separation from the temper) was analyzed according to the relative intensity of the quartz doublet at 778-780 cm^{-1} versus the main SiO band in the spectra. The results are demonstrated in Figure 5. The PMW is characterized by relatively high content of fine quartz silt in the matrix which is similar to the composition of the typical NCMW.

Fired clay: The second derivatives enabled the observation of the composition of the fired clay in the ceramic matrix. The use of second derivatives of the spectra enables the identification of whether kaolinitic or smectitic (montmorillonitic) raw material was used for the pottery production. During the firing of the raw material to pottery, kaolinite is transformed to metakaolinite and smectite to meta-smectite. Metakaolinite is characterized in the FT-IR spectra by the appearance of the main SiO band around 1096 cm^{-1}. On the other hand meta-smectite is characterized by the appearance of this band at 1030-1060 cm^{-1} (Figures 3-4). Since the main SiO band of quartz silt in the matrix overlays that of the metakaolinite, quartz subtraction was operated before applying the second derivative of the spectra. The location (cm^{-1}) of the main SiO band of the meta-smectite in the second derivative of the spectra after the quartz subtraction is depicted in Figures 6-7. According to the results, in most PMW the location of the main SiO band of the meta-clay is similar to that of meta-smectite or mixture of meta-smectite and metakaolinite, indicating that smectitic raw material or raw material containing a mixture of smectite and kaolinite was used for their preparation.

Firing temperature (°C): The location of the main SiO band of the meta-smectite in the IR spectra appears in the range 1030-1060 cm^{-1}. This band progressively shifted to higher frequencies with an increased firing temperature. Thus, the location of the main SiO band enables the determination of the firing temperature of the pottery (Figures 6-7). Calibration curves were used for this determination. The results demonstrate that most PMW were fired at high temperature, above 850°C (Figures 6-7).

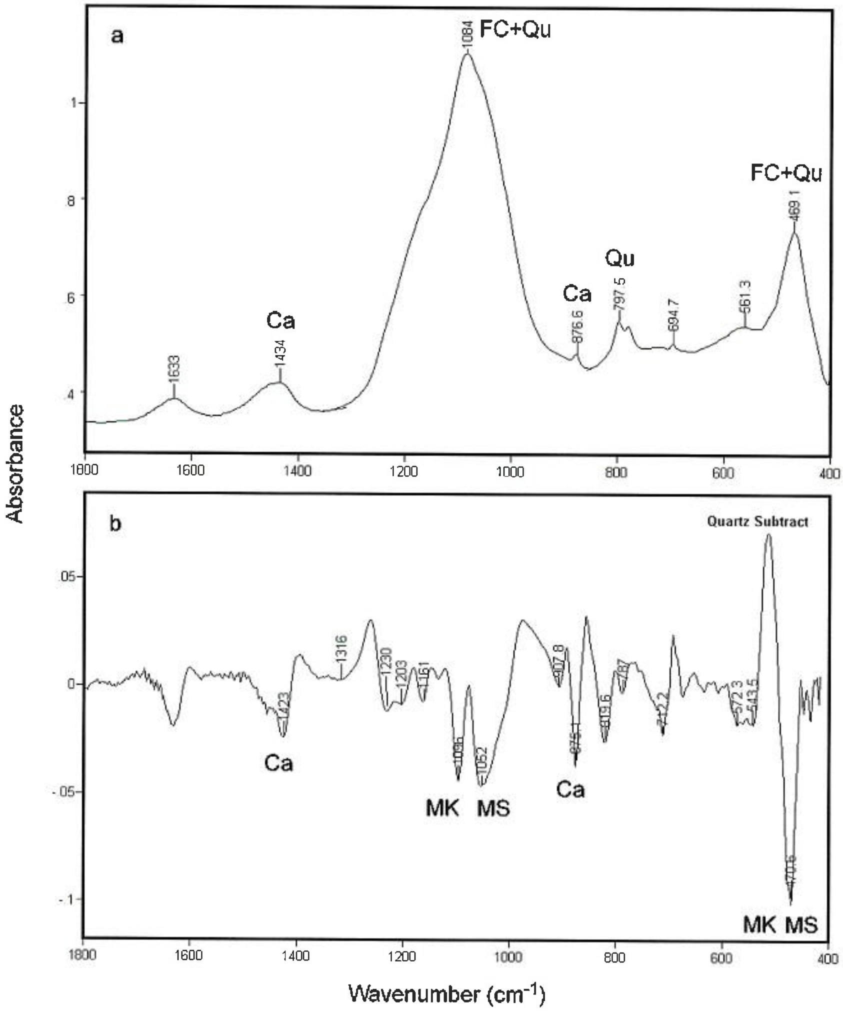

Figure 3. FT-IR spectra and second derivatives of the ceramic matrix of representative EB-1B PMW (R4-27). FC=Fired clay, MK= Meta-kaolinite, MS=Meta-smectite, G= Gehlenite, H= Hematite, Qu= Quartz, Ca= Calcite.

Discussion

Technological aspects

The material properties of the 'proto-Metallic Ware': The analysis showed that the EBIB PMW has similar material properties to those of the typical EBII–EBIII NCMW. The two groups are characterized by the low amounts of calcite in the ceramic matrix

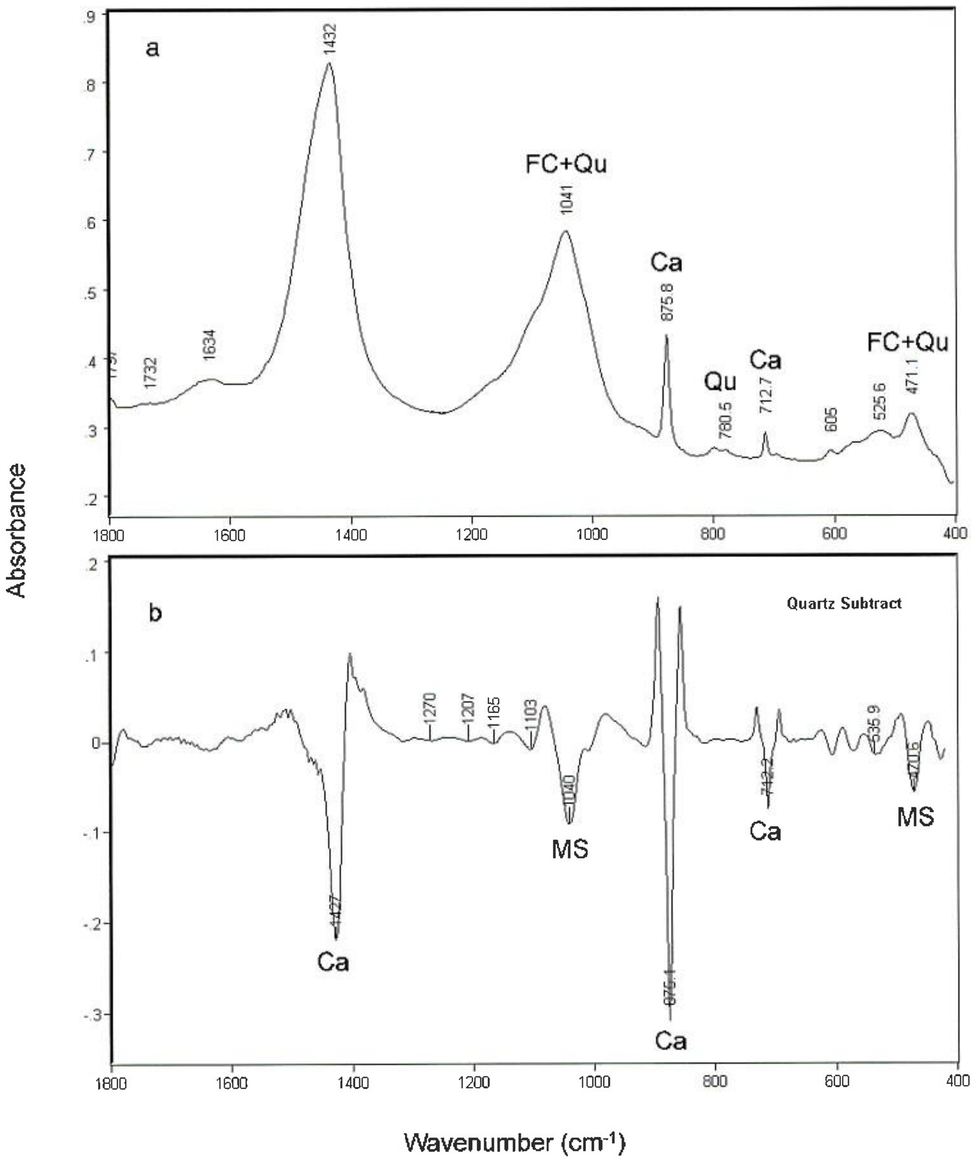

Figure 4. FT-IR spectra and second derivatives of the ceramic matrix of representative Reference EB-IB non-metallic pottery (R4-1). FC=Fired clay, MS=Meta-smectite, G= Gehlenite, H= Hematite, Qu= Quartz, Ca= Calcite.

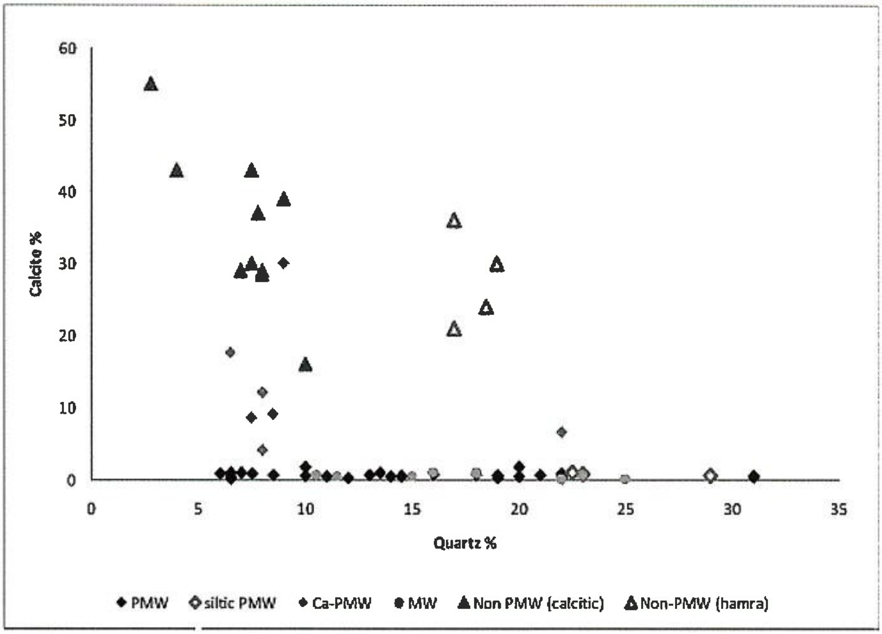

Figure 5. The amount of calcite and quartz in the different groups of the examined pottery.

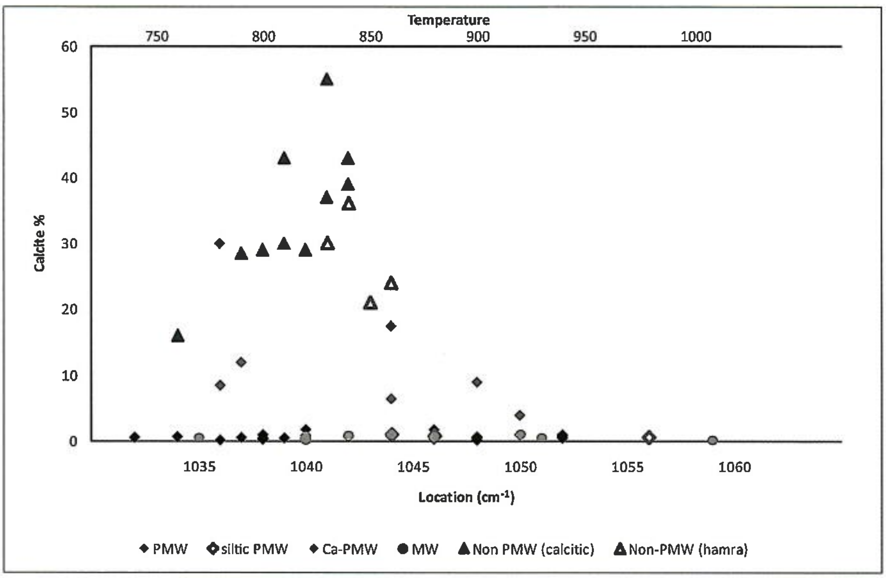

Figure 6. The firing temperature according to the location of the main SiO band of the meta-smectite and the amount of calcite in the different groups of the examined pottery.

(Figure 5), by the content of relatively large amounts of fine quartz in the matrix, by the content of quartz temper and "mud balls" and by the high firing temperature. The results demonstrate that the PMW as well as the NCMW was prepared from non-calcareous or poorly calcareous raw material. The material properties of EBIB PMW were also compared to EBIB non-'metallic' pottery. The latter pottery is usually characterized by thick walls and softer fabric. The non-metallic pottery contains large amount of calcite (Figure 5). The results demonstrate that the non-metallic pottery was prepared from calcareous raw material and is significantly different from the metallic pottery.

Selecting non-calcareous raw material

The use of non-calcareous raw material for the preparation of the PMW and the NCMW has some advantages. Such raw material enables production of pottery with thin walls. Non-calcareous vessels are usually more impermeable than calcareous vessels. Such vessels are more suitable for storing acidic food, such as wine which may react with the calcite composing the calcareous vessels. On the other hand, the production of non-calcareous raw material requires firing at a higher temperature than that needed for firing of calcareous raw material (Shoval et al. 2006). The use of non-calcareous raw material and the high firing temperature give the vessels their hard fabric and the metallic resound when struck. On the other hand, the softer character of the calcareous ceramic gives the non-metallic resounds.

The fact that the EBIB potters selected non-calcareous raw material for the preparation of the PMW demonstrates a specialization in their manufacture. It seems that the potters made an effort in the production of PMW due to their fine properties. The similarity in the material affinities between the EBIB PMW and the later EBII – EBIII NCMW confirms that the EBIB potters had knowledge of raw materials and manufacturing technologies, enabling them to produce highly fired pottery, thus confirming that the initial production technology of ceramic MW in the Land of Israel occurred some time during the late EBIB.

Selecting smectitic-kaolinitic raw material

Two main types of clay minerals are found in pottery raw materials – kaolinite and smectite. During the firing, kaolinite is transformed to metakaolinite and smectite to meta-smectite. The later phases can be identified according to the location of the main SiO band in the infrared spectra (Figures 3-4). The results demonstrate that most of the PMW was prepared from clayey raw material containing a mixture of smectite and kaolinite. The use of raw material containing smectite and iron oxides enables considerable reduction of the firing temperatures and causes the reddish colors of the 'Metallic Ware', due to the iron oxide content.

The firing temperature

The production of the MW from non-calcareous raw material requires firing at high temperatures, which gives the ceramic ware its 'metallic' properties. The results demonstrate that most pottery was fired above 850°C (Figure 6). This firing temperature is in accordance with Greenberg and Porat (1996) who stated that the vitrified clay matrix attests to temperatures higher than 850°C. The pink/orange colors of the pottery indicates that firing was mostly oxidizing, although some vessels were fired in a reduced atmosphere. In several poorly calcareous MW, some gehlenite is observed in the ceramic matrix by the second derivative. Gehlenite is formed by the reaction of the meta-clay and calcite at about 900°C (Maggetti 1981; Maggetti et al. 1984), indicating that the pottery was fired at about this temperature. According to Greenberg and Porat (1996), the re-carbonated calcite and the vitrified clay matrix attest to temperatures higher than 850°C. The 'Metallic Ware' was fired at a temperature higher than the norm for the EB non-metallic pottery (Porat 1989). The production of non-calcareous, in particular kaolinitic, raw material requires firing at high temperatures, which gives the ceramic ware its 'metallic' properties.

The origin of the pottery

The following origins were related to the groups of pottery.

Subgroup 1a (PMW)

The material composition of the PMW is similar to that of the typical EBII–EBIII NCMW. The two groups are characterized by the low amounts of calcite in the ceramic matrix (Figure 5), by the content of a relatively large amount of quartz silt in the matrix (Figures 1a, 1b), by the content of quartz temper and by the high firing temperature. The two groups frequently contain "mud balls" with siltstone, and grogs. The PMW was prepared from non-calcareous or poorly-calcareous raw material. Non-calcareous raw material is not common in the coastal plain region. Such raw material appears in Lower Cretaceous sediments and it is possible that it was used. Lower Cretaceous sediments are exposed in the Wadi Malih of the Samaria region and in the Wadi Zarqa region of Jordan, which are closer to the coastal plain sites. From an archeological perspective, it is possible that the origin of the PMW is in these regions (discussion below).

Subgroup 1b (Siltic-PMW)

The pottery of this group belongs to the 'Aphek family' bowls (Beck 1985). The 'Aphek family' clay have darker brown colors. The vessels were prepared from non-calcareous raw material (Figure 5) rich in quartz silt (Figure 1c). The high content of quartz silt in the pottery and the darker color indicates that this pottery was prepared from raw material taken from local Grumosol. Grumosol is a clayey soil deposited in marshes of the coastal plain. The carinated vessels from Tel Aphek, which were prepared from the local raw material, are different from the PMW sherds that were found at Rishpon-4.

Subgroup 1c (Ca-PMW)
containing some calcite (Figure 1d). Typologically, this group looks like PMW, but the amount of calcite in the pottery material is larger.

Group 2 (NCMW)
The EBII-III typical NCMW was manufactured from non-calcareous raw material poor in calcite (Figure 5) and containing some quartz grains and quartz silt (Figure 1b). According to Greenberg and Porat (1996), the raw material was taken from the Lower Cretaceous sediments that crop in the foothills of Mt. Hermon and in the north of Lebanon. Indeed, an EB production center of 'Metallic Ware', presumed to be in the Mt. Hermon foothills, was suggested by these authors. The kaolinite of this formation appears with sandstone which is the source for the quartz grains observed in the NCMW.

Subgroup 3a (Qu-non-PMW)
The pottery of this group was prepared from calcareous raw material rich in quartz temper (Figure 1e). Quartz grains are common in local raw materials such as Hamra soil and the alluvium of the Yarkon River and it seems that these raw materials were used for this subgroup.

Subgroup 3b (Ca-non-PMW)
The pottery of this group was prepared from calcareous raw material, and it contains monocrystalline calcite temper (Figure 1f). Such raw material is common in areas where limestone is exposed, such as the Samarian hills.

Archeological aspects

The distribution of the 'proto-Metallic Ware'
The distribution of the PMW in EBIB sites of the Land of Israel is demonstrated in Figure 7. The EBIB pottery at Rishpon-4 is characterized by two outstanding phenomena. First, there is a close similarity between the pottery assemblage from that site and those from Jordan Valley sites, such as Tel Shalem, Tel Beth Shean, Tel Bet Yerah and Tell Abu al-Kharaz. Moreover, most vessel shapes are also found in other coastal plain sites of central Israel, such as Shoham, Tel Lod and Tel Aphek. Thus, the resemblance of the pottery assemblage to the Jordan Valley sites is well attested. The petrographic analyses of a ribbed and ridged hole-mouth vessel from Rishpon-4 (Table 1: R4-1) seems to confirm a preparation in the Samaria region or in the adjacent Jordan valley sites such as Tel Beth Shean, which are in vicinity for the vessel. Second, there is rather high proportion of PMW at Rishpon-4, which may be connected to the first phenomenon.

The broader spatial distribution of PMW in the Land of Israel should be discussed. In addition to that of the coastal plain sites, PMW contexts have been reported to date from five sites from the Jordan Valley: Tel Yaqush, Tel Shalem, Tel Beth Shean, Tell Abu al-Kharaz and recently from Tel Beth Yerah. In Tel Yaqush, the PMW appears with 'Grain Wash' and MW jars (Esse 1993: 1503) and thus hints to an EBIB date for both. Since the excavation was not fully reported, one cannot exclude the possibility that the Grain Wash vessel was in fact a band painted decorated jar that continues well into EBII (complete vessels from Tel Beth Yerah, e.g. Greenberg and Eisenberg 2006: Fig. 5.79). Another curious fact that could support this possibility was that the MW jar from Yaqush, appearing side by side with the 'grain washed' jar, was 'fully developed, combed MW jars' (Esse 1993: 1503). In this respect one should keep in mind the limited repertoire, non-combed MW found in Rishpon-4.

The few MW sherds of Tel Shalem also included combed jars (Eisenberg 1996: 12) and once more this cannot be considered as decisive evidence. These vessels seem to be more developed MW, perhaps NCMW (as observed by Paz) and their combed texture is more at home in an EBII context. Their appearance at EBIB Tel Shalem seems rather curious. An on-going study of the EBIB pottery from Tel Beth Shean has resulted in the notion that PMW was also found at this site (Mazar and Rotem 2009: 143-144). The resemblance between the sherds from both Tel Beth Shean and Tel Shalem was noted (Mazar and Rotem, 2009: pers. comm.) and the fact that all evolved from secure EBIB contexts may fix their date firmly. Thus, the difference in surface treatment between them and the PMW pottery from the central coastal plain sites may result from reasons other than chronology (discussion below).

The pottery from Tell Abu al-Kharaz, where a complete jug of 'Early Metallic Burnished Ware' was found (Fischer 2000: 208, Fig. 12.2: 10), presents a more reliable picture,. The shape of the vessel as well as its manufacturing technique is more typical of EBIB than EBII, which resembles the Rishpon-4 PMW assemblage. The material from Tell Abu al-Kharaz has been discussed at length (Fischer 1994; Fischer and Toivonen-Skage 1995) and one may find it plausible that PMW did exist at the site.

The 1967 excavation of the Tel Beth Yerah yielded a similar phenomenon. A large fragment of a 'Crackled Ware' shaped bowl was found within a secure EBIB locus, which is a well known hallmark of EBIB in this region (Esse 1989). What is curious is the fact that this sherd had 'Metallic Ware' characteristics. Paz applied the term 'proto-Metallic' in the report to describe the fact that the vessel presents a kind of hybrid form in-between the late EBIB (according to the shape) and the very early EBII (according to the clay and firing technique (Paz 2006: 283, Fig. 7.21: 11). An intriguing fact of Tel Bet Yerah is the almost complete absence of PMW from the assemblages of all excavations at this large site. The few sherds reported so far from the site against tens of thousands of local normative EBIB sherds contrasts with the proportion noted at Rishpon-4. This is mainly because Tel Bet Yerah is much closer to the production center of the NCMW.

Some intriguing questions

The question of why the small site of Rishpon-4 is rather rich in PMW remains open, since this site is located far away from the main foci of the main phenomenon. It seems

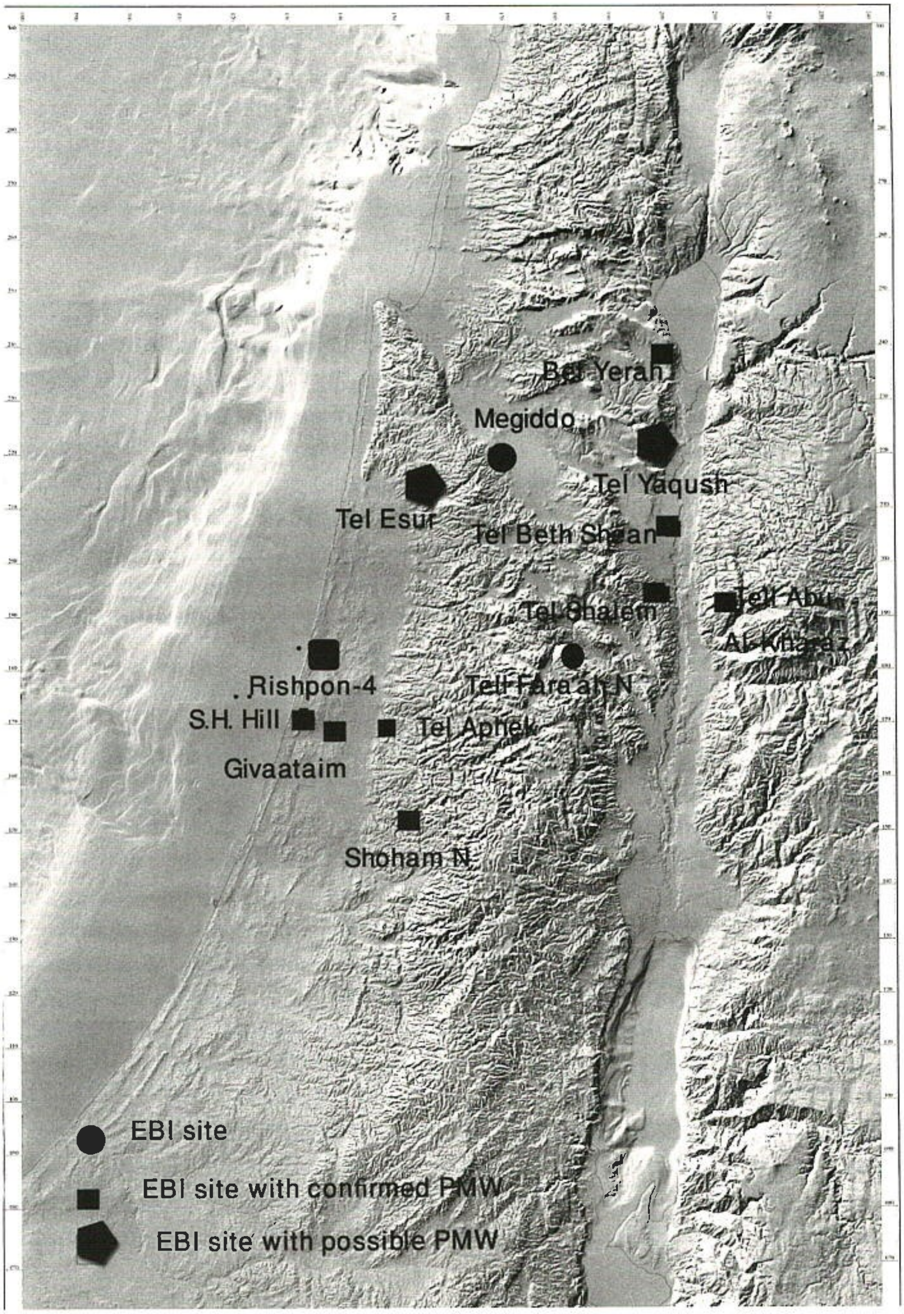

Figure 7. The distribution of the 'proto-Metallic Ware' in EBIB sites of the Land of Israel. The locations of the sites are demonstrated on a Shaded Relief Map of Israel by Hall (1997).

that this question will remain open until further close analyses of pottery assemblages in other EBIB contexts is conducted, and new evidence for PMW emerges.

Another question is whether the PMW and the typical EBII–EBIII NCMW have the same origin. A complete absence of EBIB sites in the center of the production area of the NCMW (the foothills of Mt. Hermon and southern Lebanon as defined by Greenberg and Porat 1996) indicates a different location. This seems to be in sharp contrast to the settlement growth and urbanization that took place during EBII (Greenberg 1987, 2002). Major sites such as Tel Dan and Tel Hazor, and the most important 'candidates' for the production of NCMW in the Mt. Hermon vicinity – Ein Kuniyeh and Ein El-Rahman – seem to have been occupied no earlier than EBII (Greenberg 2002: 73-79). Furthermore, the entire northern Golan Heights was devoid of even meager evidence of EBI occupation (Hartal 1989: 119). One should however note that the research carried out by Hartal was published more than 20 years ago and thus extra caution should be exercised before we establish the lack of any EBI remains in this region. Thus, there is the question as to the nature and identity of the initial producers of MW, which from an archaeological perspective are unclear.

In any case, the rather large amounts of PMW pottery found at Rishpon-4 could have been exported to the site from the northern Jordan valley. If the vessels traveled on land routes, they must have been known at sites located along the main trading routes of the period. Milevski (2005: 64) stated, referring to EBII NCMW, that the distribution line of the vessels from their production center passed through the coastal plain and the Shephelah, rather than the Jordan Valley. If we assume that the earlier settlement system of EBIB used more or less the same routes, such a reconstruction is plausible. Still, the appearance of proto-MW sherds at Jordan Valley sites is problematic in this sense.

The four sites (Rishpon-4, the Slaughterhouse Hill, Tel Aphek and the cemetery of Givatayim) represent a cluster that is connected to the Yarkon River. One may refer to a possible connection between them and the Jordan Valley sites with respect to PMW.

Another possible source for the 'proto-Metallic Ware'

It turns out that one cannot accept the presence of a rich PMW assemblage in the central coastal plain as an isolated phenomenon. The lacuna in our knowledge as to the presence of PMW in other regions may derive from several reasons.

First, pottery sherds from excavated sites that were found in EBIB contexts may not have been recognized as 'metallic' and discarded, or may have been considered as 'regular' ware vessels, not drawn and therefore not published.

Second, complete PMW vessels may not have been recognized as such since they did not fit the common known typology of MW (including combing). Since petrographic analysis was not a routine procedure for earlier excavations, some of the vessels that were found at sites such as Tel Azor (Ben-Tor 1975) and that were described as being made of 'red clay', may actually have been PMW.

The large geographic gap between the well-known 'homeland' of EBII – EBIII NCMW – that is the Hermon foothills – and the central coastal plain sites where EBIB PMW was located, such as Rishpon-4, Shoham north and Tel Aphek, may point towards another possible source for the pottery. A look at the geological map (Sneh et al. 1998) reveals a large outcrop of Lower Cretaceous formations situated along Wadi Zarqa which flows to the Jordan River. Although completely unstudied, it is important to point to Wadi Zarqa as another possible source for fine pottery that could have reached sites such as Tell es-Sa'idiyeh and Tell Handaquq North as well as sites located west of the Jordan River.

A more plausible solution for the source of PMW may be sought. Following the Yarkon-Ayalon tributary eastwards to Tel Aphek and further eastwards, the close relation to Wadi Faraa'h and the Samarian hills region is unavoidable. Indeed, scattered Lower Cretaceous outcrops are well known in the region between Wadi Fara'ah and Wadi Malih, ca. 30 km. northwards. The presence of pottery made from Lower Cretaceous clay in this vicinity was reported by Bar (2008). The detailed fieldwork conducted by Bar has revealed that the so-called 'Umm-Hammad Ware' was, practically, made in the Samarian hill region from Lower Cretaceous clay that evolved from the western flank of Wadi Fara'ah (Bar 2008: 154-163).

If indeed Lower Cretaceous clay was used to produce pottery vessels in the above-mentioned region, it is possible that the capability of creating highly fired vessels that were actually 'metallic' in nature, was present and thus we should expect to find vessels of this type in the Samarian EBI sites. The existence of MW prepared from Lower Cretaceous sediment at Tel el-Fara'ah north has already been pointed out (Greenberg and Porat 1996: 11). The few PMW sherds that were discovered at Tel Shalem could have originated from the Samarian region as well, in view of the proximity of Tel Shalem to Wadi Malih. However, as mentioned before, the combed surface of these vessels set them apart from the PMW of the central coastal plain, whether in chronology or cultural traits.

The possibility that both coastal plain (uncombed vessels) and Jordan Valley (combed vessels) PMW were produced in late EBIB has already been discussed above. The differences in external treatment between the pottery of the two regions may be explained by the following theories.

One, the combed types of PMW were manufactured as the typical EBII – EBIII NCMW in the close vicinity of Mt. Hermon during late EBIB, and thus combing became one of the hallmarks of the well-known EBII NCMW. On the other hand, the uncombed PMW pottery was produced elsewhere, probably in the Samaria region. There are some difficulties with this theory. As mentioned above, the Hermon foothills area is devoid any EBIB sites that could have operated the system that was needed for the creation of PMW pottery, namely kilns appropriate for firing at 900-1000 degrees. The occurrence of combed PMW at Tel Shalem, adjacent to a possible Samarian hill Lower Cretaceous source (Wadi Malih), seems to pose another difficulty in relating the PMW to the Hermon foothills.

Two, the Jordan Valley combed version of PMW was a little later than the coastal plain uncombed version, thus creating two subsequent latest EBIB phases. This theory is even less plausible due to the close typological resemblance between non-metallic assemblages of both regions. If, then, the Jordan valley sites such as Tel Bet Yerah, Tel Beth Shean and Tel Shalem represent the latest EBIB, they can not post-date the coastal plain sites. All of the above point towards a possibility that regional stylistic factors went beyond the differences mentioned above. The scanty amount of published PMW from Jordan Valley sites (excluding Tell Abu al-Kharaz) makes the definition of this ware problematic.

Summary and conclusions

The PMW has distinct material properties which enable its characterization. Its material properties are similar to those of the typical EBII–EBIII NCMW. The two groups are characterized by the low amounts of calcite in the ceramic matrix, by the content of a relatively large amount of fine quartz in the matrix, by the content of quartz temper and by the high firing temperature. The two groups frequently contain "mud balls" with siltstone, and grogs. The PMW was prepared from non-calcareous or poorly-calcareous raw material.

The typological and petrographic study that was presented in the current article brings to light for the first time a detailed view of the first appearance of PMW in EBIB. Since non-calcareous raw material, which was used for the preparation of the PMW, is not common in the region, it is possible that the Lower Cretaceous outcrops were employed for the production of the highly fired EBIB vessels. The data from coastal plain settlements and burial sites seems very clear and delineates a restricted repertoire of shapes, mainly bowls and small sized jars. No platters and pithoi were apparent and none of the vessels was combed.

On the other hand, the data from Jordan valley settlement sites (except Tell Abu al-Kharaz) gives us only a vague impression of the nature of PMW along the Jordan River. The scanty amounts of PMW sherds from Tel Bet Yerah, the odd combed vessels from Tel Shalem and Tel Beth Shean, all hint to variability in technological traits in different regions. In other words, it may be suggested that the PMW were manufactured in at least two production centers. It seems that the uncombed vessels that were found in the central coastal plain sites originated in the Samaria region. Another production center, possibly located in the Hermon foothills, or maybe further northwest in Lebanon, may have been the source of PMW at northern Jordan Valley sites such as Tel Bet Yerah. The sites that were clustered in the vicinity of the Beth Shean Valley may have imported PMW vessels from more than one possible source, but considering the scanty data that has been published to date from these sites, one cannot yet reach any firm conclusions.

Albeit not in the scope of the current article, the socio-political implications of a large scale initiative that ended with the production of the initial metallic-ware vessels should be at least briefly outlined. First and foremost, it is clear that the EBIB potters of various regions were well aware of the geography and physical traits of the clay that was needed to create the fine PMW. They knew where to quarry the material, and furthermore, they knew the technique that enabled high temperature firing for the vessels. The spatial distribution of PMW in two main locations (central coastal plain and the Jordan Valley) may hint to the existence of two contemporaneous mechanisms, each of them employing the whole chain of quarrying, producing and trading of finished vessels. If we speculate another possible production center for PMW along Wadi Zarqa, which may have been connected to the eastern Jordan Valley sites, we might get the picture of three or more such mechanisms that may have been connected with the emerging proto-urban centers during late EBIB (Getzov et. al. 2001: 22-24; Paz 2002). The first appearance of nucleated and sometimes fortified settlements in late EBIB may have motivated a higher level of pottery production, one of whose reflections was PMW.

By the end of the 4th millennium BCE, along with the spread of urban culture throughout the southern Levant, the vicinity of the northern Jordan Valley, probably the Hermon vicinity became the sole production center of the EBII NCMW that accorded well within the 'new order' that now monopolized large portions of the northern ceramic production (e.g. Greenberg 2002: 93-95).

In the end, It is important to note that the EBIB PMW sherds presented here are only the 'tip of the iceberg' of a phenomenon which seems to be much wider and should be further investigated.

Acknowledgements

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Notes

1. The term 'proto-metallic ware' was used for the first time by Paz (2006: 283), while analyzing the EBIB assemblage from Bet Yerah. In a recent article that focused on the EBIB architecture and finds in Beth Shean, the authors use the same term, while noting the existence of seemingly similar pottery (Mazar and Rotem 2009: 143-144).

2. It is important to note that Rishpon-4 was the only site where all of the PMW that was found during excavation was examined. At Aphek, the score of PMW sherds came from Area G alone, and the sherds from Shoham north resulted from an initial examination of selected loci only. Furthermore, the few PMW body sherds from the cemetery of Givatayim were representative of dozens of complete vessels we were not allowed to examine petrographically.

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TERRA COTTA AT THE NATIONAL MUSEUM OF ANTIQUITIES: THE CONSERVATION OF A FIGURINE OF APHRODITE

Renske Dooijes

From December 2, 2009 until September 12, 2010 the National Museum of Antiquities in Leiden features an exhibition of terracotta objects, all belonging to the museum's permanent collection. The Terracotta exhibition shows over a hundred objects including Greek figures of women ('Tanagras'), architectural fragments, medieval toys, prehistoric animal figures and mould-made terracottas from the Ancient Near East. During the preparation of this exhibition, a mould-made Tanagra figurine was restored. The entire restoration process was recorded on film and is now shown to the public during the exhibition. In this paper I shall discuss the conservation treatment.

The small terracotta statue represents Aphrodite, the goddess of love (Figure1). She carries a child in her left arm, probably the god Eros. The small child originally had two wings attached to his back (Figure 2). Aphrodite is wearing a himation (mantle) over a chiton (dress) and a tiara adorns her hair. The terracotta was found in Myrina (Turkey) and dates from the late Hellenistic period, around the 1st century BC. The museum acquired the object as early as 1889 through Alfred O. van Lennep, the Dutch consul in Smyrna (the present-day city of Izmir). The object was described in the inventory book by Conrad Leemans, the then director of the museum: "March 1889, LKA 1129, fired earthenware. Image of a woman, dressed in a long robe hanging down to the ground...". Further on, there are some remarks about the condition of the object. Leemans writes that it consists of several fragments that had already been repaired when the object entered the museum collection. The text also mentions that several bigger fragments of the figure had been lost.

Further examination of the terracotta showed that the statue was once painted, probably in bright colours. The himation and chiton worn by Aphrodite were originally covered with a white slip layer, which probably served as a base for further painting. The lower part of the chiton was decorated with white horizontal bands, which are still visible (Figures 1 and 3). The white paint was made from a white clay and was fired. After firing natural pigments, bound with egg yolk or casein, were used to decorate skin, hair and clothing. Although some faint traces of pink can be seen on the face of Eros, there is hardly anything left of these original colours.

As we have seen before, the figurine of Aphrodite had probably been restored around the time of its acquisition. Indeed, the figurine now consists of a total of fifteen fragments glued together with shellac, an adhesive commonly used in those days. Unfortunately the

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shellac had darkened and had become hard and brittle over time (Figures 1 and 3). In some locations plaster (calciumsulphate) was used to enforce and support the restored fragments. The missing fragments in the body of the figurine were not reconstructed during the early restoration.

The first step of the new conservation treatment was to clean the surface. I used a soft brush to remove loose particles of dust from the surface of the object. The subsequent dismantling of the old adhesive bonding proved to be very difficult. Shellac tends to become almost insoluble over time. At first I tried to soften the old adhesive with ethanol via the join lines, using micro pipettes. Since this did not work, I placed compresses dampened with ethanol on the join lines. The complete object was then placed in a fume hood. After several days the old adhesive had softened sufficiently and the glued pieces could be taken apart. I removed the remaining glue on the sherds with a scalpel and with cotton swabs soaked in ethanol. The old plaster supports on the back of the sherds were then carefully removed using scalpels and cotton swabs with water. Figure 4 shows the cleaned fragments of the figurine. Some interesting technological aspects came to light after closer examination of the loose and cleaned sherds. On some fragments fingerprints could be seen that were left by the potter when pressing the wet clay into the mould (Figure 5). Other fragments showed traces of tools that had been used by the potter to smoothen the clay (Figure 6).

Solvent-based adhesives are commonly used to restore low-fired and porous pottery. The fragments of Aphrodite were rebonded with Paraloid B72, an Acrylate glue based on ethylmetacrylate-metylacrylate copolymere. To prevent the fragments from shifting during the curing of the adhesive, they were temporarily held in position with small clamps.

After the bonding of the fragments, I used plaster to fill in the missing parts. I used sheets of dental wax as a temporary support behind the gaps (Figure 7). The plaster was tinted with dry pigments matching the colour of the sherds. After curing, I modelled the plaster into shape and then smoothed it with sandpaper and various tools (Figure 8). The break lines between the sherds were filled in with Modostuc, a calcium carbonate and PVAC-based filling material. The same material was used to retouch the plaster infills, to match the original colour of the figurine. This material, when mixed with water, can be used as a paint and gives a nice matte finish similar to the original surface of the object.

Restored to its former glory, Aphrodite can be admired in the National Museum of Antiquities (Figure 9).

Figure 1. Aphrodite before restoration.

Figure 2. Eros originally had two wings attached to his back.

Figure 3. Fragment of chiton decorated with white horizontal bands.

Figure 4. Cleaned fragments of the figure.

Figure 5. Fragment with fingerprints of the potter.

Figure 6. Fragment with traces of tools left by the potter.

Figure 7. Sheets of dental wax were used as a support behind the gaps.

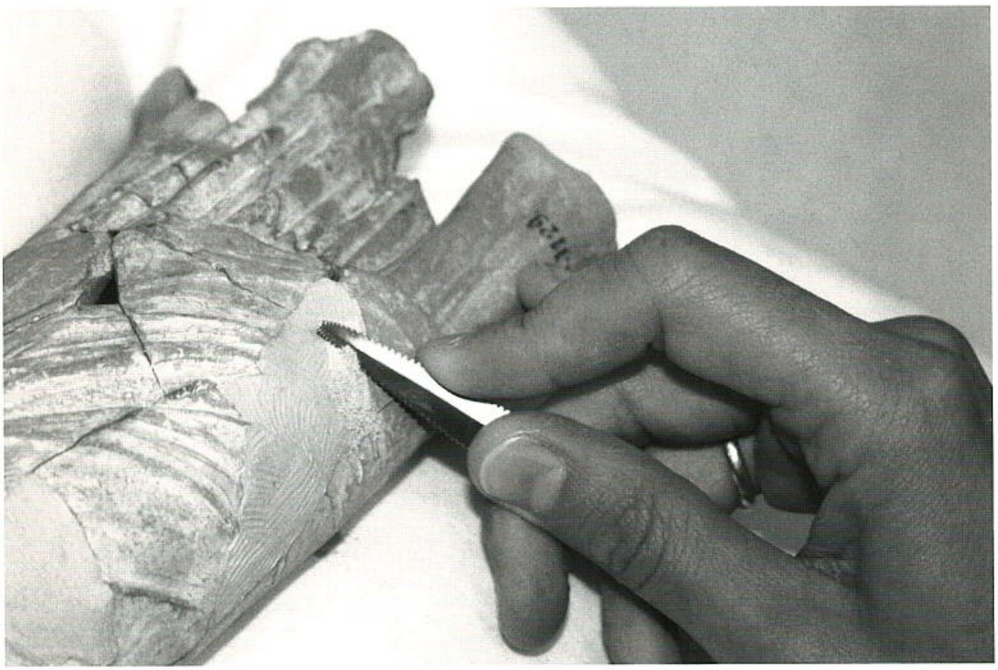

Figure 8. The plaster infills are smoothed.

Figure 9. Aphrodite after restoration.

BOOK REVIEW

Identity and Reciprocity in 15th Century Philippines by Grace Barretto-Tesoro. BAR International Series 1813, 2008. 193 pgs.

Marc Neupert

In the opening pages of *Identity and Reciprocity in 15th Century Philippines* by Grace Barretto-Tesoro, a reader might get the impression that this volume is simply a welcome departure from the chiefdom-dominated models found in much recent literature on Philippine prehistory. This in itself would make the volume a worthwhile read, but Barretto-Tesoro's volume goes much further. Using a wide range of methodological and theoretical approaches, she develops a picture of 15th century life in the Philippines that treats the complexities of ancient social life with both rigor and empathy.

Identity and Reciprocity in 15th Century Philippines is an examination of burials and their associated mortuary items from several sites in Calatagan, which lies in the Batangas region of the island of Luzon. This area is within the Tagalog region and Barretto-Tesoro's view is that these burials probably belong to them. The materials and records used in this analysis come from much earlier excavations, some from over fifty years ago, and are currently housed in museums in the Philippines; most notably the National Museum of the Philippines. So, among its other qualities, this volume also demonstrates the continued research potential of long-stored materials for archaeologists with fresh theoretical perspectives and analytical techniques.

Barretto-Tesoro brings an agency-perspective approach to her analysis, arguing that "individuals negotiated their identity and status through routines like pottery production, participation in raiding, feasting, trading and ritual performances." The second major theme of the volume is heterarchy, the idea that many forms of lateral and vertical relationships may exist within a society. For those archaeologists unsatisfied with the more traditional hierarchical approach to prehistoric social complexity, heterarchy provides an additional avenue for explaining networks of social relations. Barretto-Tesoro does not contrast hierarchical and heterarchical approaches within her volume, rather she looks for possible combinations of these structures. For those readers interested in the application of heterarchical ideas to prehistory, this volume provides both an overview and example of the approach.

To set up her detailed examination of earthenware pottery and burials, Barretto-Tesoro first plunges into a detailed examination of Philippine ethnohistory and ethnography with a particular focus on the "people's daily activities and the different

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contexts of individual's actions, intentions, and objects, especially those similar to items found in Calatagan." Specifically, she examines how "the multiple activities people performed contributed to the different identities they possessed, and that each activity and identity are materialized by the specific use of objects." This multidimensional aspect of identity and its association with objects is taken as an indicator of heterarchy. Within this section, Barretto-Tesoro's discussion of utang na loob, a reciprocal system of social and moral indebtedness, reveals with great richness a key value system of Tagalog society and its implications for heterarchy, agency and identity.

The analysis of the Calatagan pottery assemblage proceeds on several fronts. Barretto-Tesoro first develops a classification based on style and fabric then undertakes a metrical examination of the pots using the coefficient of variation within types to assess standardization. She then examines the pottery's fabric with analyses of inclusions, firing atmosphere, and porosity. Lastly, she undertakes a production cost analysis to ascertain relative levels of labor investment among the pottery types. From these data, she infers that Calatagan pottery production was not specialized or centralized and neither were the vessels "inferior status goods despite the foreign trade relations." This is an important finding in that it demonstrates a different response to foreign trade than that of nearby Tanjay, where Junker found that pottery manufacture was undertaken by centralized specialists in order support a complex trade system organized by chiefs. Rather, the Calatagan pottery assemblage appears to have been organized at the household level without elite management. Thus, Barretto-Tesoro establishes that long distance trade did not have the same effect throughout the Philippine archipelago and that hierarchical, ranked societies were not the only outcome of foreign trade in this region.

Having dismissed the centralized and specialized economic model as appropriate to Calatagan, Barretto-Tesoro then investigates how an agency approach might provide a richer portrait of Calatagan society in the 15th century. To do this she embarks on a five-chapter journey through mortuary assemblages and the rituals that created them, seeking to understand their meaning in relation to cultural identity, prestige, age, gender, and so on. There are moments of true vividness as when Barretto-Tesoro discusses pottery being used as provisions for the dead, offerings for the spirits, or as "body extensions" (replacing crania lost to head-taking activities). From these analyses the reader gradually begins to appreciate the wonderful complexity of identity and social relations, and all its inherent negotiations, within Calatagan society. This is heterarchy.

In conclusion, in *Identity and Reciprocity in 15th Century Philippines*, Grace Barretto-Tesoro has used the Calatagan burial sites to contribute to two key areas in Philippine prehistory: "the representation of identities and statuses through earthenware vessels (and other funerary objects) and the burial practice and the key elements of complexity (craft standardization and hierarchy)." Although her research materials came from museum storage rooms, Barretto-Tesoro nevertheless breaks new ground in Philippine archaeology.

BOOK REVIEW

Dragos Gheorghiu (ed.) 2009. *Early Farmers, Late Foragers, and Ceramic Traditions: On the Beginning of Pottery in the Near East and Europe*, Cambridge.

Olivier P. Nieuwenhuyse

The nice little volume *Early Farmers, Late Foragers, and Ceramic Traditions* edited by Dragos Gheorghiu, accompanies a growing number of papers, monographs, edited volumes, and even entire conferences, focusing on the earliest introduction of ceramics in the Near East and the Old World. This reflects a genuine increase in archaeological interest, which is also shown in the numerous early pottery sites researched in the field, the critical re-evaluation of earlier discoveries, and an increasing host of innovative laboratory studies. A novel research field seems to be emerging, which aims to understand the first introduction of fired clay containers in human societies. There can be little doubt that the adoption of pottery marked a major turning point in our history – ceramics are a major pillar sustaining our globalized world today. Yet in contrast to earlier work, there is an emerging consensus amongst many scholars that no singular model explains the wide diversity seen in the archaeological record. If we wish to explain when, how and why communities first adopted pottery, context *matters*. Books such as these are therefore valuable contributions. They offer scholars specialised in particular parts of the world quick access to relevant insights emerging elsewhere. As many exciting new discoveries in this field are really *new*, few specialists will have much chance to update themselves. This volume is recommended to everyone interested in the initial adoption of ceramics in Europe.

The book collects a series of syntheses by established ceramic specialists, each familiar with the evidence from a specific region. Together they cover a broad territorial swathe stretching from the Middle East towards Europe and Scandinavia. This also implies a temporal dimension: the case studies start with the earliest Pottery Neolithic cultures in the Near East, dated to the 7^{th} millennium BC, and successively move forward in time to reach the 3^{rd} millennium of Neolithic Sweden in the final chapter. The editor tactfully steers away from imposing a simplistic "Ex Oriente Lux" perspective, and takes care to allow each participant to speak on the behalf of his or her specific spatial-chronological context. In his introduction chapter, the editor reviews existing views regarding the first emergence of ceramics. This crucial chapter certainly could have been somewhat more extensive. The author briefly touches on issues such as materiality, secondary products, alternatives to pottery, and the symbolism associated

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with early ceramics, but he does not explore these issues much beyond the surface. Gheorghiu discusses the two opposing models with regard to the Neolithization of Europe – colonization by immigrants versus indigenous adoption – and their differential potential impact on the spread of ceramic technologies. This dynamic forms a major thread in the chapters to follow. He concludes with outlining five broad regional ceramic traditions: Continental Eastern Mediterranean, the Balkans, the Mediterranean Littoral, Central Europe and Northwestern Europe-Scandinavia. These regional distinctions offer the reader a useful mental map for the chapters that follow, but they do not explicitly surface in the chapters that follow. The introduction leaves the reader wishing that its author had pushed his editorial bird's eye just a little further.

The book takes off with Mehmet Özdoğan's discussion of recent evidence from the Near East and Turkey. People in this region adopted pottery around 7000 cal. BC. In contrast to Europe, pottery was not originally part of the 'Neolithic package', but was added to it several thousands of years after the rise of sedentary farming communities. Long before pottery, several excellent alternatives were available for making durable containers, in clay, plaster, reed or stone. Why Neolithic groups in the Near East decided to shift to ceramics remains a question so far unanswered. Also, as Özdoğan points out, the hypothetical 'experimental' stage appears to be missing: early ceramics in the Near East seem to spring onto the cultural stage fully developed. Is the initial stage still missing? The author presents some of the major ceramic traditions – Dark-Faced Burnished Ware, various types of Coarse Ware – and concludes with discussing the westward expansion of the Neolithic way of life across the Bosporus into Europe.

The three following chapters by Ezster Bánffy, Michela Spataro and Italo Muntoni review the evidence from the Balkans, the Adriatic region and southern Italy. The fifth chapter by Pilar Prieto-Martínez extends the Mediterranean perspective into the Iberian Peninsula. In the Balkans, the earliest pottery belongs to the Körös and Starčevo-Criş cultures, followed by the early Linear Bandkeramik cultures; along the Mediterranean coast various categories of Impressed Ware appear at the beginning of the sixth millennium BC, whereas far to the west in Galicia morphologically homogeneous, plain vessels dominate. The first introduction of ceramics in these parts is interwoven with the spread of the Neolithic, either by colonizing farming communities or by the local adoption by former hunter-gatherers. Bánffy succeeds in bringing home the sheer archaeological complexity of this phenomenon in Hungary, while Prieto-Martínez does so for Northwestern Spain. Spataro, Muntoni and Prieto-Martínez ably summarize much new and ongoing work on the organization of early pottery production in their respective areas.

Chapters six to ten by Jutte De Roever, Anne Hauzeur, George Nash, Fredrik Hallgren and Åsa Larsson move the regional perspective much further north, into Northwestern Europe and Scandinavia. Here a very different mix of Neolithization processes and indigenous hunter-gatherer developments pertains. On the one hand there was a slow spread of societies that present the full Neolithic package, including the Linear Bandkeramik, La Hoguette, Limburg, and Trichterrandbecher (Funnel Beaker) cultures.

Across the Neolithic border, on the other hand, there were various well-documented instances of foraging groups who interacted with these settlers in various ways. Sometimes these foragers adopted pottery production. An intriguing example from the Dutch wetlands are the Mesolithic hunter-gatherers of the Swifterband culture (5300-3400 BC) discussed by De Roever. The characteristic Swifterband vessels with a pointed base are comparable with those from the Ertebølle foragers in Denmark (4500-3200 BC) discussed by Nash. In Sweden, southern Finland and western Russia, the Comb Ware culture people began making ceramics already around 5000 BC without changing their hunter-gatherer life style. Then there were other groups who rejected the adoption of ceramics, such as the Slate Culture from northern Scandinavia, discussed by Hallgren. Scandinavian archaeology, finally, yields an intriguing example of a "de-Neolithization" process, as exemplified by the Pitt Ware Culture from Eastern Sweden (3400-2350) discussed by Larsson. Known for its abundant quantities of strikingly-decorated pottery, the Pitt Ware Culture represented a forceful continuation of hunter-gatherer life ways long after the Neolithic had established itself across most of Europe.

CURRENT RESEARCH OF THE LEIDEN DEPARTMENT OF POTTERY TECHNOLOGY (2009)

Research projects in cooperation with:

Leiden University (Faculty of Archaeology):

Caribbean Archaeology:

- 'Communicating Communities, Ceramics and Social Change' (Netherlands Foundation for Scientific Research /NWO; C. L. Hofman);
- Tobago (A. Boomert).

Meso-America:

- 'Ceramics and Social Change. The Impact of the Spanish Conquest on Middle America's Material Culture (Netherlands Foundation for Scientific Research /NWO; G. Hernández Sánchez).

Leiden University (Faculty of Archaeology / the Netherlands National Museum of Antiquities:

- 'Abrupt Climate Change and Cultural Transformation' (Netherlands Foundation for Scientific Research/NWO; P.M.M.G. Akkermans and O.P. Nieuwenhuyse).

The Netherlands-Flemish Institute in Cairo (NVIC):

- An ethnoarchaeological documentation project at the Fustat pottery workshops, Egypt (K. Duistermaat).

Delft University of Technology and Leiden University (Faculty of Archaeology):

- Iron Age IIc/III pottery from Tell Deir 'Alla (Centre of Art and Archaeological Studies/ CAAS; J. Dik and N.C.F. Groot).

University of Texas, Austin

- Pottery from Tel Yin'am and Khirbet Beit Gan, Israel (H. Liebowitz and A. McKinney Dehnisch).

Working Group on Mesopotamian Pottery:

- A Corpus of Mesopotamian Pottery (Second Millennium B.C.) (H. Gasche and J.A. Armstrong).

The Netherlands National Museum of Antiquities:

- Terra cotta exhibition.

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