# LEIDEN JOURNAL OF POTTERY STUDIES

VOLUME 24 2008



ISSN 1574-1753

# COMPARISON OF COMPOSITIONAL ANALYSES OF IRON AGE CERAMICS FROM TWO SITES IN JORDAN

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*Abstract*

*Iron Age pottery, including Late Bronze/Iron Age I collar rim storage jars, Iron Age II black burnished bowls, unique cult pieces, cookware, and the regular repertoire from two sites (Tell Hesban and Tell el-'Umeiri) is examined using petrographic analysis and Instrumental Neutron Activation Analysis (INAA). We compare the results of each study with the morphological categories based on vessel shape and surface finishes to learn about change and continuity of clay bodies and organization of the ceramics industry in ancient Jordan.*

## Introduction

Mineralogical and chemical analyses of pottery excavated at Tell Hesban was carried out to examine diversity of raw materials within and between the long span of habitation and use of the site from the Iron Age I to recent times.[1] To specifically investigate the regional Iron Age I and II ceramics industry, we compared sherds excavated at Tell Hesban and Tell el-'Umeiri (Figure 1). Relative proximity of the two sites, located southwest of Amman in the Madaba Plains region, permits a regional assessment of pottery manufacture and distribution for central Jordan.

## Material and methods

Hesban pottery J. Sauer excavated and collected during the initial excavation seasons provides the basis for our compositional analysis. The material is currently part of the collection at Canadian University College in Lacombe, Alberta, on study loan from Andrews University.

Our original criteria for selecting Hesban sherds was to sample the widest range of vessel types, fabrics, and firing patterns based on macroscopic appearance of the clay bodies. An earlier, preliminary petrographic analysis of sherds from Tell el-'Umeiri (London et al. 1991), also guided our Hesban sherd selection.

The sherds submitted for Hesban petrographic analysis include 310 sherds from Tell Hesban (Petrographic Hesban samples (PH 1-291 and PH 298-316[2]) and six sherds excavated at Tell el-'Umeiri (PH 292-297[3]). Thin section analysis of 230 sherds,

*Leiden Journal of Pottery Studies 24, 2008: 115-132*

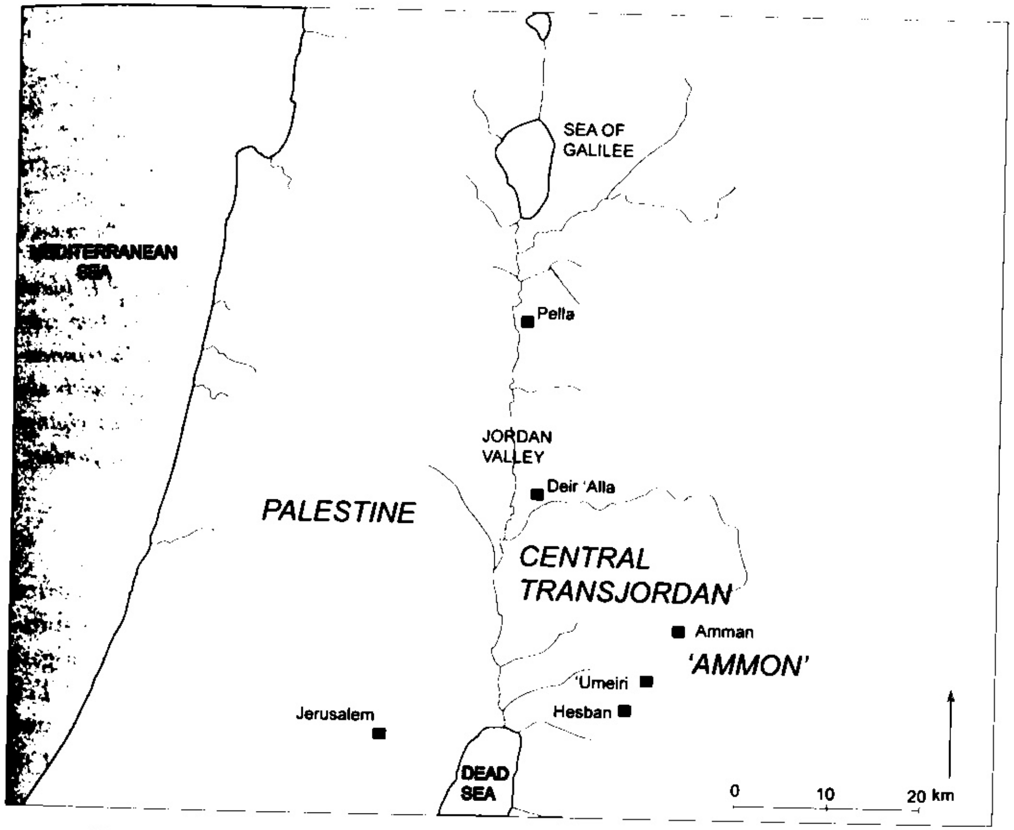


Figure 1. Location of Hesban and Tell el-'Umeiri in the Madaba Plains, Jordan

amongst which 86 sherds dating to the Late Bronze Age-Iron Age II/Persian period was executed.[4] For petrographic thin section preparation, sherds were cut parallel to the vertical axis of each pot to sample vessel walls rather than rims or handles. Examination of the thin sections, using a polarizing microscope and magnifications of ×40 and ×100, allowed identification of mineral types. R.D. Shuster, with students J. Blair and S. Kelly at the University of Nebraska, Omaha Department of Geology, recorded the type, size, orientation, shape, frequency, and sorting of inclusions in clay bodies from Hesban. Under the supervision of Jon Cole (Walla Walla University) and John Winter (Whitman College), students J. Quinn and L. Shultz examined 'Umeiri thin sections.

"Fabric" and "clay body" are used here to designate the mix of rocks, minerals, organic materials, either native or additives, blended together with the fine clay particles. In describing clay bodies, small 'voids' refer to spaces left by burned out organic material, in contrast to cracks, fissures, etc. caused during manufacture, drying, or firing. The quantities of non-plastics are in terms of 100% and do not include the amount of clay



or voids. A clay body can have 75% quartz, 20% limestone, and 5% grog inclusions. The same clay body can have 60% clay, 35% non-plastics, and 5% voids of burned out organics. We differentiated 12 main ware types, each with a different predominant inclusion based on the mineralogical analysis of 230 sherds of all periods at Hesban.

After petrographic analysis 99 Iron Age sherds were selected for Instrumental Neutron Activation Analysis (INAA), i.e. 74 of the 86 thin section samples and 25 samples from 'Umeiri (PU – Petrographic 'Umeiri). The INAA was carried out by H. Neff and M. D. Glascock at the University of Missouri Research Reactor Center (MURR).[5] The 99 Iron Age sherds include 12 collar rim store jars of Iron Age I, 10 cooking pots, 38 burnished bowls, and 39 samples from either the Hesban normal repertoire or the unique pieces. Jars, jugs, and bowls, burnished or plain, constitute the Iron Age I and II control group against which we compare and contrast the 74 Hesban and 25 sherds excavated at Tell el-'Umeiri. Here we summarize the INAA chemical results and compare those findings to the petrographic mineralogical study. INAA separates the 91 of the 99 samples into Groups 1-4 with eight samples unassigned to any group.

## INAA Group 1

Two-thirds of the 99 samples belong to INAA Group 1, including Iron Age I collar rim store jars, and the full range of Iron Age II jugs, jars, bowls, kraters, plates, plus one cooking pot (Figure 2). Group 1 encompasses virtually every petrographic group with predominantly grog, limestone, or a blend of quartz, limestone, and grog. Missing are wares with 50% or more quartz temper. At Hesban, the latter primarily is a post-Iron Age fabric. Pottery from both Hesban and 'Umeiri in Group 1 includes Iron Age I collar rim store jars, regardless of their precise shape, and Iron Age II burnished bowls with different rim shapes. Group 1 accommodates all wares (except those over 50% quartz) and all surface finishes (plain, painted, or burnished) from both sites suggesting that it was local to the Madaba Plains and/or Central Jordanian Plateau area.

Of the ten INAA cooking pots sampled, only one, PH 91, fits the Group 1 chemical profile. The sampling strategy is not likely responsible for this situation. Mineralogically this particular cooking pot matches other Iron Age II pottery with limestone temper. However, limestone is a poor choice for cookware given its tendency to decompose at relatively low temperatures. The other nine cooking pots fall outside the limestone rich fabrics typical of Group 1. Petrographic analysis of the Hesban sherds reveals that grog, calcite, quartz, or a blend, are more prevalent than limestone in cookware. PH 91 has a trace (0.1%) of powdery calcite, possibly native to the clay. In terms of rim morphology, the shape is in the newer, narrow-mouthed Iron Age II tradition.

## INAA Group 2

The 14 Iron Age and one Hellenistic bowl (PH 145) contain grog, calcite, and limestone as the primary inclusions. Pots tend to be small in size, burnished, or unusual.

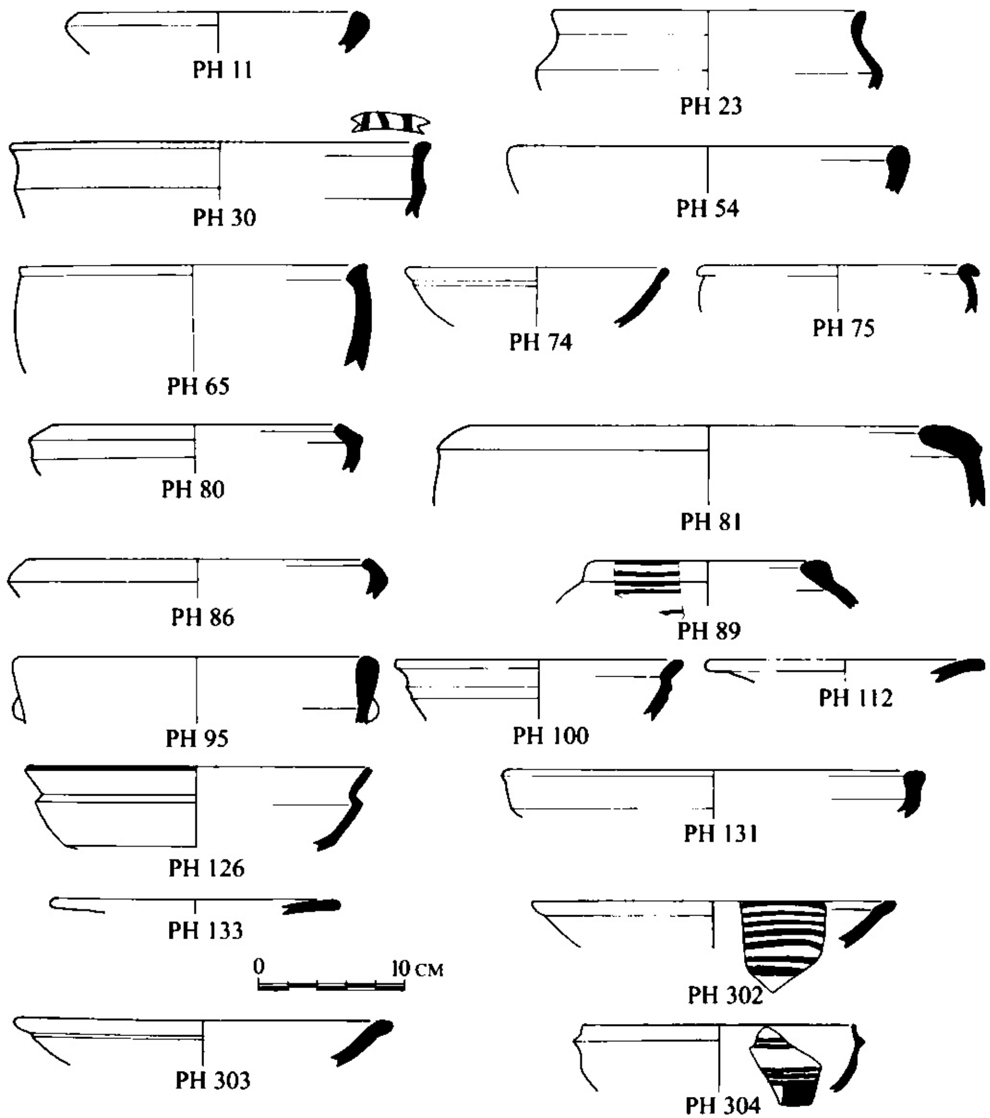


Figure 2. INAA Group 1: open forms including burnished bowls.



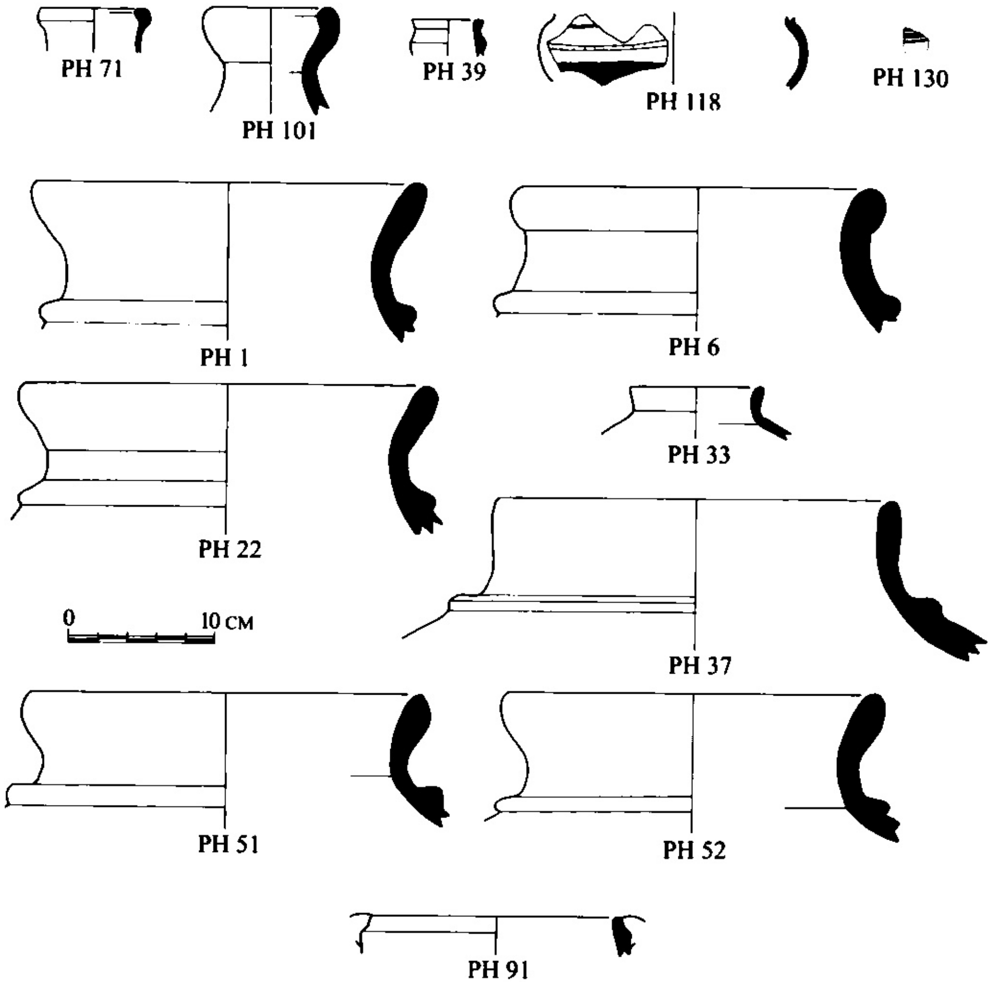


Figure 2 continued.
INAA Group 1: closed forms – six collar rim store jars and a cooking pot.

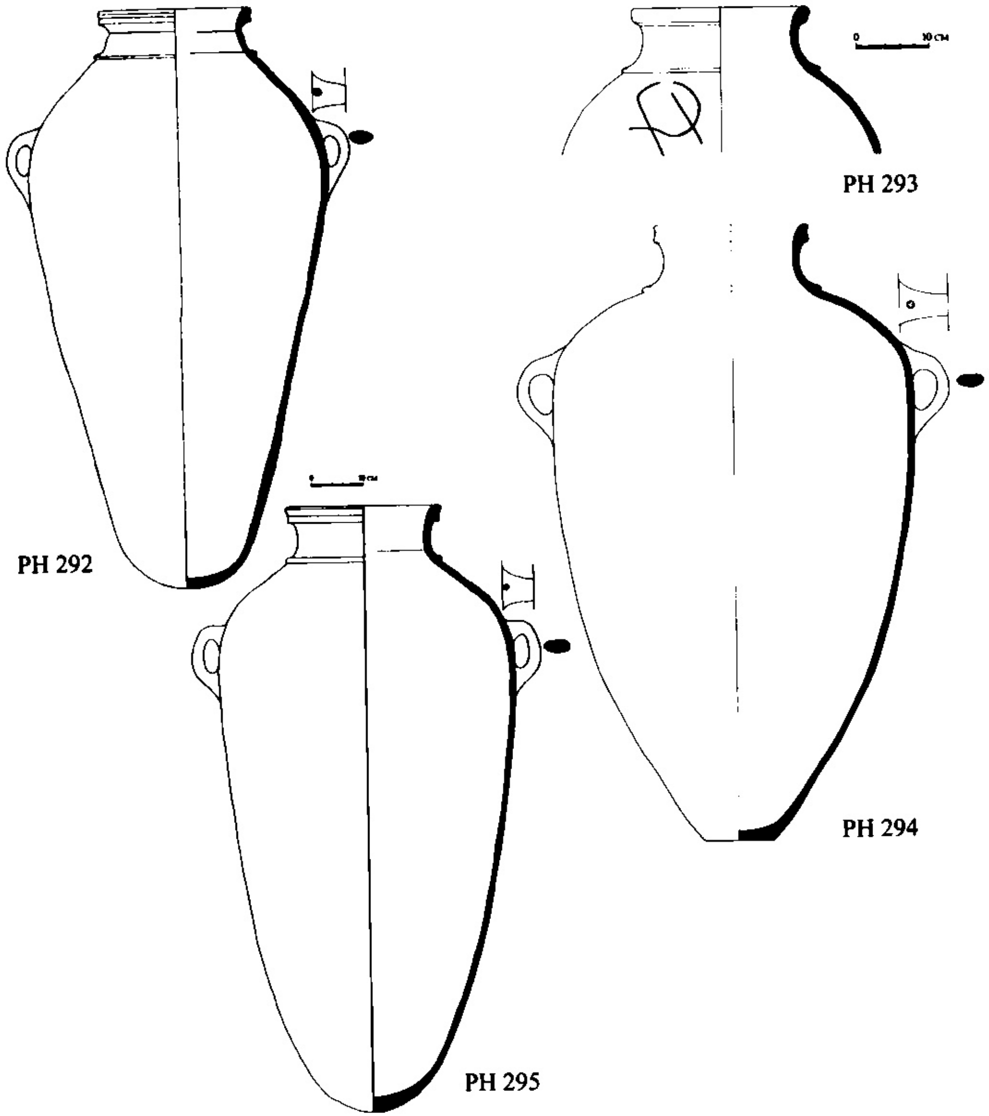


Figure 2 continued.
INAA Group 1: collar rim storage jars.



Burnished bowls are in addition to the infrequent pieces such as the plaque, flask, and mug (Figure 3). The single larger piece belongs to a possible cult stand. Cooking pots and storage jars, which constitute 25% of the total sample, are absent not due to sampling strategy. Instead, their absence reflects different sources than the less frequent shapes and some burnished bowls, including some with the nicest sheen and luster.

## INAA Group 3

The seven samples in Group 3 include: one Iron Age II jug, one Roman period bowl, and five Iron Age II cooking pots, all from Hesban (Figure 4). Unfortunately, no cookware from 'Umeiri was submitted and as a result, it cannot be concluded that Group 3 pots did not reach the site. No Iron Age bowls or jars of any size, shape, or finish are in this sub-set. The normally ubiquitous limestone is not a prominent inclusion in any sample. Calcite, quartz, or grog, predominate in individual sherds. Others have a blended mix. All except PH 124, which is grog-rich, contain some calcite. PH 135 alone has basalt. Given that five cooking pots and a jug are categorized together suggests that the same raw materials possibly suited certain non-cookware or this is a heating jug.

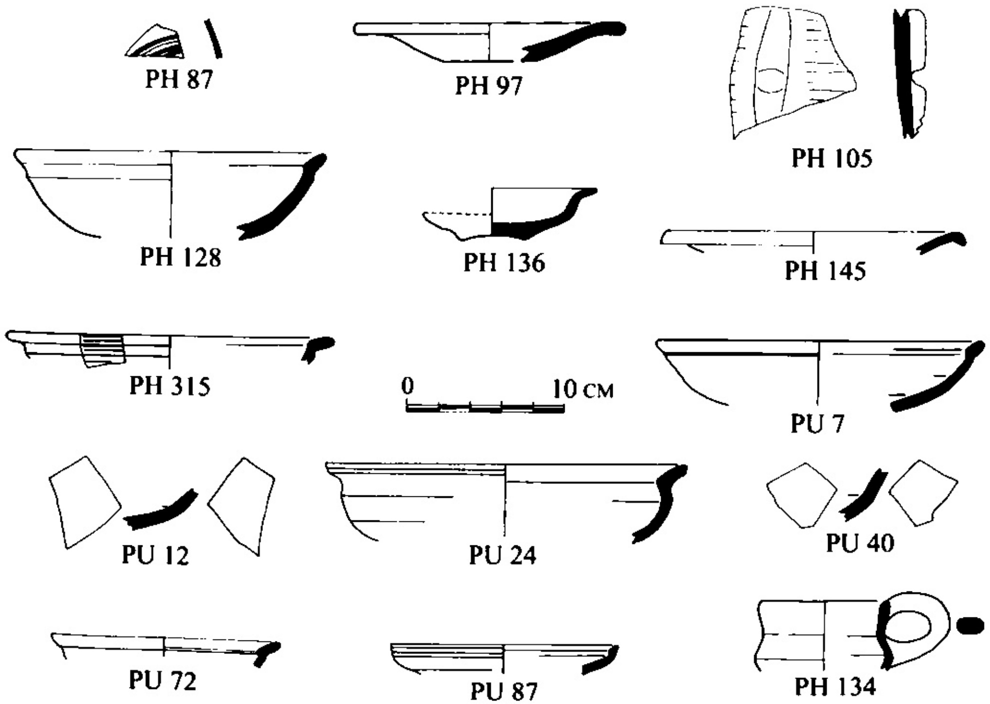


Figure 3. INAA Group 2: burnished bowls and infrequent ceramic shapes.

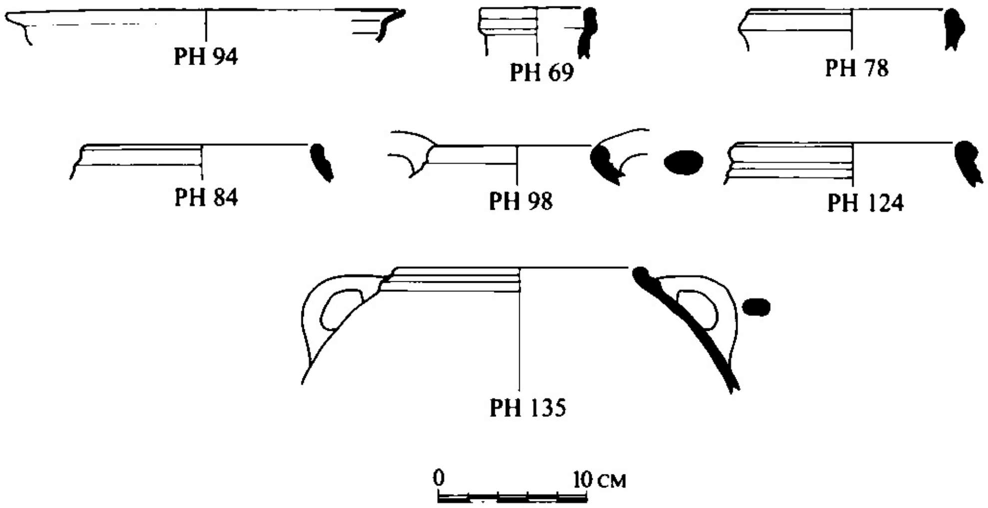


Figure 4. INAA Group 3.

The mineralogical and chemical compositions of cookers differ, in general, from most other pots. Calcite temper in PH 84 and 98 reaches approximately 95% of the total inclusions. Grog is a rare choice for temper in cookware, but it accounts for 70% of the intentionally crushed and added sherds found in PH 124. In these samples, the great abundance of a single inclusion type is rare in non-cookware.

The quartz (55%) and calcite (35%) mix in PH 135 is an uncommon combination in our sample. Most Hesban sherds with over 50% quartz are of Late Iron Age II/Persian date. Similarly, at Tell Deir 'Alla, phases V/VI of the 6th century Late Iron Age IIC, bowls include a new fabric characterized by quartz sand. In contrast, cooking pots with quartz temper start already in phase VII of the 7th century (Groot 2007: 101). PH 135 is either Late Iron Age II/Persian or it one of the early quartz-rich shapes in the Iron Age II repertoire. The implication is that cooking pots led the shift from carbonaceous inclusions, such as calcite and limestone, to quartz.

### INAA Group 4

Four Hesban cooking pots with predominantly quartz temper, to the exclusion of other minerals, comprise INAA Group 4 (Figure 5). Rim morphology varies considerably: inward or outward slanting, thin or thickened, bulbous or not. PH 298 has a rounded bulbous rim from which a handle extends. It bears closest resemblance to Group 3 rims, in contrast to the other three cookers, two with everted rims and the holemouth form of PH 300. Handles on two pots are wide, flattened ovals rather than circular in shape as on other cookers. As a group, the four rims shapes are distinct from INAA



Group 3. Herr (per. com. 2007) dates PH 298-301 to the 6-5th centuries rather than the 7th century, i.e. Persian rather than Iron Age. The entire collection could represent a chronologically distinct group from Groups 1 and 3.

### Unassigned

Eight samples fall outside the four INAA groups (Figure 6). From the 'Umeiri excavation are two collar rim store jars and a red burnished bowl. From Hesban is one of the only wheel-thrown jugs, PH 108, as well as two additional jugs and a burnished bowl. Mineralogically these samples have predominantly limestone, grog, or a blend of non-plastics plus some basalt. One red burnished bowl is made of a blend of calcite ground fine plus quartz. The collar rim store jar (PH 296) could be a Group 1 outlier. The implication is that most of the ten store jars were of local or regional manufacture designated as Group 1, while two might come from elsewhere, although it remains possible that they are somewhat unique, but distant members of Group 1.

## Discussion

The sampling strategy for the petrographic and INAA compositional studies incorporated maximum diversity in shape, color, and firing of available sherds from Hesban. Our starting point was to use mineral and chemical analyses to test the morphological and macroscopic variations archaeologists regularly detect in precise vessel morphology and clay bodies. One result of adopting such a strategy is the limited number of samples within each category of vessel type and rim shape. For example, there are differences within burnished bowl rims and bodies, and cooking pot rims. Can we determine if the source of variation resulted from different workshops, potters, and/or manufacture in different times or places? Were the red and black burnished Iron Age II bowls, known in the literature as "Ammonite Ware", made in different contemporaneous workshops in the Madaba Plains, central Jordanian plateau or elsewhere? What do differences in the firing colors represent in terms of pyrotechnology? Refiring tests taught us that the black burnished color resulted from a reducing kiln atmosphere (London et al. 2007: 82). Why did some bowls fire without the black surface and core? Were red bowls versus black bowls made from two distinct clay bodies? Some cooking pots fire red while others are dark in common with Bronze and Early Iron Age cookers. Does firing color alone change or are there other attributes, which change simultaneously?

### *Trends in clay bodies*

INAA Groups 1 and 2, in addition to the petrographic studies, demonstrate the overlap of fabrics used for Late Bronze/Iron Age I and II pottery. The Iron Age I material was limited to the collar rim storage jars. Cooking pots and a jug in INAA Group 3

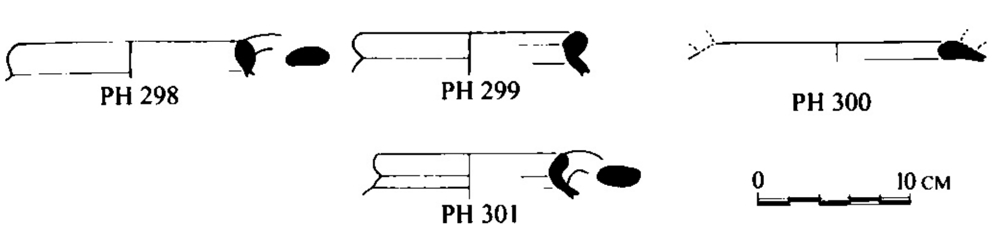


Figure 5. INAA Group 4: cooking pots.

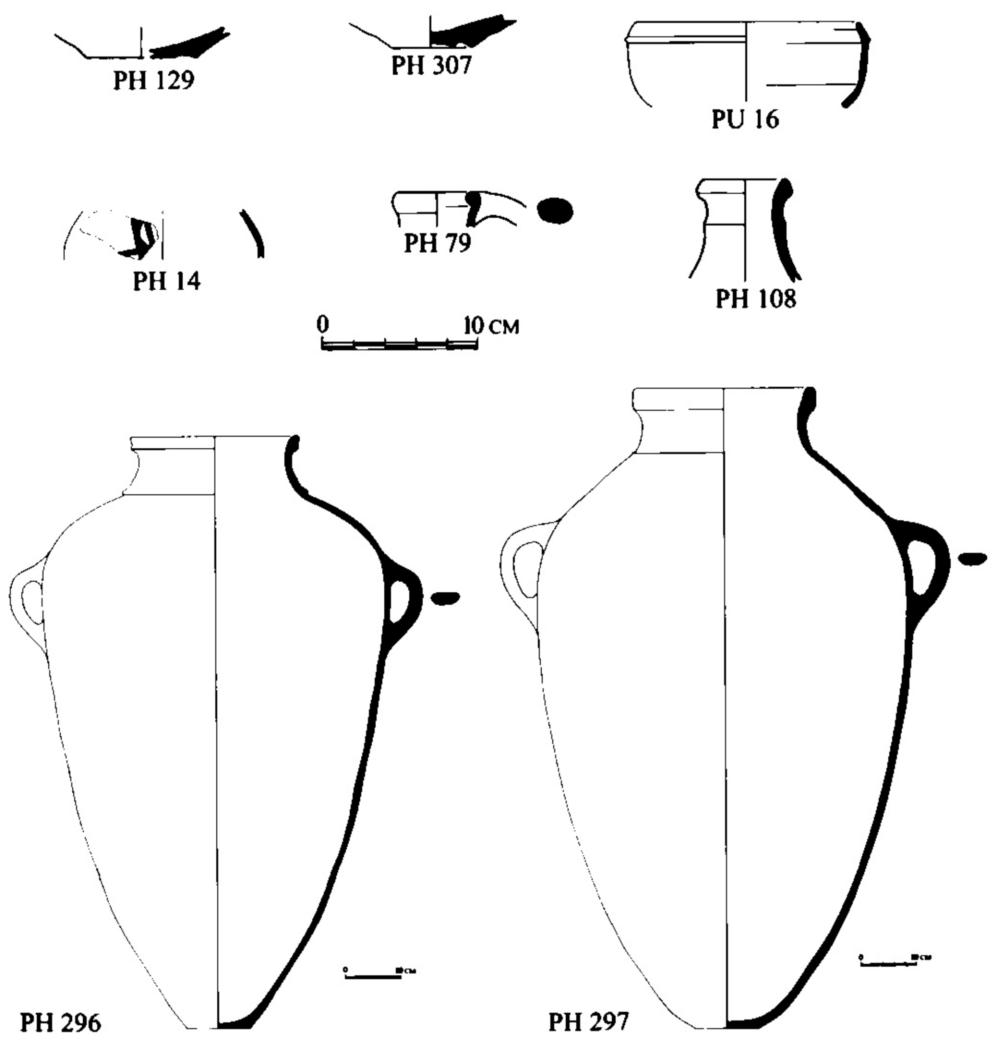


Figure 6. INAA unassigned sherds from Hesban and 'Umeiri.



display an exclusivity of non-plastics uncharacteristic for Iron Age II pottery. INAA Group 4 shows discontinuity of clay body in the choice of quartz temper for new cookware. The same is found for cookware from Deir 'Alla (Groot 2007: 101). It is feasible that potters responsible for cooking pots were among the first shift to quartz.

To understand why cooking pots might have been in the forefront of ceramic technology, even without changes in foodways, uselife of cookware can be considered. No type of pot has a shorter lifespan than cooking pots. Used daily, it experienced the most wear and tear of any pot. Archaeologists rely on changes in cooking pot rim profiles as sensitive chronological markers precisely because the pot broke and was replaced faster than any other pot. As a consequence, cookware clay bodies can shift before others given the need to replace them faster than any other type of container.

### *Iron Age I collar rim store jars*

Eight of the ten collar rim jars, excavated at Hesban or 'Umeiri, were made of clay bodies similar to the bulk of Iron Age II pottery assumed to represent local or regional manufacture. For the two outliers, an origin elsewhere is feasible, but it is impossible to make broader inferences. Herr (2000: 281) cites the repertoire from the highlands north of Jerusalem, in the region of Shechem, as most comparable to the 'Umeiri assemblage in terms of overall morphological similarities. This raises the issue of an origin of these large, heavy jars some place west of the Jordan River.

### *Regional trade*

People at Hesban and 'Umeiri accessed similar deposits or raw materials. The prevalence of limestone can make it difficult to be more precise about the origin of the jars. If not in the immediate surroundings, people at both sites took advantage of the same markets and middlemen to buy or barter for pottery. If true, the implication is Iron Age I and II societies at Hesban and 'Umeiri belonged to the same economic/trade area. Although INAA Groups 3 and 4 include Hesban sherds alone, this can easily be explained as a sampling problem due to the omission of Late Iron Age II or Iron Age II/Persian cooking pots excavated at 'Umeiri.

The greater diversity of petrographic wares than chemical groups might reflect: (1) differential treatment of the same basic clay supply; (2) variations within individual clay deposits; (3) disparate but nearby clay sources; or (4) chronological distinctions. Petrographic analysis allows one to divide Iron Age I and II pottery into more clusters than the chemical analysis, in part because we distinguish clay bodies with varying percentages of inclusions. Grog, limestone, and a blend of non-plastics, all are accommodated in INAA Group 1. Only the petrographic study recognizes basalt in pottery, usually in association with primarily limestone, calcite, or grog inclusions. In fewer instances, basalt was native to the clay, rather than an addition, intentional or not. Basalt fragments are always rare. They could have entered the clay body as a by-product from using basalt grinding equipment to crush limestone, calcite, grog, etc. Since the chemical analysis of the clay bodies discussed here, did not identify the basalt, the assumption is that it was not native to the clay. For example, in PH 135, the angularity of the grog, limestone and calcite attest to their deliberate crushing, probably using basalt equipment.

### *Organization of the Iron Age I and II ceramics industry*

According to the INAA and petrographic analyses, organization of the local ceramics industry involved potters with access to similar, locally available raw materials suitable for practically the entire repertoire of normal pottery, including jugs, jars, bowls, plus burnished or plain bowls, and cooking pots. These potters and/or workshops whose products are designated as Group 1, worked with a limestone-rich clay body to make the full range of shapes. Cooking pots, an infrequent part of the local repertoire, were perhaps made on occasion to fill the gap when no other sources of cookware were available. Late Iron Age II cooking pots from Deir 'Alla similarly contain little limestone tempering material (Groot 2007: 101). Limestone cookware was acceptable, but less desirable than cooking pots made of other inclusions.

Local ceramics include a tradition of decorated painted as well as burnished surfaces. It cannot be assumed that painted Iron Age I or II pottery represented imported pieces. Certain burnished Iron Age II bowls were made of the same basic raw materials and in the same shapes as unburnished pots. Collectively, burnished bowls do not constitute a 'fine ware' given that, in many instances, inclusions in the bowls are no finer than those in thicker walled, larger pots. In addition, the same rims and bowl types, with thick or thin walls, were available with or without burnish.

Occasionally the clay bodies of those with a burnish were made of a more refined fabric than other forms, suggesting manual crushing and/or sifting. Limestone tempering material in the local fabrics prevented potters from firing kilns to a temperature high enough to cause the inclusions to decompose. As a consequence, a low heat kiln assured that locally made bowls had a dark black or gray surface and core as a result of incomplete burning of the organic material in the clay. The low temperature assured preservation of the sheen as well.

### *Iron Age II burnished bowls*

INAA Group 2 is a collection of some of the finest burnished, almost lustrous, bowls. Also in this group are the unique cult-related ceramics, a plaque and possible cult stand. Based on the petrographic study, none were recognized as distinct from other burnished bowls. Neither rim shape nor mineralogical composition induced us to separate them into a special category as INAA suggests. The bowls and other pieces include grog, calcite, and limestone rich clay bodies, as do Group 1 burnished bowls. One feature they share, however, is firing color. Burnished bowls in Group 2 fired without



a darkened core. They are thoroughly oxidized. The absence of a darkened core implies an improved and/or more complete firing, special treatment or selection of the nonplastics, or a more forgiving clay body capable of withstanding a wider range of temperatures than burnished bowls made elsewhere using other fabrics. Absence or presence of a darkened core is significant and a feature that seems to differentiate among products of different workshops. It is likely that black burnished bowls with a dark core zone were fired in a reducing kiln atmosphere under 900 degrees Centigrade (London et al. 2007: 82). Some bowls fired red, or red and black, indicative of an oxidizing kiln atmosphere. Refiring experiments demonstrate that black bowls, burnished or not, will start to become red at 725 degrees Centigrade (Groot 2007: 100).

The results of the mineralogical and chemical tests show that Iron Age II black burnished bowls were products of multiple sources, including the region of Hesban and 'Umeiri, but not exclusively. Within the region, products of different potters or workshops have grog temper while others have the normal blend of carbonaceous inclusions, including calcite and limestone (London et al. 2007: 84). Similarities between our samples in Group 2 and raw clay material from the region around Pella indicate a second production region according to the INAA findings. Particular characteristics found in the clay bodies could signify chronological distinctions as well as different locations of manufacture. Vessel shape and rim profiles at the present are not specific to Groups 1 or 2, implying that all workshops produced the same repertoire. A larger sample might prove otherwise. INAA demonstrates that observation of the core color hints at the diversity of clay bodies and firing technologies used to make and perhaps mimic burnished bowls.

INAA divides burnished bowls into Groups 1, 2, and the unassigned category. Petrographic analysis differentiates fabric types based on the mineralogical composition of grog or limestone-rich clay bodies. The INAA addresses the important question of where the pottery might have originated and demonstrates that although the bulk of the samples probably derive from the region around Hesban and 'Umeiri, there are notable exceptions. INAA Group 2 represents pottery originating to the north of Hesban, in the Jordan Valley, possibly near Pella. Group 2 includes the rare and exotic shapes, such as the plaque, cult stand, and a flask along side the more typical, but highly burnished bowls. The implication is that unusual 'special' ceramic objects might have originated in a region outside the Madaba Plains along with a small quantity of normal and burnished shapes. Large jars of Iron Age I and II as well as cooking pots, were not among the ceramics brought from the more northern source.

### *Infrequent ceramic shapes*

Specialty items, such as the flask, plaque, and cult stand, are more likely to have been brought from greater distances than the more utilitarian ceramic pieces. Neither Iron Age I collar rim store jars nor Iron Age II cookware traveled the same route as certain burnished bowls, or the infrequent shapes including the plaque, flask, and mug. The fragment designated as a potential cult stand likewise could have been the creation of a potter who worked far from Hesban. The calcite-rich flask, was identified as mineralogically distinct the rest of the samples tested.

### *Sherds of undetermined origin*

Jars of all types belong to Group 1, other than the two unassigned samples, which could be outliers of the same group, or not. The unassigned black-burnished bowl with a stepped base excavated at Hesban, PH 307, was possibly made outside the region entirely, as was a red burnished bowl from 'Umeiri, PU 16. Neither fits the four INAA Groups.

To help resolve the unassigned bowl, consideration of the manufacturing technique of open forms with stepped bases is useful. At times the base center might fire to a slightly different color, or present a minimally different texture, than the rest of the bowl. The precise method of fabrication might account for the use of two slightly different clay bodies for the bowl. To build the bowl, initially potters made an open form, finishing the rim completely. The base, however, was left thick, flat, and unfinished. After the bowl rim was sufficiently dry to support the weight of the pot, the bowl was re-centered upside-down, on a turntable. To shape the stepped base from a thick, flat bottom, potters had two choices. One could shape and cut steps into the thick base, if the clay were still malleable. Alternatively, if it was overly hard, potters would remove the drying clay and insert fresh, wetter clay, often containing more inclusions than the bowl body. Extra inclusions were necessary in the wet clay to help it dry as fast as the bowl body. Inclusions can facilitate evaporation of moisture by opening the clay and creating space through which water migrates to the surface. An uneven drying rate would result in the drier body pulling or shrinking as it dried faster than the freshly added wet clay of the base. But this should not impact INAA designation. Potters would have added extra inclusions to the same basic clay, which sometimes fires to a slightly different color than the bowl. Therefore it appears that we have several sources, minimally three, for burnished bowls.

### *Cooking pots*

INAA differentiated most cookware (Groups 3 and 4) from the regular repertoire. Cooking pots contain exceptionally high quantities of a single non-plastic, higher than for most other vessel categories. This is probably intentional. Groups 3 and 4 have low calcium. All samples in Group 4 lack calcite or limestone, which are sources for calcium.

Group 3 samples PH 84, 98, and 135 have similar rims thickened at the top and an exterior ridge at the bottom of narrow mouths. They slant inward and two preserve a handle, although two handles was probably the norm. The presence of calcite, and the general lack of orientation for elongated voids, are reminiscent of the older Bronze Age and Early Iron Age style of cooking pot manufacture in contrast to the more forward looking narrow mouth diameters. One further new element is their red firing color of PH 84 and 98.



Although calcite predominates in PH 84, it is not the calcite rhombs of the earlier tradition. Instead, calcite powder, measures no larger than 0.01-0.4 mm. In PH 94, calcite granules measure up to 0.5 mm and no larger. The shift from large angular calcite rhombs to fine sized calcite, suggests that potters choose, for some reason, to use ground calcite or no calcite for cookware. They would pound and pulverize calcite or limestone and then sift it to remove the larger granules before adding it to the clay. Alternatively they could select quartz, which not only requires less preparatory work, but also can withstand relatively high firing temperatures, at least higher than large calcite fragments. The red firing color and absence of a darkened core is evidence for high kiln heat.

Differences in clay body composition might reflect the versatility and/or uncertainty of potters. They could represent different facets of the transition to a new technology, in which quartz temper would eventually dominate by the late Iron/Persian Age (London et al. 2007: 83). Additional evidence of the new tradition is discernable in PH 84 and 98 which both fired red and have handles. In earlier times, darkened cores and surfaces prevailed because large calcite rhombs would have decomposed before a red firing color was achieved, but the secret to the success of these pots was in grinding the calcite into powder.

Exclusivity of temper, evident in PH 84, 98 and 124 was not accidental. These clay bodies were deliberately and carefully prepared in a process requiring several steps. To achieve homogeneity of temper necessitated removal of all other non-plastics. The preferred temper, grog, quartz, or calcite was then introduced. For PH 135, the angularity of the inclusions and presence of basalt imply another stage in the work. Before the quartz and calcite were shifted, they were crushed between basalt tools. As a consequence basalt chips entered the clay body with the crushed and sifted tempering material.

The rilled rim jug in Group 3 suggests that few other shapes were made of clay bodies expressly created for cookware. No other Iron Age II jugs, jars, or bowls were made of these same fabrics. The implication is that cookware was the work of a specific group of potters who did not make the full repertoire. In PH 135, on the other hand, one sees the shift from reliance on calcite to quartz, the post-Iron Age temper of choice. It appears as if the cooking pot makers were at the forefront of ceramic change despite the highly traditional nature of their product.

Quartz is the post-Iron Age period temper of choice, yet in our sample, Late Iron Age II cooking pots appear to have been an early form with over 50% quartz sand. Two outside sources for cooking pots are defined as Groups 3 and 4. No cookware comes from the potentially northern Group 2. Differentiation of two cooking pot groups could imply chronological distinctions and/or separate places of manufacture where clay was prepared specifically for cookware. Group 4 is likely later than the Late

Iron Age II Group 3 cookers. If fabricated from clay bodies that differed from non-cookware, Group 3 cooking pots conceivably were the work of a separate group of specialists. In contrast, potters using clay body INAA Group 1 made cookware as well as the full repertoire of utilitarian shapes. The implication is that while some cookware was produced by cooking pot specialists, cookware was also in the repertoire of craft specialists responsible for the bulk of Iron Age II ceramics. It is the latter group of potters who maintained the older Bronze-Iron Age traditions in cookware clay bodies. Cookware specialists appear to have been on the cutting edge and responsible for the shift to quartz temper for cooking pots and eventually most other shapes.

## Summary

INAA and petrographic analyses reveal complexity and continuity of Iron Age I and II ceramic sources. Eight of the ten Iron Age I collar rim storage jars are of local manufacture. Iron Age II burnished bowls originated from multiple sources both within and outside the immediate region of Hesban and 'Umeiri. There was no single source. At present, we lack sufficient samples to determine if there is a correspondence between rim or body shape and clay body. If the pots were contemporaneous, several different fabrics for Iron Age II cooking pots similarly imply a range of sources. In Late Iron Age II/Persian times, potters experimented with cooking pot fabrics and could have been in the forefront of the shift to quartz temper as found in later fabrics used to shape a wide range of ceramics. The conclusion is that people at Hesban and 'Umeiri had multiple sources and options for bowls and cookware, unless it can be demonstrated, through well-stratified deposits, that the various clay bodies were chronologically distinct.

## Acknowledgments

For support from the Shelby White-Leon Levy Program for Archaeological Publications, we thank the donors and Martha Joukowsky, Phillip King, and administrators of the program, Anthony M. Appa and Kimberley Connors-Hughes. Directors of Madaba Plains Project – 'Umeiri, Lawrence T. Geraty, Larry G. Herr, and Douglas R. Clark graciously granted access to the 'Umeiri pottery. Loe Jacobs of Leiden University carried out the re-firing tests. At the Horn Archaeological Museum of Andrews University, Paul Ray selected Hesban sherds included in this study. Denise and Larry Herr graciously extended hospitality during the sampling in Lacombe.

University of British Columbia students prepared the thin sections for the petrographic analysis. Jon Cole of Walla Walla University, along with John Winter at Whitman College, supervised Whitman students Laura Shultz and Jason Quinn in their petrographic analysis of 'Umayri thin sections. Petrographic thin section analysis carried out by Jason Blair and Sheryl Kelly, former students of Robert Shuster at the University of Nebraska at Omaha thanks to a faculty grant from UNO. Geologist Otto Kopp offered his geological expertise on numerous occasions before his untimely death. Henk J. Franken provided the inspiration and direction for the study.



## Notes

1. The Tell Hesban pottery study was made possible by a grant from the Shelby White-Leon Levy Program for Archaeological Publications. Full details of the samples will be published in the final publication currently with Andrews University Press.

2. These sherds (PH samples 298-316) were selected by P. Ray from the Hesban sherds housed at Andrews University.

3. Sherds excavated at 'Umeiri and submitted as part of the Hesban petrographic analysis carry a "PH" designation, such as PH 292-297. All other 'Umeiri sherds have "PU" numbers.

4. Thin sections of Hesban sherds include 86 Late Bronze-Iron II/Persian sherds (38%), 84 Hellenistic-Byzantine (37%) and 60 (25%) of Islamic date.

5. The Hesban INAA research will be published in detail in the final Hesban pottery volume or elsewhere.

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