# The Origin of the Pottery of Kuntillet 'Ajrud

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KUNTILLET 'Ajrud (Ḥ. Teiman) is in north-eastern Sinai, 50 km. south of Kadesh Barnea and 15 km. west of Darb el-Ghazza, on the road which led in antiquity to Elat and southern Sinai. The junction of several natural routes and the existence of wells near the site determined its location in the middle of the desert.

The excavations held at the site[1] revealed that the remains consisted of two buildings. The main building, which yielded most of the finds, is a rectangular structure measuring 25 × 15 m. It comprises an open courtyard with an entrance complex in the east and two storage rooms in the south and west.

The most important finds at the site, which demonstrate its uniqueness, are a number of drawings and inscriptions in the early Hebrew and Phoenician scripts on stone and pottery vessels and on the plaster of the walls. Research on the inscriptions, finds and architecture brought the excavator to the conclusion that the site functioned for only a short period at the beginning of the eighth century B.C.E. and had connections not only with Judah but also with Israel. The excavator assumed that the site was a religious centre inhabited by a group of priests who gave blessings to travellers journeying to the south.

A considerable amount of pottery was found, all of the Iron Age II: sherds of local 'Negbite' hand-made types were entirely lacking. Typological study of the vessels yielded good comparisons from three regions: Judah, the southern coast and the north of Israel (and Phoenicia). This fact, together with other evidence of Israelite influence, motivated the excavator to submit the vessels for neutron activation analysis (NAA). The present report is concerned with this study.

The purpose of determining provenience in the laboratory is to circumvent the need to assign an origin to vessels on the basis of stylistic criteria alone. Care was therefore taken to sample the various types; in all, 23 vessels were selected for analysis.

The most distinctive was a relatively rare pithos characterized, among other features, by its size and hole-mouth opening. Two of the 11 pithoi which were sampled bore inscriptions and decoration. For reasons which will become clear below, we shall discuss the provenience of these vessels together with others of the same type excavated at different places. Seven of these were from excavations in or near Jerusalem: the

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[1] Z. Meshel: *Kuntillet 'Ajrud: A Religious Centre from the Time of the Judean Monarchy on the Border of Sinai* (Israel Museum Catalogue 75), Jerusalem, 1978; idem, Did Jahweh Have a Consort?, *Biblical Archaeology Review* 5 (1979), pp. 24–35; Pirhiya Beck: The Drawings from Ḥorvat Teiman (Kuntillet 'Ajrud), *Tel Aviv* 9 (1982), pp. 3–68.

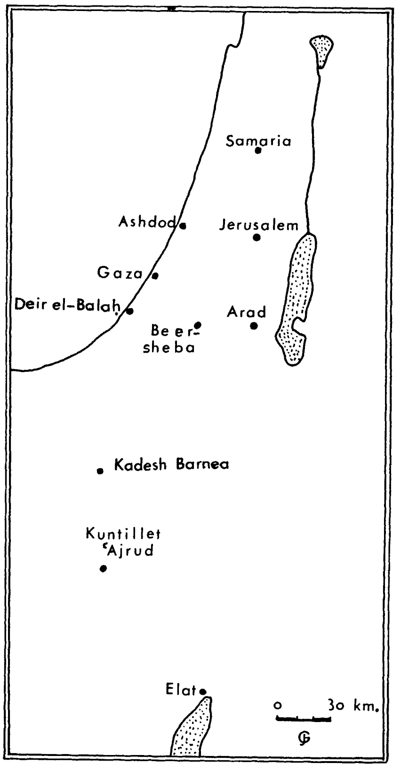


Fig. 1. Distribution map of sampled pottery and reference groups.

Jewish Quarter of the Old City,[2] the Western Wall[3] and Giloh on the southern outskirts of Jerusalem.[4] Five other pithoi were from Beer-sheba and three from Arad (see Fig. 1 for distribution of sampled pottery and reference groups). Most of these were sampled specifically for the present study, but a few had already been analysed in connection with earlier provenience studies.

The excavation at 'Ajrud also turned up storage-jars of four different types. Seven of these were analysed, as well as two others from Jerusalem.

Another important find at 'Ajrud was a number of vessels of 'Samaria ware', two of which were analysed. These were of importance for establishing a connection with the north.

Two other bowls were selected because of their distinctive fabrics. Both were made of fine clay, one pure cream in colour and the other pinkish-cream. Finally, a cooking pot was analysed.

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[2] N. Avigad: *Discovering Jerusalem*, Nashville, 1983, pp. 40–44, though the pithoi are not described.

[3] Unpublished vessels of large capacity provided by B. Mazar.

[4] A. Mazar: Giloh — An Early Israelite Settlement Site near Jerusalem, *IEJ* 31 (1981), pp. 1–31.

Table 1 lists all the vessels analysed, giving find site, our laboratory number, registration number, vessel type and origin for each vessel.

Since none of the vessels from 'Ajrud was *a priori* suitable as reference material for this study, there remained the problem of recognizing local composition if any of the vessels turned out to be locally made. Several ovens were found at the site and the wall of one of these was sampled. The ovens were undoubtedly made of local clay. Three unbaked clay stoppers of dimensions commensurate with openings in the pithoi were also sampled. Finally, a crude unbaked clay loom weight was sampled.

## METHOD OF PROVENIENCE DETERMINATION

The process of formation of clays from parent rocks provides good reason to believe that their chemical compositions will vary from place to place. By the same token, ceramics whose compositions reflect those of the clays from which they were made should also display distinctive variations. If this is so, the chemical composition of a vessel should reveal where it was made, irrespective of its appearance or where it was found. However, the composition of the vessel cannot in itself tell where it came from; for this one needs to find a match in composition with reference material. Reference material may consist of clays collected *in situ* in the vicinity of an ancient site or of a group of pottery vessels for which a strong case can be made for local manufacture. The matching of compositions is based upon statistical criteria which will be explained below. At present, we will simply point out that the analytical technique must be capable of measuring simultaneously a considerable array of chemical elements so as to encompass those which have diverse chemical properties, and to do so with high precision. More than 99% of the bulk of a clay is made up of relatively few elements termed major: some of these are of little use for provenience work. Consequently, the analytical technique must be particularly sensitive for measuring many trace elements which are present only in the parts-per-million range. Experience has shown that neutron activation analysis is eminently suitable for this task.

## PROVENIENCE OF THE HOLE-MOUTH PITHOI

In addition to the 11 hole-mouth pithoi from 'Ajrud, 15 others from Jerusalem, Beersheba and Arad have been analysed. All but one of these (Arad 59) had similar compositions from which we may deduce that they originated from Jerusalem. We shall deal first with these 26 vessels.

Clays have been collected from Jerusalem and its vicinity in order to obtain a perspective on their chemical characteristics and the variations which might be expected in the pottery which was made there. Jerusalem is located on a limestone ridge which drops abruptly to the east into the Jordan Valley rift, and more gradually westwards to the coastal plain. Extending some distance to the north and south of Jerusalem is a well-known clay body named the Motza Formation. The analysis of clays collected there confirmed that they had a common geochemical history, but there were easily

Table 1. List of samples from Kuntillet 'Ajrud and material connected with the 'Ajrud pithoi.

| Find site | Lab. No. | Registration No. Museum | Locus | Basket | Type | Provenience | Fig. | Pl. |
|---|---|---|---|---|---|---|---|---|
| 'Ajrud | 5 | 20731 | 93 | 773 | Coarse pithos | Motza clay | 2:2 | |
| 'Ajrud | 6 | 20720 | 53 | 482 | Hole-mouth pithos | Motza clay | 2:1 | 33:A |
| 'Ajrud | 7 | 20730 | 50 | 481 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 8 | 20728 | 50 | 487 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 9 | 20733 | Surf. | 8 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 10 | 20741 | Surf. | 2 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 12 | 20732 | 171 | 1193 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 19 | 20727 | 50 | 725 | Hole-mouth pithos | Motza clay | 2:1 | |
| 'Ajrud | 22 | 57916 | | | Hole-mouth pithos | Motza clay | | |
| 'Ajrud | 27 | S-78.4 | 6 | 16/1 | Hole-mouth pithos | Motza clay | | |
| 'Ajrud | 28 | S-78.46 | 19 | 144/3 | Hole-mouth pithos | Motza clay | | |
| Giloh | 1 | 306/1 | | | Hole-mouth pithos | Motza clay | | |
| Giloh | 2 | 33713 | | | Hole-mouth pithos | Motza clay | | |
| Giloh | 3 | 36313 | | | Hole-mouth pithos | Motza clay | | |
| Western Wall | 1 | 23043/1 | 76 | 193 M/43 | Hole-mouth pithos | Motza clay | | |
| Western Wall | 2 | 23043/2 | 76 | 193 M/93 | Hole-mouth pithos | Motza clay | | |
| Jewish Quarter | 117 | G 5943 | | | Large pithos with *lmlk* seal | Motza clay | | |
| Jewish Quarter | 157 | 80-833 | | | Hole-mouth pithos with inscribed *ṭet* | Motza clay | | |
| Beer-sheba | 102 | | 1259 | | Hole-mouth pithos | Motza clay | | |
| Beer-sheba | 103 | | 1259 | | Hole-mouth pithos | Motza clay | | |
| Beer-sheba | 53 | 1142/1 | | | Hole-mouth pithos with *lmlk* seal | Motza clay | | |
| Beer-sheba | 181 | 6985/1 | | | Hole-mouth pithos | Motza clay | | |
| Beer-sheba | 182 | 6049/1 | | | Hole-mouth pithos | Motza clay | | |
| Arad | 58 | 20745 | | | Hole-mouth pithos | Motza clay | | |
| Arad | 60 | 20744 | | | Hole-mouth pithos | Motza clay | | |
| Arad | 59 | C 268/5 | | | Hole-mouth pithos | Ashdod | | |
| 'Ajrud | 23 | | 160 | 1151/30 | Storage-jar | Tel Miqne | | |
| 'Ajrud | 24 | | 5 | 14/30 | Storage-jar | Tel Miqne | | |
| 'Ajrud | 25 | S-78-25 | 14 | 97/1 | Storage-jar | Tel Miqne | 2:6 | 33:D |
| 'Ajrud | 4 | 20734 | 156 | 1131 | Storage-jar | Ashdod | 2:5 | |
| 'Ajrud | 13 | 20722 | 104 | 1023 | Storage-jar | Ashdod | 2:3 | 33:B |
| 'Ajrud | 17 | 20721 | 102 | 1009 | Storage-jar | Ashdod | 2:3 | |
| 'Ajrud | 21 | 20735 | 158 | 1116 | Storage-jar | Ashdod | 2:4 | |
| 'Ajrud | 15 | 20725/1 | 13 | 118 | 'Samaria Ware' | Northern Israel | 2:8 | 33:C |
| 'Ajrud | 16 | 20725/2 | 13 | 118 | 'Samaria Ware' | Northern Israel | 2:8 | |
| 'Ajrud | 3 | 20726 | 7 | 40 | Loom weight | Local 'Ajrud | | |
| 'Ajrud | 14 | 20723 | 259 | 1382 | Piece of oven | Local 'Ajrud | | |
| 'Ajrud | 26 | S-78-264 | 50 | 390/34 | Stopper for pithos | Local 'Ajrud | | |
| 'Ajrud | 29 | S-78-113 | | | Stopper for pithos | Local 'Ajrud | | |
| 'Ajrud | 30 | | | 511 | Stopper for pithos | Local 'Ajrud | | |
| 'Ajrud | 20 | 20724 | 104 | 1016 | Cooking pot | Unknown | 2:7 | |
| 'Ajrud | 11 | 20738 | 254 | 1259 | Bowl, cream ware | Unknown | | |
| 'Ajrud | 18 | 20739 | 262 | 1364 | Bowl, cream ware | Unknown | | |
| Arad | 61 | 20746 | | | Storage-jar | Unknown | | |

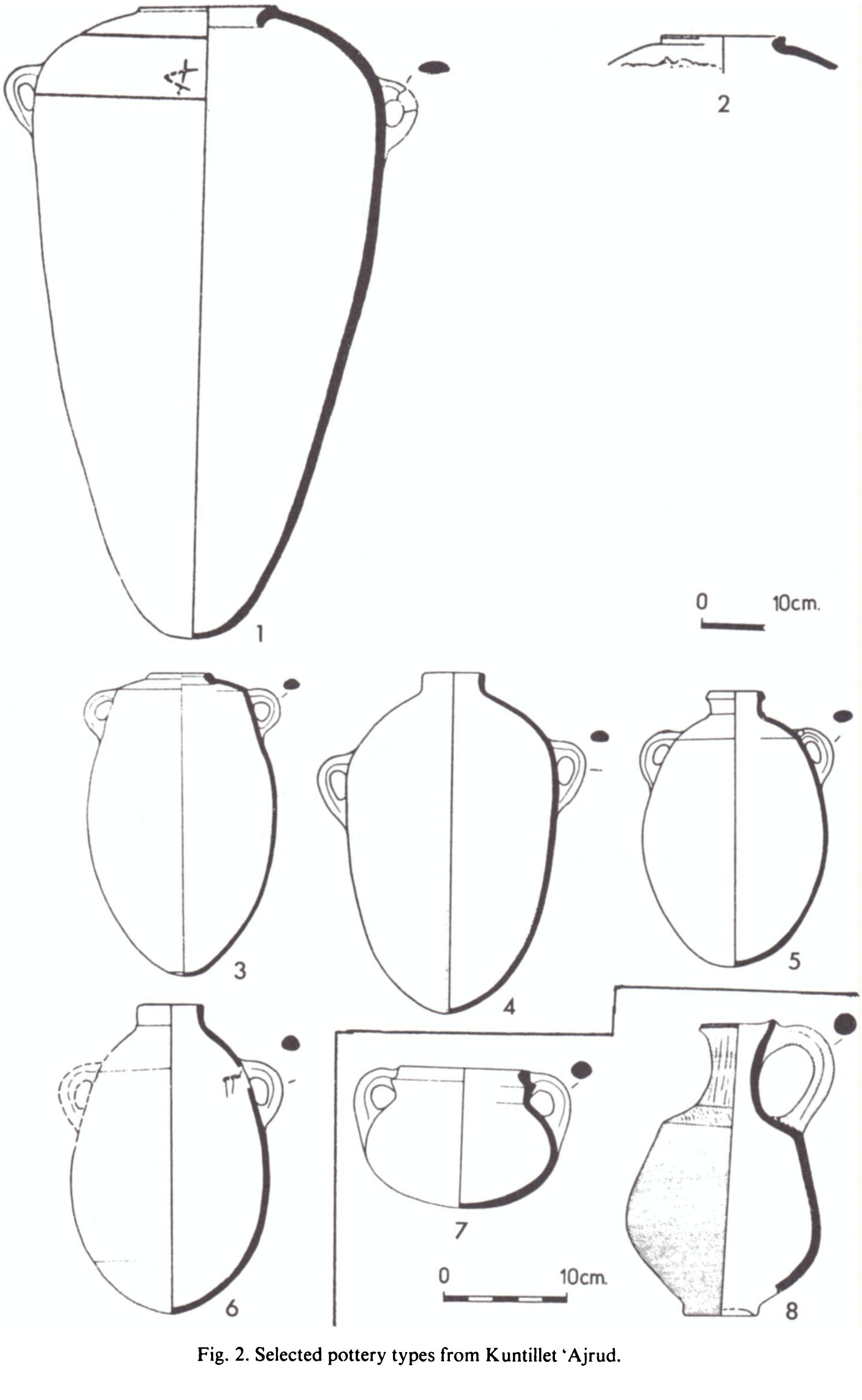


Fig. 2. Selected pottery types from Kuntillet 'Ajrud.

discernible variations in chemical composition. However, the results of the study do not permit us to state exactly where the ancient potters drew their clays. In the first place, it was not possible to sample such an extensive formation thoroughly, so we do not know what may have been missed. More importantly, samples taken from different levels at a single sampling locus sometimes showed greater variations than were found between different loci.

The outcome of these factors is that, although there are chemical matches between the pithoi and clays, we cannot state with certainty that they were made specifically in Jerusalem; they may have been made at sites some kilometres to the north or south. Nevertheless, Jerusalem was the centre of power during the period of our vessels and we shall assume provenience from Jerusalem.

In explaining how provenience was assigned, it is necessary to compare the analytical data for the pithoi with those for reference material. In the interests of brevity we shall not show the data for individual pithoi; furthermore, the display of such voluminous data would not be the most convenient way to illustrate how the matching of compositions is accomplished.

Although it transpired that all 25 pithoi were made in Jerusalem, we first chose to separate them into two subgroups with 20 members and 5 members respectively, since the members of one subgroup agreed more closely in composition with one another than they did with members of the other subgroup.

The data for the group of 20 pithoi are shown in Column 1 of Table 2. The data entry for each element consists of paired numbers symbolized by M and $\sigma$, in which M is the mean value and $\sigma$ relates to the spread of values among the individual members.

Let us assume that we obtain a sample of clay from the vicinity of a site and see how far the value for a single element deviates from M of the pithos group. If it deviates by less than $1\sigma$, there is a high probability that the clay is a chemical member of the pithos group so far as that element is concerned. However, it is risky to assign provenience on the basis of only one (or a few) elements because, more often than not, completely different clay sources will contain a few elements which by chance have the same values. It is thus prudent to measure a large array of elements.

Column 2 shows the data for clay taken from the village of Motza itself, several km. to the west of the centre of Jerusalem. Two samples were in fact analysed but, since they were almost identical in composition, only the average values are shown. The clay deposit at Motza must be large because a commercial tile factory was sited there and operated almost up to the present.

A cursory view of the data reveals that this clay is closely similar in composition to that of the pithos group. Clays taken from other outcrops in Jerusalem did not agree so well. When we compare the Motza clay to the pithos group by statistical analysis, element by element, we find that the deviations are just what one would expect if the pithoi were made from this clay source.

Column 3 shows the subgroup of hole-mouth pithoi composed of 5 vessels. It is immediately evident that the data have the same general pattern as those for the Motza clay, but the match is much poorer than was found for the group of 20 pithoi. Statistical

Table 2

| Element | Pithoi (20 vessels) $M \pm \sigma$ | Motza clay $M \pm \sigma$ | 'Ajrud (subgroup of 5 hole-mouth pithoi) $M \pm \sigma$ | Jerusalem reference group (20 vessels) $M \pm \sigma$ |
|---|---|---|---|---|
| Ca % | 10.0 ± 2.3 | 8.9 | 5.5 ± 2.3 | 7.7 ± 1.1 |
| Ce | 45.5 ± 3.5 | 46.4 | 54.7 ± 1.8 | 49.8 ± 1.9 |
| Co | 13.2 ± 1.3 | 11.9 | 15.8 ± 0.7 | 14.0 ± 0.9 |
| Cr | 91 ± 8 | 96.7 | 122 ± 9 | 115 ± 6 |
| Cs | 3.63 ± 0.67 | 5.65 | 5.4 ± 1.1 | 6.0 ± 0.5 |
| Eu | 1.06 ± 0.09 | 1.06 | 1.26 ± 0.05 | 1.20 ± 0.05 |
| Fe % | 3.17 ± 0.21 | 3.15 | 4.02 ± 0.09 | 3.98 ± 0.15 |
| Hf | 3.86 ± 0.9 | 3.43 | 4.41 ± 0.35 | 3.83 ± 0.19 |
| K % | 3.36 ± 0.59 | 4.03 | 4.5 ± 1.0 | 4.73 ± 0.51 |
| La | 21.0 ± 1.8 | 21.1 | 25.4 ± 0.8 | 23.8 ± 0.7 |
| Lu | 0.328 ± 0.039 | 0.30 | 0.38 ± 0.04 | 0.33 ± 0.03 |
| Ni | 43 ± 18 | 30 | 68 ± 12 | 54 ± 14 |
| Rb | 81 ± 19 | 114 | 116 ± 16 | 112 ± 8 |
| Sc | 14.9 ± 1.2 | 16.1 | 17.6 ± 1.7 | 18.6 ± 0.9 |
| Ta | 0.63 ± 0.08 | 0.67 | 0.86 ± 0.11 | 0.71 ± 0.03 |
| Th | 6.14 ± 0.45 | 6.67 | 8.08 ± 0.36 | 7.18 ± 0.25 |
| Ti % | 0.41 ± 0.06 | 0.39 | 0.44 ± 0.14 | 0.28 ± 0.07 |
| U | 2.25 ± 0.37 | 2.16 | 2.26 ± 0.19 | 2.33 ± 0.25 |
| Yb | 2.09 ± 0.18 | 2.07 | 2.51 ± 0.20 | 2.39 ± 0.12 |

analysis confirmed this. Examination of the data pertaining to other clays of the Jerusalem area failed to yield a match with the group of pithoi in Column 3.

Column 4 pertains to a group of 20 vessels of the Early Roman period excavated in Jerusalem. This group, which comprises diverse vessel forms, is chemically homogeneous and the vessels were undoubtedly made at one place. Since it is highly unlikely that all of them were brought to Jerusalem from one external source, there can be little doubt that they are valid reference material for Jerusalem.

A scan of the data in Columns 3 and 4 shows that the composition of the pithoi is much closer to that of this Jerusalem reference group than it is to the Motza clay. Nevertheless, there is still not a satisfactory statistical match. This shortcoming is not surprising because, as noted above, the clay sampling of the Jerusalem area was far from comprehensive and what was sampled showed considerable diversity. Our interpretation is that more than one clay source was used and we have not yet sampled the source used in the manufacture of the Early Roman vessels from Jerusalem and the five pithoi from 'Ajrud.

As already mentioned, one hole-mouth pithos excavated at Arad (Arad 59) was not manufactured in Jerusalem. This is extraneous to the issue of the provenience of pottery found at 'Ajrud, but it demonstrates that not every pithos of this type can be assigned provenience from Jerusalem simply on the grounds of its appearance. The only discernible difference between this jar and the others lies in the fabric colour, which is somewhat darker than those made in Jerusalem. We shall now show that this vessel was made in the southern coastal region of Israel, probably at Ashdod.

Through the years, about 700 pieces of pottery from Ashdod have been analysed, mostly in the Berkeley laboratory. The results from only a small proportion of these have been published.[5] The vessels could be separated into a considerable number of very similar chemical groups, one of which is shown in Column 1 of Table 3.

This group comprises only 19 vessels, but about 80 vessels have this composition. The smaller group is adequate to serve as reference material for Ashdod, since the vessels cover a chronological range from MB II to the Persian period and the vessel forms are diverse.

Table 3

| Element | Ashdod reference group (19 pieces) $M \pm \sigma$ | Arad 59 (1 piece) |
|---|---|---|
| Ca % | 5.0 ± 0.9 | 11.05 |
| Ce | 65.8 ± 3.0 | 67.52 |
| Co | 19.26 ± 1.05 | 19.90 |
| Cr | 118 ± 7 | 122 |
| Cs | 1.7 ± 0.4 | 1.64 |
| Eu | 1.46 ± 0.07 | 1.50 |
| Fe % | 4.28 ± 0.20 | 4.40 |
| Hf | 10.80 ± 1.00 | 10.04 |
| La | 30.7 ± 1.8 | 30.9 |
| Lu | 0.42 ± 0.03 | 0.47 |
| Na % | 0.68 ± 0.06 | 1.03 |
| Ni | 50 ± 15 | 58 |
| Rb | 54 ± 10 | 68 |
| Sc | 14.60 ± 0.56 | 14.92 |
| Sm | 5.87 ± 0.24 | 5.98 |
| Ta | 1.33 ± 0.05 | 1.36 |
| Th | 7.63 ± 0.40 | 7.66 |
| Ti % | 0.65 ± 0.03 | 0.66 |
| U | 2.07 ± 0.18 | 3.25 |
| Yb | 2.93 ± 0.27 | 3.11 |

[5] I. Perlman *et al.*: Provenience Studies of Pottery Employing Neutron Activation Analysis, in M. Dothan: *Ashdod II-III* ('Atiqot, English Series 9-10), Jerusalem, 1971, pp. 216–219; I. Perlman and F. Asaro: Provenience Studies on Pottery of Strata 11–10, in M. Dothan and Y. Porath: *Ashdod IV* ('Atiqot, English Series 15), Jerusalem, 1982, pp. 70–90; F. Asaro *et al.*: An Introductory Study of Mycenaean IIIC:1 Ware from Tel Ashdod, *Archaeometry* 13 (1971), pp. 169–175.

Column 2 of Table 3 shows the data for Arad 59. All the elements, apart from calcium (Ca) and uranium (U), give an excellent statistical match with the Ashdod group and there can be little doubt that Arad 59 was made at Ashdod.

Calcium occurs only to the extent of a few per cent in clay minerals, but calcite is very often found admixed with clays, sometimes as a major component. A section made in a bank of red clay at Ashdod revealed prominent lenses of chalky calcite interspersed with the clay; thus the potters had ready access to clays which contained any amount of calcite desired. A large proportion of vessels made at Ashdod had calcium values similar to that shown in Column 1, but pottery with much higher calcium values was not uncommon. It is tempting to speculate that clays with high calcite values were chosen for specific applications such as large jars, for it is believed that calcite adds strength and hardness.

## PROVENIENCE OF THE STORAGE-JARS

Seven storage-jars representing four types were analysed. We shall deal first with four of these jars ('Ajrud 4, 13, 17 and 21) and show that they were almost certainly made in the southern coastal region.

The compositions of pottery from sites such as Ashdod, Ashkelon, Tell Qasile and Tell el-'Ajjul have certain distinctive characteristics in common, making it relatively easy to identify any vessel made in this region. However, complications arise in assigning provenience to a specific site.

The most convenient way to describe this problem is to focus on Ashdod. As mentioned above, about 700 vessels from this site have been analysed; the data may be separated into a number of chemical groups which do not differ greatly from one another. The question which cannot yet be answered is whether all of these groups were made locally. Vessels from other sites have similar compositions but are too few in number to establish a pattern for the movement of pottery between the various sites. We shall return to this point after presenting data from a different part of the coastal plain.

Table 4 displays four data columns, two of which pertain to ceramics from Deir el-Balaḥ (DEBL), a site about 15 km. south-west of Gaza best known for its cemetery containing burials in striking anthropomorphic ceramic coffins. Since their style was in the Egyptian tradition, the question of where they were made was of interest. Fifteen coffins were sampled for analysis[6] together with eleven common-ware vessels to serve as reference material.

We shall see that the 'Ajrud jars provide a satisfactory match with Deir el-Balaḥ material. It must be emphasized, however, that this does not necessarily imply that the 'Ajrud jars were made there, since it is not yet clear whether the site was inhabited in Iron Age II. The data from Deir el-Balaḥ are used here solely to demonstrate the composition of pottery made in the region.

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6 I. Perlman *et al.*: Provenance of the Deir el-Balaḥ Coffins, *IEJ* 23 (1973), p. 151.

Table 4

| Element | DEBL-I (10 pieces) | DEBL-II (8 pieces) | 'Ajrud 17, 21 | 'Ajrud 4, 13 |
|---|---|---|---|---|
| Ca % | 8.8 ± 1.2 | 6.1 ± 1.2 | 10.3 | 10.8 |
| Ce | 55.6 ± 3.3 | 66.1 ± 5.5 | 55.4 | 59.6 |
| Co | 15.7 ± 0.8 | 18.0 ± 1.1 | 15.6 | 16.7 |
| Cr | 94 ± 5 | 104 ± 11 | 99 | 137 |
| Cs | 1.6 ± 0.3 | 1.6 ± 0.4 | 1.6 | 1.8 |
| Eu | 1.28 ± 0.10 | 1.43 ± 0.13 | 1.14 | 1.37 |
| Fe % | 3.50 ± 0.12 | 4.21 ± 0.25 | 3.48 | 3.86 |
| Hf | 8.8 ± 0.8 | 9.1 ± 1.0 | 8.7 | 8.2 |
| La | 27.4 ± 1.6 | 30.2 ± 2.0 | 25.8 | 30.1 |
| Lu | 0.38 ± 0.03 | 0.41 ± 0.03 | 0.38 | 0.43 |
| Sc | 11.5 ± 0.4 | 13.3 ± 0.8 | 11.4 | 13.6 |
| Ta | 1.07 ± 0.03 | 1.25 ± 0.07 | 1.08 | 1.21 |
| Th | 6.45 ± 0.25 | 7.52 ± 0.44 | 6.44 | 7.22 |
| Ti % | 0.46 ± 0.04 | 0.55 ± 0.03 | 0.52 | 0.59 |
| U | 1.51 ± 0.12 | 1.62 ± 0.18 | 1.94 | 1.86 |
| Yb | 2.47 ± 0.13 | 2.76 ± 0.23 | 2.42 | 3.08 |

The results of these analyses showed clearly that the coffins were made locally. The data for the coffins separated into two subgroups, as did the reference vessels, and there was an excellent match between coffins and reference vessels in each subgroup. In Table 4, these chemical groups are shown under DEBL-I and DEBL-II. Since the compositions of coffins and vessels were statistically identical, the data have been combined in each of these columns.

Mention should be made of supporting evidence that the composition of the Deir el-Balaḥ material does indeed represent clay of the region. Tell er-Ridan is a site 5 km. south of Deir el-Balaḥ from which a number of sherds have been analysed. The data are not shown here but they give a good match with DEBL-II. Tell er-Ridan can definitely be ruled out as the source of the 'Ajrud jars, because no evidence was found for habitation in Iron Age II. So the question as to where the jars were made remains unanswered.

We now return to the data for the four storage-jars from 'Ajrud. Two of the jars ('Ajrud 17 and 21) were closely similar to each other in composition except for a couple of elements; only the mean values for the various elements are shown in Column 3 of Table 4. The match between these jars and DEBL-I is statistically valid except for one element, uranium, which is somewhat discordant.

The other two jars ('Ajrud 4 and 13) were closely similar to each other in all aspects, so only the mean values are shown. It can be seen that these jars give a satisfactory match with DEBL-II except for the element chromium.

In view of the archaeological evidence that Tell er-Ridan can be ruled out and Deir el-Balaḥ is still questionable, the question of where *in this region* the 'Ajrud jars could have been made cannot be answered.

We now return to the data for the four storage-jars from 'Ajrud. Two of the jars ('Ajrud 17 and 21) were closely similar to each other in composition except for a couple of elements; only the mean values for the various elements are shown in Column 3 of Table 4. The match between these jars and DEBL-I is statistically valid except for one element, uranium, which is somewhat discordant.

The above discussion has tacitly assumed that the region from Gaza to Ashdod has been ruled out on the basis of the chemical compositions of pottery in this area. This assumption is not quite valid. Our knowledge of the Gaza region comes from a scanty collection of five sherds from Tell el-'Ajjul. Although the composition of this pottery does not match the 'Ajrud jars as well as DEBL-II, it is too close to be ignored. Our reason for not giving this 'Ajjul ware greater weight is that this 'reference group' has few members, and a scattering of other plain wares did not provide a coherent picture.

The above discussion does not end the recital of difficulties in assigning provenience at a specific site when dealing with the southern coastal region. The great majority of the hundreds of vessels from Ashdod were clearly different in composition from the 'Ajrud jars under discussion, but a group of about 80 vessels were not greatly different. This group comprised vessels from the Bronze Age and the Persian period as well as the Iron Age, and thus it seems likely that they were made at Ashdod.

As the result of this confusing information, we are left with limited conclusions: the provenience of many vessels found at different places can be assigned with confidence to Ashdod, but for others it is prudent to use the more general term 'southern coastal region'.

The remaining three jars from 'Ajrud ('Ajrud 23, 24 and 25) had inscriptions which were incised before firing, and in this regard were different from the other. Their compositions also differed to a small but significant extent from those of all vessels from the southern coastal region. Recently, a preliminary study was made of pottery from Tel Miqne (ancient Ekron) which lies a few km. south of Ashdod's latitude and about 20 km. inland.[7] The analytical results have not yet been published. The data in Column 1 of Table 5 pertain to a group of 10 Iron Age I vessels which were taken to serve as reference material for Miqne. In Column 2 are shown the data for three 'Ajrud jars. It may be seen that the match is about as good as could be expected. Since the region has not been well documented by pottery analyses, we must be content to say that 'Ajrud 23, 24 and 25 may have come from the Miqne region.

## 'SAMARIA WARE'

One of the important pottery finds at 'Ajrud was a number of vessels of 'Samaria Ware', so called because their distribution pattern points to an origin in the north of Israel. Two of these ('Ajrud 15 and 16) were analysed in an attempt to establish a connection between this distant region and Kuntillet 'Ajrud. Unfortunately, we have not

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[7] J. Gunneweg *et al.*: On the Origin of Pottery from Tel Miqne (Ekron), *BASOR* 262 (1986), in press.

Table 5

| Element | Miqne, Iron Age I* (10 vessels) M ± σ | 'Ajrud** (3 vessels) M ± σ |
|---|---|---|
| Ca % | 11.9 ± 2.5 | 9.0 ± 2.8 |
| Ce | 52.1 ± 4.5 | 52.9 ± 6.0 |
| Co | 13.4 ± 1.3 | 11.45 ± 0.85 |
| Cr | 96 ± 12 | 106 ± 18 |
| Cs | 1.23 ± 0.28 | 1.62 ± 0.33 |
| Eu | 1.10 ± 0.11 | 1.11 ± 0.10 |
| Fe % | 2.98 ± 0.29 | 2.94 ± 0.29 |
| Hf | 9.13 ± 1.83 | 7.78 ± 1.43 |
| La | 25.2 ± 2.6 | 24.8 ± 2.6 |
| Lu | 0.38 ± 0.04 | 0.34 ± 0.04 |
| Na % | 0.43 ± 0.08 | 1.06 ± 0.19 |
| Ni | 63 ± 18 | 65 ± 10 |
| Rb | 54 ± 4 | 56 ± 5 |
| Sc | 10.32 ± 1.18 | 10.50 ± 0.89 |
| Ta | 0.96 ± 0.11 | 0.93 ± 0.09 |
| Th | 6.10 ± 0.52 | 6.40 ± 0.94 |
| Ti % | 0.54 ± 0.12 | 0.47 ± 0.03 |
| U | 2.50 ± 0.53 | 2.65 ± 0.18 |
| Yb | 2.52 ± 0.14 | 2.36 ± 0.22 |

* To appear in *BASOR* 262 (1986), Table 2:2.
** 'Ajrud 23, 24, 25 (inscribed storage-jars).

yet analysed suitable reference material from various northern sites, and therefore a complete picture of the provenience of the 'Samaria Ware' is still lacking. Nevertheless, a good case can be made that the 'Ajrud vessels came from somewhere in the north on the basis of data obtained from 'Samaria Ware' found in northern sites.

The first data column in Table 6 pertains to the 'Ajrud vessels, for which the mean values are shown. The next column shows the data for a small group of three 'Samaria Ware' bowls found at Samaria. The match between the two columns is good for all elements except uranium, which is statistically discordant. From this agreement it seems highly likely that all of these vessels were made in the same place; however, we cannot establish that this place is Samaria on the basis of only three bowls and in the absence of supplementary reference material from Samaria.

Before continuing with the discussion of other 'Samaria Ware' vessels, it is worth mentioning some peculiarities in the composition of the vessels just presented. The calcium values are higher than 20%, indicating that the clay contained about 50% calcite, which dilutes the other elements and accounts for their low values. Calcareous pottery is found at some sites in other regions, but in the hilly country of the north all of the pottery has this characteristic.

We shall now point out two unusual relationships between certain elements. The two Rare Earth elements, Ce and La, are found in the Earth's crust in the ratio of about 2:1;

Table 6

| Element | 'Samaria Ware', 'Ajrud 15, 16 (2 pieces) M ± σ | 'Samaria Ware'* (3 pieces) M ± σ | 'Samaria Ware', Hazor (7 pieces) M ± σ |
|---|---|---|---|
| Ca % | 21.2 ± 0.4 | 23.7 ± 1.4 | 25.2 ± 1.1 |
| Ce | 36.6 ± 0.7 | 34.4 ± 3.4 | 29.6 ± 2.9 |
| Co | 9.01 ± 0.97 | 9.6 ± 0.4 | 7.0 ± 1.1 |
| Cr | 157 ± 12 | 167 ± 7 | 149 ± 40 |
| Cs | 1.91 ± 0.14 | 1.9 ± 0.2 | 1.6 ± 0.2 |
| Eu | 1.09 ± 0.02 | 1.11 ± 0.14 | 0.93 ± 0.11 |
| Fe % | 1.95 ± 0.33 | 2.01 ± 0.14 | 1.83 ± 0.44 |
| Hf | 1.53 ± 0.13 | 1.54 ± 0.18 | 1.30 ± 0.14 |
| La | 30.8 ± 1.6 | 28.4 ± 2.8 | 22.9 ± 2.5 |
| Lu | 0.470 ± 0.014 | 0.43 ± 0.03 | 0.37 ± 0.04 |
| Na % | 0.68 ± 0.13 | 0.18 ± 0.02 | 0.17 ± 0.04 |
| Ni | 77 ± 26 | 81 ± 8 | 81 ± 18 |
| Rb | 38 ± 4 | 41 ± 11 | 29 ± 5 |
| Sc | 10.31 ± 0.19 | 10.45 ± 0.65 | 8.83 ± 1.04 |
| Sm | 4.43 ± 0.13 | — — | 3.80 ± 0.46 |
| Ta | 0.43 ± 0.03 | 0.51 ± 0.10 | 0.33 ± 0.04 |
| Th | 4.41 ± 0.40 | 4.57 ± 0.12 | 3.54 ± 0.44 |
| Ti | 0.19 ± 0.04 | 0.15 ± 0.02 | 0.21 ± 0.04 |
| U | 4.08 ± 1.15 | 3.60 ± 0.13 | 4.56 ± 2.23 |
| Yb | 2.91 ± 0.06 | 2.81 ± 0.10 | 2.61 ± 0.36 |

* BALATA 10, 11 and SAMARIA 1 (unpublished data from the Berkeley Data Bank).

since they have almost identical chemical properties, this ratio is preserved during the formation of clays from their parent rocks. It will be noted in both Columns 1 and 2 that the Ce values are only a little greater than those for La. A separation of Ce to this degree can only take place under unusual environmental conditions, one of which is in deep seawater. Another anomalous relationship exists in the pair of elements, Co and Sc. In clays, Co is almost always considerably more abundant than Sc; in these vessels, Sc is actually a little higher than Co.

These factors have been pointed out here only to emphasize that the clays from which these vessels were made have distinctive characteristics.

Hazor is the second place from which 'Samaria Ware' was analysed. Column 3 shows the data for a group of seven bowls; it is readily seen that they have the same characteristics as the vessels from Samaria and 'Ajrud. In the absence of independent source material from Hazor, we cannot tell whether or not the vessels were made there. However, a good deal can be said about where these 'Samaria Ware' vessels were *not* made. The southern and central regions, both coastal and inland, can be ruled out with confidence. Large numbers of vessels from the northern coastal plain have also been analysed and, although a number of elements show a similarity to those of 'Samaria

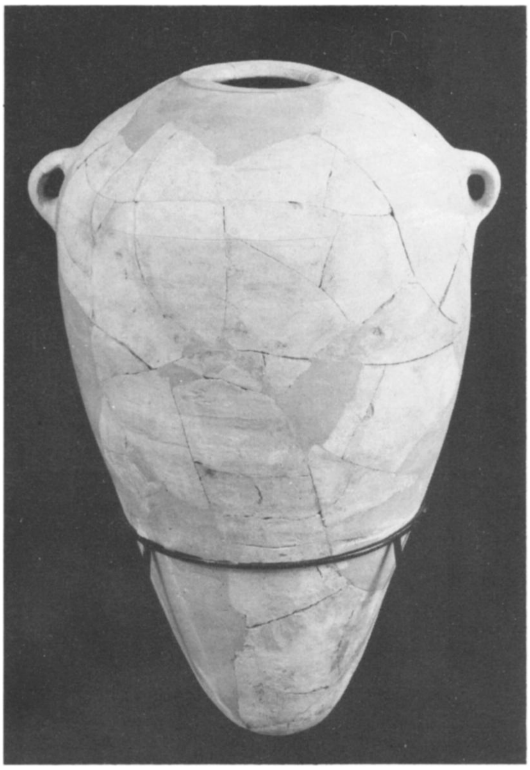
Ware', too many elements are grossly different. Also ruled out are some northern inland valleys, including the Jordan River basin. This leaves the northern hilly region as the source of the ware, which supports the archaeological evidence.

As a footnote to this discussion on the provenience of 'Samaria Ware', mention should be made of bowls from Hazor which are not shown in Table 6. These showed considerable diversity in composition among themselves, indicating that bowls of this type were made in several places.

The cooking pot, 'Ajrud 20, has a chemical composition which is not shown here. Its provenience is as yet unknown, as are those of the two cream ware bowls ('Ajrud 11, 18) and a storage-jar from Arad (Arad 61).

## SUMMARY

Neutron activation analysis partially confirms the conclusion of the typological study that pottery found at Kuntillet 'Ajrud was made in Judah, in the southern coastal region and in the north of Israel. Twenty of the large pithoi from Jerusalem, Beer-sheba, Arad, and Kuntillet 'Ajrud were made in Jerusalem; one was definitely not made there, but came from the Ashdod region. Other jars which were found at Kuntillet 'Ajrud matched pottery from the southern coast of Israel, while 'Samaria Ware' seems to have originated in the hilly country of northern Israel. The laboratory study has accurately assigned provenience to most of the pottery found at 'Ajrud and has confirmed the apparent absence of locally manufactured pottery. It upholds the conclusions of the excavator about the character of the site and its connections with other regions.



A: Pithos.

B: Storage-jar.

C: 'Samaria Ware' jug.

D: Inscribed storage-jar.

ORIGIN OF POTTERY OF KUNTILLET 'AJRUD