

Metallic Burnished Early Bronze Age Ware from Tall Abū al-Kharaz

Introduction

Tall Abū al-Kharaz is situated at a strategic point in the Jordan Valley north of Wādī al-Yābis (for further information see: Glueck 1951; de Contenson 1960; 1964; Mellaart 1962; Mittmann 1970, Ibrahim *et al.* 1976; Mabry and Palumbo 1988; Fischer 1991a). The summit of Tall Abū al-Kharaz is 142.70 m below mean sea level. According to the Palestine Grid Coordinate System, the coordinates of the summit are, to an accuracy of 50-100 m, 206.2 E and 200.6 N (FIG. 1).

In 1989 the Swedish Jordan Expedition (*Swed-JordEx*) carried out excavations on the western slope of the *tall* about 80 m west of the summit. It was shown that pottery from the Early Bronze Age I and II was well represented at the site. The 1991 campaign confirmed these observations. During the second season of excavation an area was exposed which revealed remains belonging to an extensive Early Bronze Age settlement. The generosity of the Department of Antiquities of Jordan, and its Director General Prof. Safwan Tell, made it possible to fulfill the main objectives of the expedition. Thanks are due to Professor Alexander Lodding for his kindness in loaning the SIMS equipment for the necessary analyses.

This paper deals with an investigation of an Early Bronze Age ware excavated in the fall of 1991 at Tall Abū al-Kharaz. The ware is designated as Metallic Burnished because of its special surface treatment. The aim of the present study is to:

1. study the ware and shapes;
2. analyze the "metallic burnish" in order to increase our understanding of ceramic production techniques.

Stratigraphy: A Brief Summing-up of the Early Bronze Age Strata in Trenches VII A-D, VIII and IX (FIG. 2)

The oldest phase in this area is represented by a destruction layer found directly on bedrock. It contains a series of rooms enclosed by walls of sun-dried mudbricks. Most of the walls are built on stone foundations

of one or more courses.

None of the walls shows signs of dislocation caused by earthquakes. It seems rather that the cause of destruction was a conflagration. An ash layer intermingled with burnt mudbricks, charcoal and fallen superstructures covered a variety of vessels and tools. The tools were made of bone, bronze and stone. No human skeletons were found.

The pottery consists of large storage vessels of Grain-wash/Bandslip ware. A variety of holemouth and other large jars were found. Small vessels are represented by bowls, jugs and juglets, amphoriskoi and platters. Many of them are burnished either vertically or diagonally, thus showing different net patterns.

The next phase can be divided into different sub-phases. Within this phase a destruction layer was found which is clearly recognizable in almost all the trenches.

The pottery and other finds resemble the vessels from the previous phase, indicating continuity. Grain-wash/Bandslip wares are frequent, together with platters and minor vessels, traditionally dated within the Early Bronze Age II period. Among the latter hard-fired, thin-walled vessels of a mainly fine fabric with a grey to brownish-grey "metallic burnish" and "metallic sound" were found. These vessels are partly manufactured or at least finished on a slow wheel. Their improved production technique and excellent finish reflect the high skill of the potters.

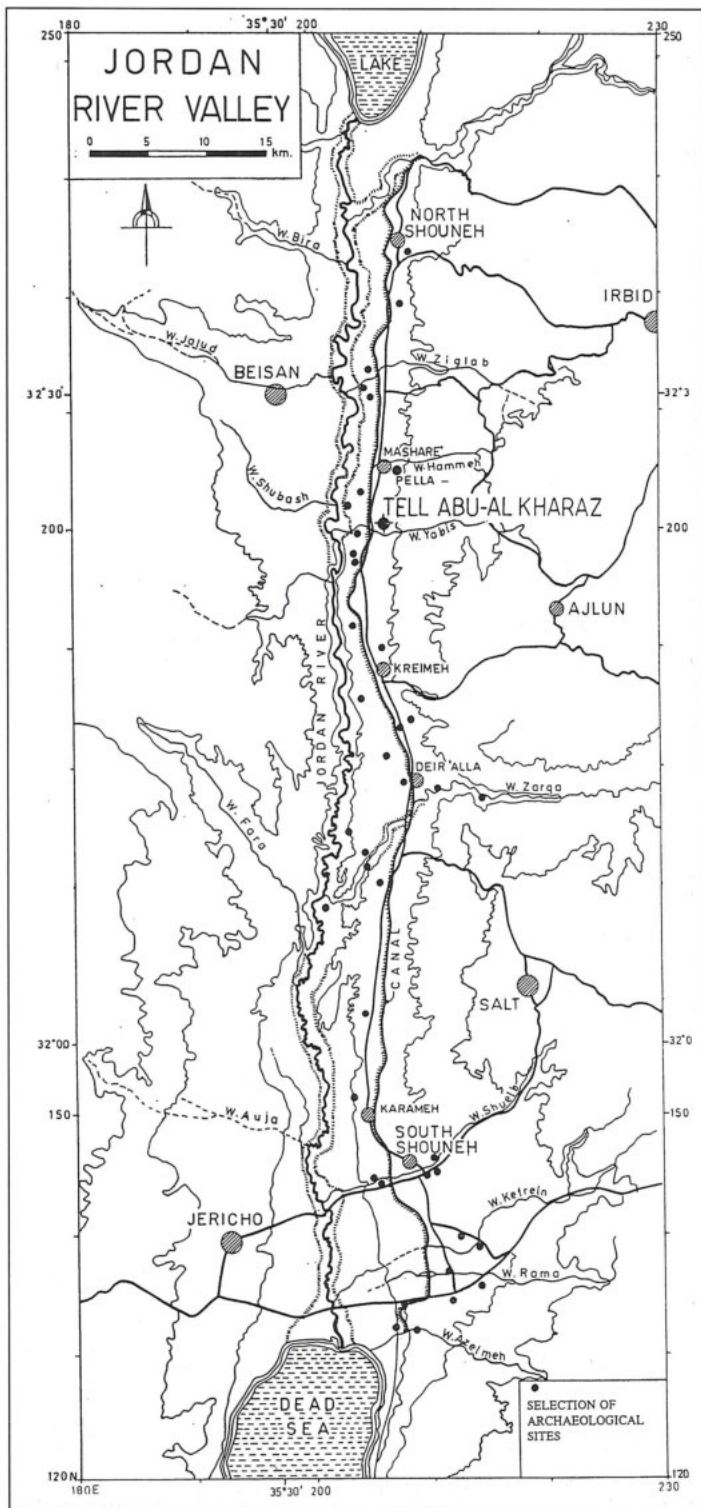
THE METALLIC BURNISHED WARE

1. The Pottery

The 1991 excavations at Tall Abū al-Kharaz produced nine vessels which were classified as "Metallic Burnished" (FIGS. 3-6). The criteria listed below were common to this ware. Only ware which satisfied the following description was studied any further.

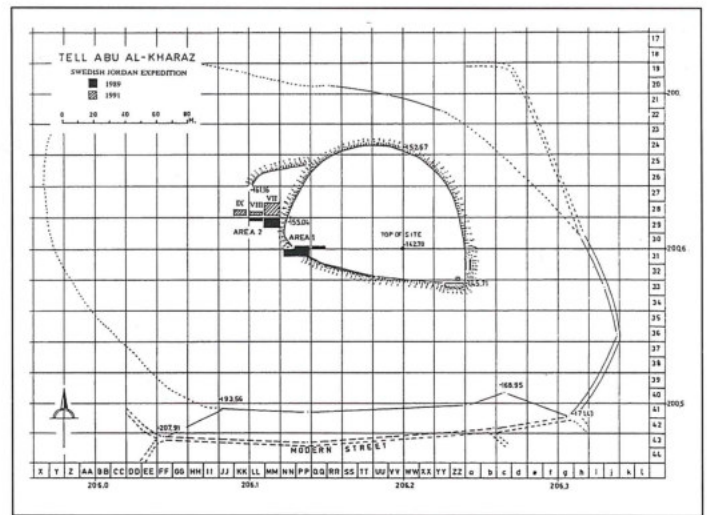
1.1. Definition

Ware: hard-fired; different shades of grey to brown clay, sometimes orange tan and pinkish-orange; grey cores oc-



1. Map of the Jordan Valley, showing Tall Abū al-Kharaz.

cur; the small vessels show mainly a range of very fine (<0.1 mm), fine (<0.25 mm) and medium (<0.5 mm) inclusions, the jugs medium (<0.5 mm) to coarse (c. 1 mm) inclusions (Wentworth 1922; 1933); the matt slip is applied in one or two layers with red, brown and grey shades; the outermost surface treatment is a vertical or,



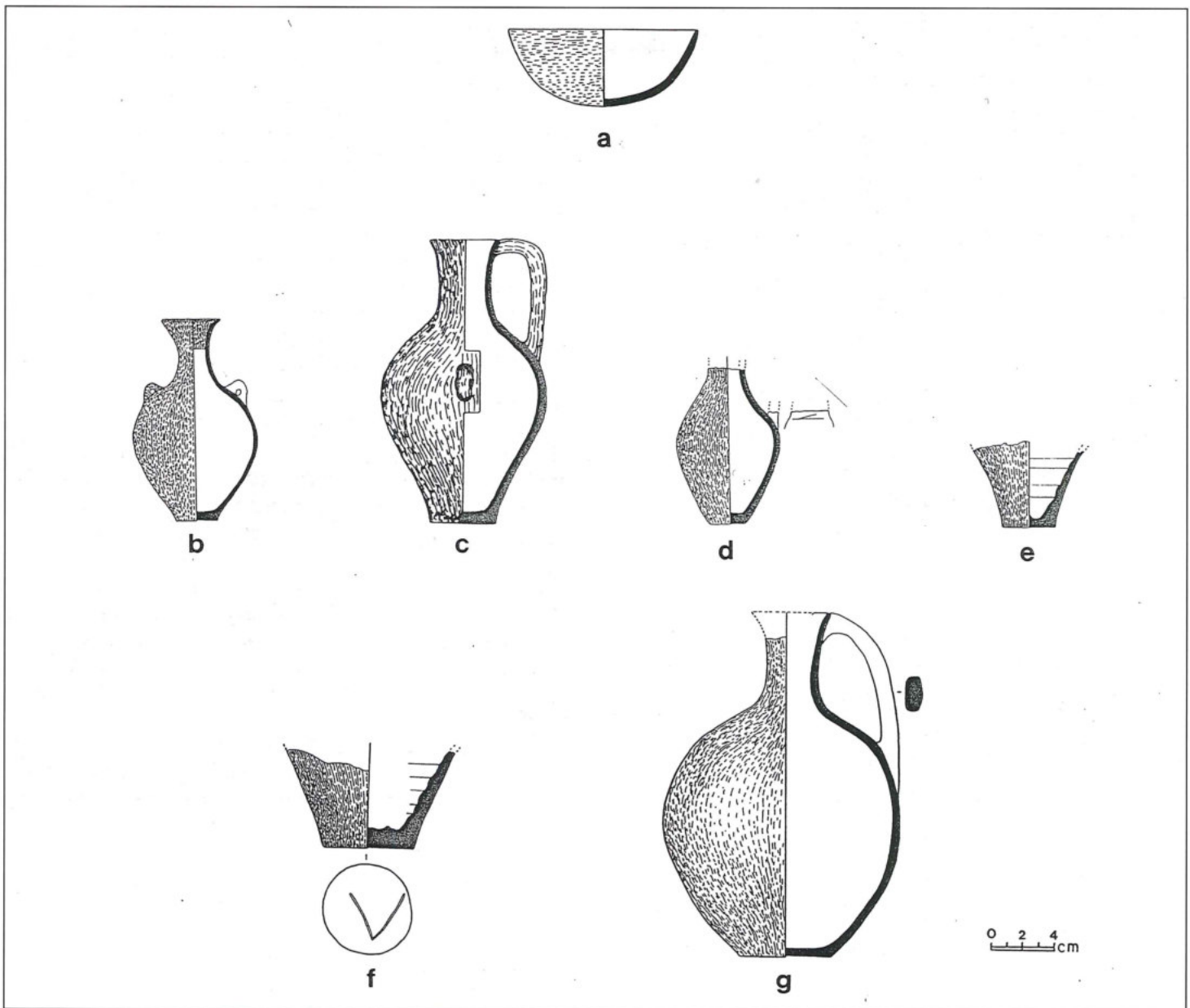
2. Sketch of the position of Trenches VII, VIII and IX.

in the case of the small bowl, horizontal high burnish with a grey to brownish-grey and occasionally fluorescent appearance, resulting in a metallic lustre. Shapes: small bowl; amphoriskoi; juglets; and jugs.

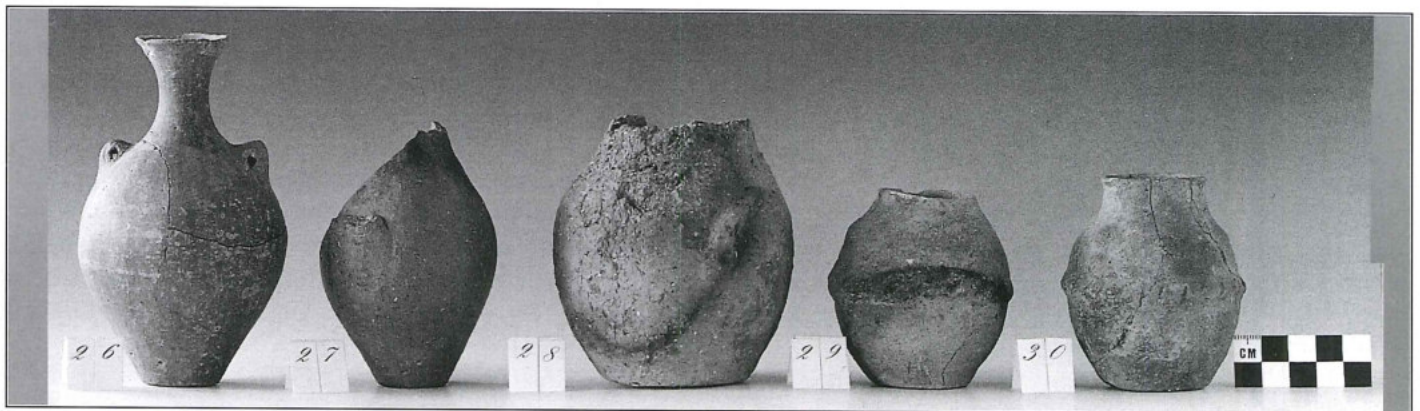
1.2. Pottery Descriptions and Parallels

The identification number is the database code, which is a combination of site-year-trench-stratum-locus-find number (if classified as find; Fischer 1991a); HM/WM = hand/wheel made; H = hard fired; parallels refer to shapes.

1. K91VIA12L246, small bowl, WM, H, dark grey, very fine inclusions, reddish-brown - greyish-brown slip, horizontally metallic burnished on outside (FIG. 3a). Parallel: Amiran 1978: PL. 13:20.
2. K91VIIC6L140N0271, amphoriskos with two vertical pierced lug handles, HM/WM, H, light brown to grey, fine inclusions, reddish brown - greyish-brown slip, vertically metallic burnished (FIG. 3b). Parallels: de Vaux and Steve 1948: FIGS. 8:9, 9:7; Tufnell 1958: PLS. 58:134, 61:266; Kenyon 1960: 104, FIG. 35:9; Kenyon and Holland 1982: 233, FIG. 87: 29; Schaub 1981: 114, FIG. 19:8.
3. K91VIII5L144N0343, amphoriskos with two vertical pierced lug handles and one vertical handle from body to rim, WM?, H, brownish-grey, medium dark grey and crushed pottery inclusions, reddish-brown slip, vertically metallic burnished (FIG. 3c). Parallels: Wright 1937: 58, FIG. B:IV:c (unpierced lugs?); Kenyon 1960: 173, FIG 64:4; Kenyon and Holland 1982: 229, FIG. 85:9 (jug with unpierced lugs); Amiran 1970: 59, PHOTO 56; Amiran 1978: PL. 25:3 (juglet with unpierced, degenerated handles).
4. K91V9L103, rim and neck of amphoriskos or juglet, WM, H, pinkish-orange, medium inclusions of mainly crushed pottery, light reddish-brown slip, vertically metallic burnished. D. of rim 4.3 cm, D. of neck 2.2



3. Metallic Burnished wares: a. small bowl (1.), b. amphoriskos (2.), c. amphoriskos (3.), d. juglet (5.), e. amphoriskos or juglet (6.), f. jug (7.), g. jug (8.); numbers within brackets refer to "1.2. Pottery Descriptions and Parallels".



4. Amphoriskos 2. K91VIIC6L140N0271 (26); juglet 5. K91VIII5L144N0295 (27); the other juglets (28-30; none is Metallic Burnished ware) were found in the same context as (27).



5. Amphoriskos 3. K91VIII5L144N0343 *in situ* in Early Bronze Age destruction layer.

cm. For parallels see 2. and 3. above.

5. K91VIII5L144N0295, juglet with one vertical handle from body to rim, body and base HM (possibly in a mould), neck WM, H, light brown, grey core, medium-coarse inclusions of mainly crushed pottery, reddish grey slip, vertically metallic burnished with fluorescent appearance, pot mark on lower part of handle (FIG. 3d). Parallels: Wright 1937: 58, FIG. B:IV:d; Tufnell 1958: PL. 58:99; Kenyon and Holland 1982: 233, FIG. 87:1; Dorell 1991: 82-84, 85, FIG. 18:7.
6. K91VIID7L175N0287, amphoriskos or juglet, WM, H, grey, medium coarse dark grey to black inclusions, grey slip, vertically metallic burnished (FIG. 3e). For parallels see 2. and 3. above.
7. K91VIIB12L230N0408, jug, HM, H, light greyish-brown, coarse white and grey inclusions, reddish brown - matt brown slip, vertically metallic burnished (FIG. 3f). Parallels: Amiran 1970: 62, PHOTO 57; Schaub 1981: 77-78, 115, FIG. 19:3,5.
8. K91VIID7L0175N0292, jug, WM, H, orange tan, dark grey core, medium white and black inclusions, brown slip, vertically metallic burnished, base with

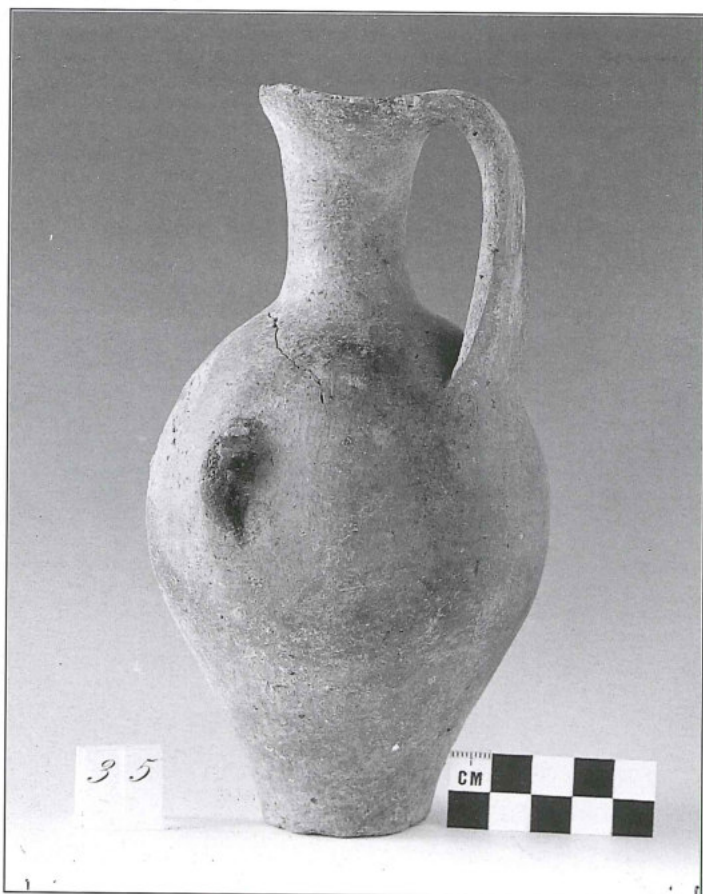
potter's mark (FIG. 3g).

9. K91IX3L223, closed vessel (jug?), HM?, H, light grey, medium coarse crushed pottery inclusions, orange-brown slip, very thin vertically metallic burnished. Approximate D. of body >15 cm.

2. Analysis of the Surface Treatment by Secondary Ion Mass Spectrometry (SIMS)

SIMS was used for the analyses of the surfaces and the underlying slip and ware. SIMS is a surface analyzing method which makes it possible to define even very small portions of a sample, both in-depth and along-surface (step-scan). The high sensitivity of SIMS in chemical and isotopic detection (ppb-ppm), and the efficient topographical resolution (nm-micron both in depth and laterally) make it in many respects superior to other surface analytical techniques in interdisciplinary sciences (e.g. Fischer *et al.* 1985; 1989; Lodding 1988; Fischer 1991b).

The instrument at the SIMS laboratory of the Department of Physics at the Chalmers University of Technology in Gothenburg, which was used in the present



6. Amphoriskos 3. K91VIII5L144N0343.

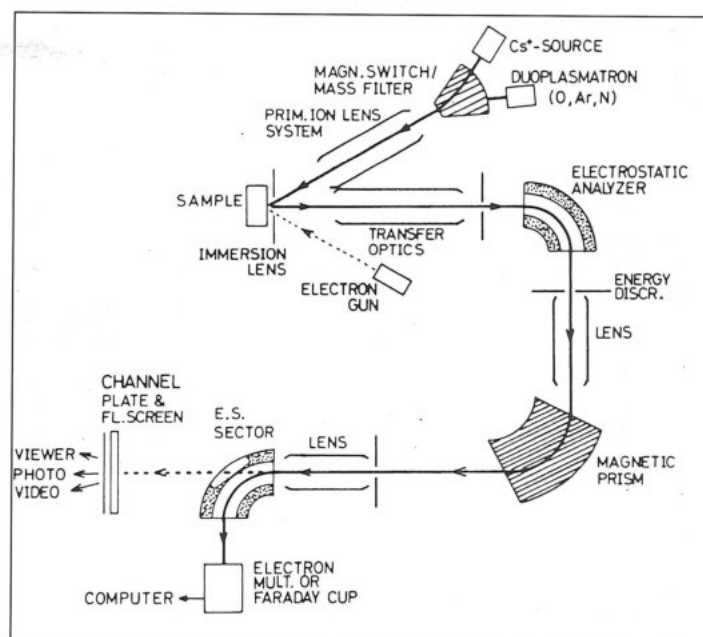
study, is the only multi-purpose SIMS in Scandinavia. This equipment, a Cameca 3/4F ion probe, is therefore especially suitable for use in archaeometry. Archaeometric investigations have been performed at the laboratory since 1984.

2.1. Principles and Features of SIMS

Secondary ion mass spectrometry is based on the following functions (FIG. 7; Lodding 1988):

- Bombardment of the sample surface with focused primary ions, with sputtering of the outermost atomic layers.
- Mass-spectrometric separation of the ionized species (sputtered atoms, molecules and clusters) according to their mass-to-charge ratios.
- Collection of the separated secondary ions as quantifiable mass spectra, as in-depth or along-surface (step-scan) profiles of elemental concentrations, or as element distribution images of the sputtered surface.

The primary ions (usually O_2^+ , O^- or Cs^+) are accelerated and focused at a selected impact area on the specimen. The focused beam can be narrow (micro-probe; 0.2-1.0 microns) or relatively wide (10-300 microns), permitting analysis of a smaller or larger area. The collision cascade following the incidence of a primary ion re-



7. Schematic drawing of a Cameca 3/4F ion probe.

sults in the reshuffling of some 50-500 matrix atoms, and emission of secondary particles either neutral or ionized. Secondary ions from the specimen are extracted into the mass spectrometer, the operation of which is based either on electric/magnetic deflection fields (e.g. the Cameca ion probes) or on the quadrupole/time-of-flight principle. Secondary ions with a given mass-to-charge ratio, and within a certain range (window) of kinetic energy, are collected for pulse or current measurements, ion-optic imaging, and data processing.

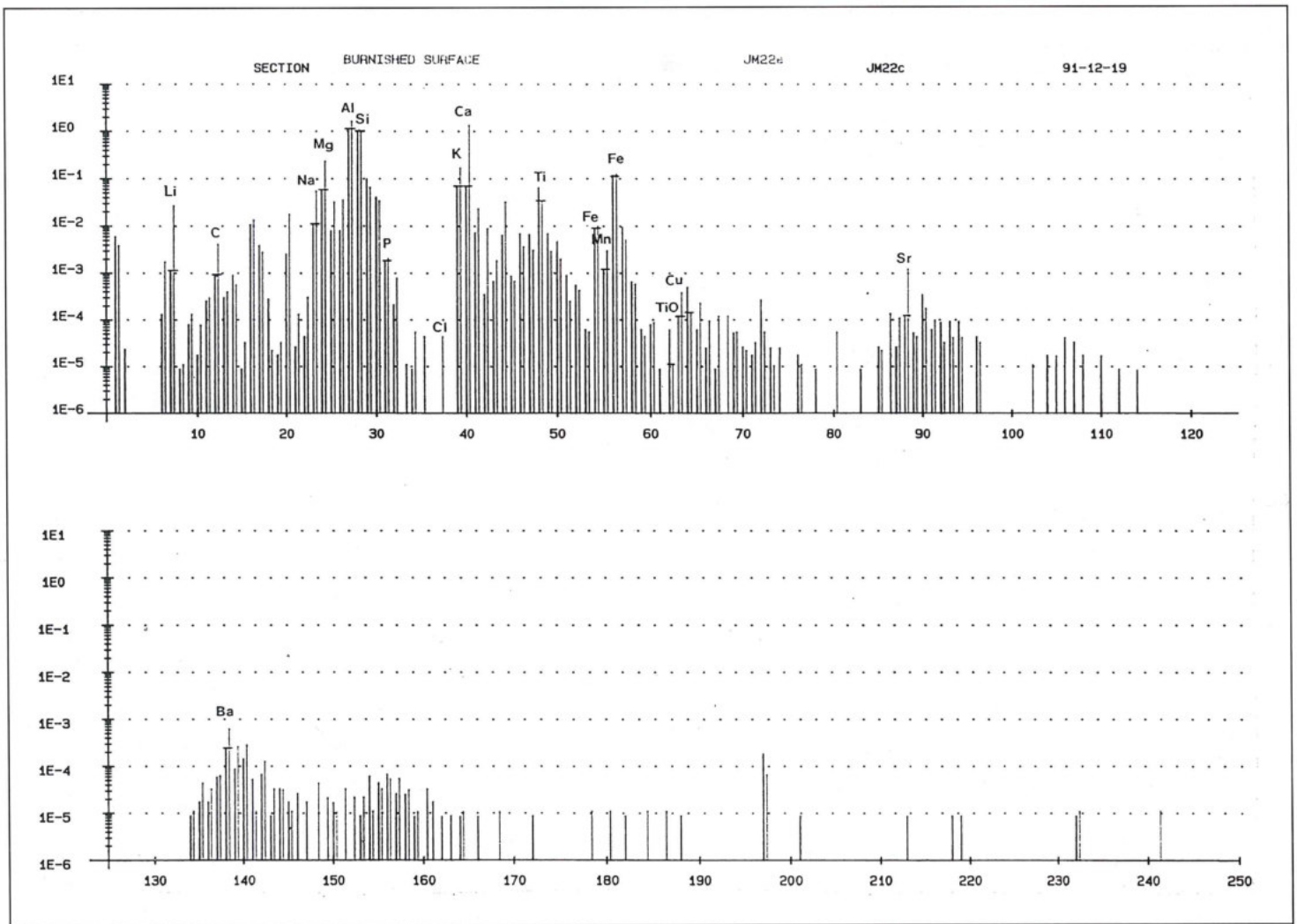
An advantage of SIMS which is especially important to archaeometry, is that the method may be considered virtually "nondestructive" apart from the fact that the sample size should not exceed 25mm by 12mm. A sample size of a few mm^3 is sufficient for a SIMS analysis. Analyzed samples can be returned.

2.2. Sample Preparation

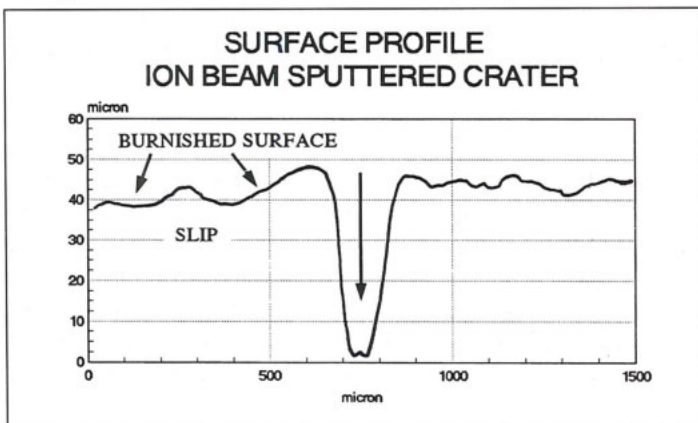
The samples were cleaned in water with a soft brush. No chemicals were used. The surface or the section of samples can be analyzed (either in an in-depth, or a step-scan mode which was not used in the current project). Sections of samples are polished with silicon carbide grinding paper, grit 600, and held in the SIMS sample holder (D. 25mm, max. height 12mm) with an embedding resin. The embedding procedure is the same as for surface analyses. Non-conducting samples (e.g. pottery) are also thinly gold-coated under vacuum, in order to provide a conducting surface layer – a precondition of all SIMS analyses.

2.3. The Applied Analyzing Mode

The gold-coated sample surfaces were bombarded with



8. Two spectra of the Metallic Burnished jug 9. K91IX3L223; arranged in pairs for mass number: clay matrix to the left, "burnished surface" to the right. Mass number on x-axis and intensity on y-axis.



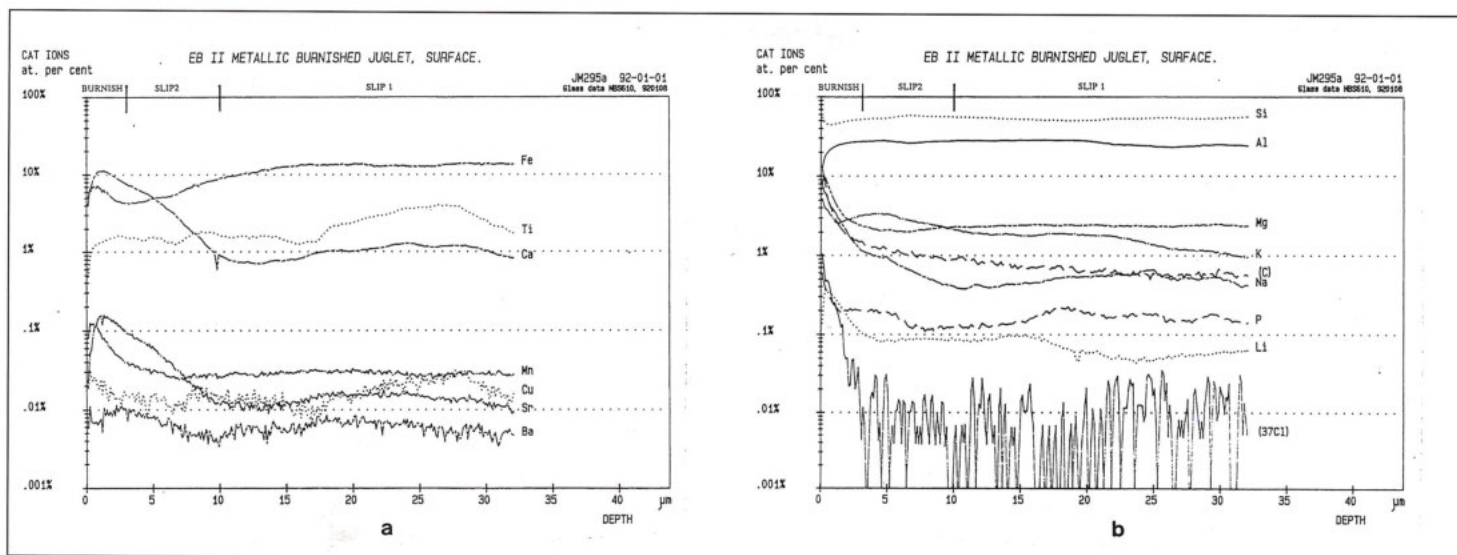
9. A crater in the surface of jug 7. K91VIIB12L230N0408 as the result of the primary ion beam sputtering (measured by the Talysurf).

a beam of O^- primary ions, c. 25 microns in diameter, accelerated through 12.7kV at a primary current of 175-200nA. The beam raster was 150x150 microns. The sec-

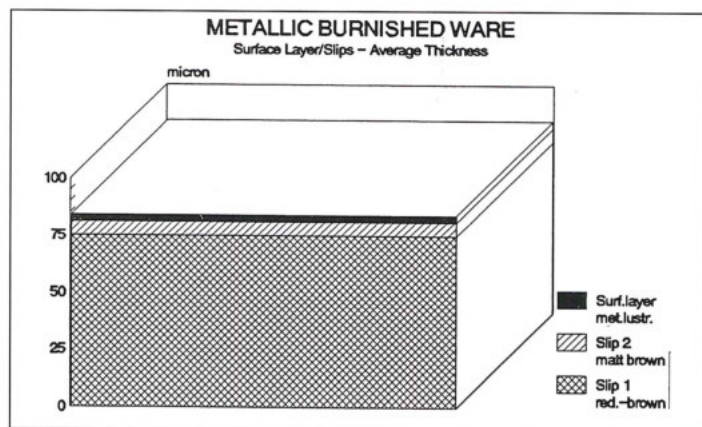
ondary positive ions were extracted and transmitted for mass separation from an analyzed area of 32x32 microns. Profiling of secondary negative ions was not performed since experimental problems due to charging of an insulating sample may arise. The kinetic energy window admitted only ions in the 75eV to 125eV range. The build-up of surface charge was countered by automatically adjusting the high voltage sample potential.

2.3.1. Fast-Spectrum Mode

Samples from all nine vessels were analyzed. The analyzing instrument was used initially in the fast-spectrum mode. Average sputtering time for each analysis was c. 450 seconds. All existing masses from 1 to 250 were exhibited in a single table for each sample analysis (see the spectra of the clay matrix compared with the surface of 9. K91IX3L223 in FIG. 8). For statistical reasons each sample was analyzed at three different points on the surface and likewise on the section of the same ware (clay



10 a. and b. In-depth analysis of the surface layer/slip 2/slip 1 of juglet 5. K91VIII5L144N0295; depth on x-axis and positive ion concentration on y-axis.



11. Average thickness of slips and surface layer of jug 7. K91VIIB12L230N0408 as measured by the Talysurf.

matrix). Care was taken to avoid analyses of areas not representative of the clay matrix, e.g. large inclusions. Each clay matrix spot to be analyzed was marked in a stereo microscope prior to the SIMS analysis. This offered a good topographical definition.

2.3.2. In-Depth Analyses

As implied from the study of the fast mass spectra, the following masses were chosen to study the changes and interpenetration between the surface layer, the underlying slip and the clay matrix by means of in-depth analyses: 7-Li, 12-C, 23-Na, 24-Mg, 27-Al, 28-Si, 31-P, 37-Cl, 39-K, 40-Ca, 48-Ti, 54-Fe, 55-Mn, 56-Fe, 63-Cu, 64-TiO, 65-Cu, 88-Sr, 138-Ba.

Five samples were analyzed in-depth [numbers within brackets refer to "1.2. Pottery Descriptions and Parallels": small bowl (1. K91VIIA12L246), amphoriskos or juglet (4. K91V9L103), juglet (5. K91VIII5L144N0295), amphoriskos or juglet (6. K91VIID7L175N0287), and

jug (7. K91VIIB12L230N0408)].

Three hundred in-depth analyses (i.e. 300 cycles) of the 19 chosen masses were performed, starting at the surface and sputtering through it, and into or through the underlying slip(s) (FIG. 9). Average sputtering time for the 300 cycles was 28 000 seconds and an average depth of c. 35 microns as measured from the surface was reached (i.e. within each cycle a layer c. 0.12 microns thick was analyzed with respect to the concentration of all the relevant elements).

Results

FIG. 10 and TABLE 1 show the positive ion concentrations at increasing depth. The sample is the juglet 5. K91VIII5L144N0295. The figure and the table may serve as examples of the average elemental concentration of the Metallic Burnished ware. This analysis will be discussed below.

The thickness of the surface layer is approximately 3 microns, which corresponds to the depth of penetration after 25 cycles (FIG. 8). The elemental profiles of the following masses show clear differences in concentration as compared to the slips below:

Lithium, calcium, manganese: apart from a low concentration in the outermost layer (<1-2 microns) the concentration is much higher in the surface layer than in the slip.

Carbon, sodium, magnesium, phosphorus, chlorine: very much higher concentration in the surface layer.

Potassium: elevated concentration in the outermost layer of the surface layer.

Iron: a higher concentration in the surface layer than in the outermost slip, but lower than in the deeper portions of Slip 1.

Table 1. Metallic burnished juglet K91 VIII5L144N0295. Mean values of element concentrations at different depths (Mol% of cations). Distance from surface in microns.

Element	Surface Layer		Slip 2	Slip 1
	0 - 0.6	0 - 3	3.1 - 10.2	10.3 - 33
Li	0.29	0.22	871ppm	672ppm
C	6.0	3.4	1.1	0.66
Na	5.2	3.1	0.71	0.49
Mg	6.6	4.6	2.2	2.4
Al	13.5	21.8	27.1	26.1
Si	50.2	48.6	54.6	52.3
P	0.41	0.25	0.15	0.16
Cl	0.63	0.22	91ppm	94ppm
K	4.1	3.1	2.9	1.6
Ca	5.8	7.3	3.5	1.0
Ti	0.93	1.4	1.54	2.45
Mn	0.11	750ppm	290ppm	290ppm
Fe	6.1	5.6	6.0	12.6
Cu	250ppm	190ppm	140ppm	170ppm
Sr	660ppm	0.12	420ppm	140ppm
Ba	75ppm	85ppm	65ppm	60ppm
Total	99.97	99.81	99.98	99.90

Aluminum: appears to be substituted by silicon in the outermost layer.

Titanium and titanium oxide: show low concentration in the outermost surface layer.

Copper: is somewhat more concentrated in the outermost surface layer than in the outermost layers of the slip.

Discussion

The examination of the samples with a stereo-microscope indicated a surface treatment which was applied on top of the slip. The surface-profiling instrument (Talysurf 10, manufactured by TaylorHobson) lent support to this assumption with measurements of the thickness of the outermost layer and the slip(s) (FIG. 11). It has been suggested that the burnish of a similar group of pottery,

namely the Early Bronze Age burnished ware found at Bāb adh-Dhrā', is the result of polishing the leather-hard clay with a smooth tool, thus presenting a compacted surface with a micro layer of clay brought to the surface to give a dull sheen (Johnston and Schaub 1976). As regards the Early Bronze Age Metallic Burnished ware from Tall Abū al-Kharaz, it rather seems that the "burnish" is an additional substance applied as strokes of coating on top of the slip. This has also been demonstrated by SIMS-analyses. Furthermore it was shown that the elemental compositions of the two slips are more related to each other than to the surface layer. This kind of manufacturing technique is without doubt time consuming. It was obviously used for both fine and coarse wares to achieve a more appealing look and perhaps to imitate

bronze vessels. Such a surface treatment certainly delays the evaporation of the liquid contents. It appears therefore that these vessels were intended for a special purpose and to hold particularly valuable substances.

It is difficult at present to define accurately the nature of the applied surface layer. However, the high concentrations of carbon, sodium, magnesium, chlorine, potassium and phosphorus indicate a material in which an organic substance has the function of a binder. It seems therefore that the final result is likely to have been achieved either by "glazing" (see e.g. the almost fluorescent surface of juglet 5. K91VIII5L144N0295) or by a post-firing treatment.

Glaze is by definition a glass-coating melted onto the surface of a once fired ceramic (biscuit) during a secondary firing process (glost; Rice 1987). However, even an unfired vessel can be treated with a glaze and be completed in a single firing process. During the cooling process glaze does not form a crystalline structure and therefore keeps the properties of a glass-liquid (Rhodes 1973; Nelson 1984). According to Rhodes (1973), three components characterize a glaze: network formers, network modifiers and intermediates.

Network formers mainly consolidate oxygen with cations (e.g. Si and P) resulting in SiO_2 and P_2O_5 . Network modifiers act as fluxes by lowering the melting point of silica (c. 1710°C). Among the most common fluxes Na_2O , MgO , K_2O and CaO may be mentioned. Intermediates either increase the viscosity (if this has been lowered too much by the fluxes) and/or increase the strength of the glaze in firing. A common intermediate is Al_2O_3 . Among the oxides used to stain the glaze, those of iron, manganese and copper should be mentioned. Organic materials are commonly used to bind the raw glaze.

Generally glazes are divided into high-temperature, hard glazes, above 1200°C, or low-temperature, soft glazes, below 1200°C (cf. Brody 1979). Low-temperature glazes with firing temperatures of 800-1000°C from about 3500 BC. Egypt and Iran are reported (Vandiver 1990).

All the elements and oxides essential to produce a soft alkaline glaze are confirmed by SIMS analyses. However, some observations do not entirely support the "glaze-theory". Chief among these is the fact that the surface layer is applied in strokes. It is not found at spots difficult to reach with a brush or another tool, e.g. inside handles or on the body below a handle. One would rather expect the potter to use either dipping, splashing or pouring as a technique to apply the raw glaze liquid, which would result in a glaze at parts of a vessel tricky to reach with tools.

As suggested above, another possibility might be that a post-firing treatment was applied to the vessels. The most common way seems to be to apply different organic

substances to the pot while it is still hot (Arnold 1985). This would possibly explain the very high carbon content of 6% "on surface" (0-0.6 microns), respectively the mean value of 3.4% carbon in the outermost layer (0-3 microns; see TABLE 1)). Resins, beeswax or various concoctions of plants, possibly intermingled with a "liquid slip" can be used to achieve a glaze-like surface (ref. to the relatively high aluminum and silicon contents of the surface layer in TABLE 1). The final treatment of the surface was most likely performed by burnishing with different tools or textiles, and solutions.

During the authors' study of the available relevant literature, the terms "Metallic ware", and "Abydos ware" and "Foreign ware" from Egypt, were found in a number of publications (Engberg and Shipton 1934: *passim*; de Vaux and Steve 1948: 556; Kantor 1965: 29, FIG. 5:AG; Hennessy 1967: *passim*; Amiran 1970: 59-66; Kühne 1976: 33-72; Dever and Richard 1977: 10; Amiran 1978: PL. 13:20, 23; Callaway 1980: 84, FIG. 62:11, 12, 18, 19; Cohen and Dever 1981: 63; Ben-Tor *et al.* 1981: 160, 162; Bar-Yosef *et al.* 1986: 148, FIG. 13:3; Dornemann 1988: 13-42; Gal 1988: FIG 3:7; Rast and Schaub 1989: 431, FIG. 256). Those wares are dated from Early Bronze Age IC (Callaway; see ref. above)/II-IV. It must be stressed that the designation "Metallic ware" in the above publications relates to the metallic-hard fired clay and not to the surface treatment. However, the ware in the current study designated as Metallic Burnished is related to "Metallic" and "Abydos/Foreign wares" as far as the hard-fired clay, the Early Bronze Age II date, and certain shapes are concerned. The search for the suggested, descriptive designation "metallic burnished" was unsuccessful. It is conceivable that other designations were used in earlier publications to describe the colour shades of comparable wares. The designation "metallic burnished" is intended to provide descriptive differentiation from other Early Bronze Age burnished wares. It is possible that this group of pottery constitutes a separate group among other burnished wares from the Early Bronze Age by virtue of a different production technique.

References

- Amiran, R. 1970. *Ancient Pottery of the Holy Land*. Jerusalem: Rutgers University Press.
- 1978. *Early Arad. The Chalcolithic Settlement and Early Bronze Age City*. Jerusalem: The Israel Exploration Society.
- Arnold, D. E. 1985. *Ceramic Theory and Cultural Process*. Cambridge: Cambridge University Press.
- Bar-Yosef, O., Belfer-Cohen, A., Goren, A., Hershkovitz, I., Ilan, O., Mienis, H. K. and Sass, B. 1986. Nawamis and Habitation Sites near Gebel Gunna, Southern Sinai. *IEJ* 36.

- Ben-Tor, A., Portugali, Y. and Avissar, M. 1981. The First Two Seasons of Excavations at Tel Quashish, 1978-1979: Preliminary Report. *IEJ* 31: 137-164.
- Brody, H. 1979. *The Book of Low-Fire Ceramics*. New York: Holt *et al.*
- Callaway, J. A. 1980. The Early Bronze Age Citadel and Lower City at Ai (et-Tell). A Report of the Joint Archaeological Expedition to Ai (et-Tell): No. 2. *ASOR Excavation Reports*.
- Cohen, R. and Dever, W. G. 1981. Preliminary Report of the Third and Final Season of the "Central Negev Highlands Project". *BASOR* 243.
- de Contenson, H. 1960. Three Soundings in the Jordan Valley. *ADAJ* 4-5: 12-98.
- 1964. The 1953 Survey of the Yarmouk and Jordan Valleys. *ADAJ* 89: 30-46.
- Dever, W. G. and Richard, S. 1977. A Reevaluation of Tell Beit Mirsim Stratum J. *BASOR* 226: 1-14.
- Dorell, P. G. 1991. In J. N. Tubb and P. G. Dorell, Tell es-Sa'idiyeh: Interim Report on the Fifth (1990) Season of Excavations. *Levant* 23: 67-86.
- Dornemann, R. H. 1988. Tell Hadidi: One Bronze Age Site Among Many in the Tabqa Dam Salvage Area. *BASOR* 270: 13-42.
- Engberg, R. M. and Shipton, G. M. 1934. Notes on the Chalcolithic and Early Bronze Age Pottery of Megiddo. *PEFQS* 1934: 90-93.
- Fischer, P. M. 1991a. Tell Abu al-Kharaz. The Swedish Jordan Expedition 1989. First Season Preliminary Report from Trial Soundings. *ADAJ* 35: 67-104.
- 1991b. Canaanite Pottery from Hala Sultan Tekke. Analysis with Secondary Ion Mass Spectrometry (SIMS). Pp. 152-161 in H. G. Gale (ed.), *Bronze Age Trade in the Mediterranean*. Studies in Mediterranean Archaeology 40.
- Fischer, P. M., Norén, J. G., Lodding, A. R. E. and Odelius, H. 1985. Quantitative Secondary Ion Mass Spectrometry (SIMS) of Prehistoric Teeth. Pp. 438-442 in *SIMS V*. Berlin and New York: Springer.
- Fischer, P. M., Lodding, A. R. E. and Norén, J. 1989. Trace Elements and Dating Studies of Teeth by Secondary Ion Mass Spectrometry (SIMS). Pp. 109-119 in Y. Maniatis (ed), *Archaeometry*. Amsterdam, Oxford, New York and Tokyo.
- Gal, Z. 1988. H. Shahal Tahtit and the 'Early Enclosures'. *IEJ* 38.
- Glueck, N. 1951. Explorations in Eastern Palestine IV. *AASOR* 25-28.
- Hennessy, B. 1967. *The Foreign Relations of Palestine During the Early Bronze Age*. London: B. Quaritch.
- Ibrahim, M., Sauer, J. A. and Yassine, K. 1976. The East Jordan Valley Survey, 1975. *BASOR* 222: 41-66.
- Johnston, R. H. and Schaub, R. T. 1976. Bab edh-Dhra, 1975. Selected Pottery from Bab edh-Dhra, 1975. *AASOR* 43: 33-50.
- Kantor, H. J. 1965. The Relative Chronology of Egypt and its Foreign Correlations Before the Late Bronze Age. Pp. 1-46 in R. W. Ehrich (ed.), *Chronologies in Old World Archaeology*. Chicago: University of Chicago.
- Kenyon, K. M. 1960. *Excavations at Jericho, I, The Tombs Excavated in 1952-4*. London: British School of Archaeology in Jerusalem.
- Kenyon, K. M. and Holland T. A. 1982. *Excavations at Jericho, IV, The Pottery Type Series and other Finds*. London: British School of Archaeology in Jerusalem.
- Kühne, H. 1976. Die Keramik von Tall Chuera. *Vorderasiatische Forschungen der Max Freiherr von Oppenheim-Stiftung I*. Berlin: Gebrüder Mann.
- Lodding, A. 1988. Secondary Ion Mass Spectrometry. Pp. 125-171 in F. Adams, R. Gijbels and R. Van Grieken (eds.), *Inorganic Mass Spectrometry*. Chemical Analysis Ser. 95. New York: Wiley and Sons.
- Mabry, J. and Palumbo, G. 1988. The 1987 Wadi el-Yabis Survey. *ADAJ* 32: 275-305.
- Mellaart, J. 1962. Preliminary Report of the Archaeological Survey of the Yarmouk and Jordan Valleys. *ADAJ* 6-7: 126-158.
- Mittmann, S. 1970. *Beiträge zur Siedlungs- und Territorialgeschichte des Nördlichen Ostjordanlandes*. Wiesbaden: Harrasowitz.
- Nelson, G. C. 1984. *Ceramics: A Potter's Handbook*. New York: CBS College Publishing.
- Rhodes, D. 1973. *Clay and Glazes for the Potter*. Philadelphia: Chilton Books.
- Rast, R. T. and Schaub, W. E. 1989. *Bab edh-Dhra: Excavations in the Cemetery Directed by Paul Lapp (1965-67)*. Reports of the Expedition to the Dead Sea Plain, Jordan, Vol. 1. *ASOR*.
- Rice, P. M. 1987. *Pottery Analysis. A Source Book*. Chicago.
- Schaub, R. T. 1981. Ceramic Sequences in the Tomb Groups at Bab edh-Dhra. *AASOR* 46: 69-118.
- Tufnell, O. 1958. *Lachish IV. The Bronze Age*. London and Oxford.
- Vandiver, P. B. 1990. Ancient Glazes. *Scientific American* 262,4: 106-113.
- de Vaux, R. and Steve, A. M. 1948. La seconde campagne de fouilles à Tell el-Far'ah, près Naplous. *RB*.
- Wentworth, C. K. 1922. A Scale of Grade and Class Terms for Clastic Sediments. *Journal of Geology* 30: 377-392.
- 1933. Fundamental Limits to the Sizes of Clastic Grains. *Science* 77: 633-634.
- Wright, G. E. 1937. *The Pottery of Palestine from the Earliest Times to the End of the Early Bronze Age*. New Haven, Con.