The Making of Aegean Stirrup Jars: Technique, Tradition, and Trade

THE MAKING OF AEGEAN STIRRUP JARS: TECHNIQUE, TRADITION, AND TRADE[1]

(PLATES 1–6)

INTRODUCTION

ONE of the most distinctive shapes in the repertoire of the bronze age Aegean potter was the 'stirrup' or 'false-necked' jar. This vessel type originated in the workshops of Middle Minoan Crete,[2] and by the early decades of the fifteenth century BC it was being produced in the ateliers of the Greek mainland.[3] Thereafter, it quickly became one of the most characteristic forms among the cultures of the Aegean world, enjoying a high degree of popularity for over three centuries until its role in society was replaced by the lekythos at the close of the Bronze Age.[4]

Furumark, in his landmark study of Mycenaean pottery,[5] classified all stirrup jars under his form 46, and further subdivided them into twenty-two individual shapes (FS 164–85) that exhibit a seemingly limitless variety of body profile. These vessels range in size from large containers that must certainly have been used for bulk storage or shipping to tiny, personal jars that fit comfortably in the palm of the hand. Fabric also varies widely, from mixtures so coarse that they attract the word 'domestic', to clays so finely levigated that they form gifts worthy of presentation at the highest levels of society.

The specific morphological features that cause the stirrup jar to stand out in any pottery assemblage are all concentrated in the upper part of the vessel: a central, but false (i.e. non-functional), neck topped by a disc from which (usually) two handles join the shoulder, and a true (i.e. pouring) spout that has been offset on the shoulder. It seems that the specific features of the stirrup jar were intended to facilitate the extraction of their contents: (scented/flavoured?) olive oils and/or other speciality liquids of similar viscosity.[6] The distinctiveness of this combination of elements was also

[1] This project arose from discussions with J. Tubb, and we are grateful for his continuing interest and support. The contributions of J. Leach and V. Newman in discussing and testing our interpretations concerning ceramic technique were invaluable, and are gratefully acknowledged. Similarly we should like to thank V. Hankey for her interest and for helpful discussions. Our thanks are also due to M. S. Humphrey for assistance in carrying out X-ray diffraction analyses, and to K. J. Matthews for help with the neutron activation analyses. We are grateful to Professor H. Mommsen for his helpful comments on some aspects of the neutron activation analyses.

[2] A. Furumark, *Mycenaean Pottery*, i: *Analysis and Classification* (2nd edn; Stockholm, 1941), 19, 38; P. P. Betancourt, *The History of Minoan Pottery* (Princeton, 1985), 105.

[3] Late Helladic II A: P. A. Mountjoy, *Mycenaean Decorated Pottery: A Guide to Identification* (Göteborg, 1986), 30–1.

[4] Mountjoy (n. 3), 199.

[5] Furumark (n. 2), 610–15; cf. Mountjoy (n. 3), under appropriate headings.

[6] Furumark (n. 2), 19; A. Leonard, jun., 'Considerations of morphological variation in the Mycenaean pottery from the southeastern Mediterranean', *BASOR* 241 (1987), 87–101; H. W. Haskell, 'Coarse-ware stirrup-jars at Mycenae', *BSA* 76 (1981), 225–38; id., 'From palace to town administration', in O. Krzyszowska and L. Nixon (eds), *Minoan Society: The Proceedings of the Cambridge Colloquium 1981* (Bristol, 1983), 121–8. It is interesting, however, that the elements that account for such convenient 'one-handed' extraction from the smaller (later) jars could not have played that role in the larger (heavier) vessels that began the series nor, for that matter, in the big domestic stirrup jars such as FS 164. Yet they all share these morphological common denominators.

significant to the scribes of the palace at Pylos who around *c.*1200 BC recorded the transfer of quantities of olive oil in the shape known to them as *ka-ra-re-we.*[7]

In addition to its appeal at home, the stirrup jar (with its valuable contents) was traded widely beyond the shores of the Aegean sea, having been found at sites from Sardinia to Syria and from Anatolia to Nubia.[8] These Aegean imports were particularly welcome in the markets of Cyprus and Syria–Palestine,[9] where, especially in the thirteenth century BC (LH/LM III B), they came increasingly into competition with products packaged in stirrup jars whose 'Levanto-Mycenaean' fabrics have suggested (visually) that they were the products of non-Aegean workshops.[10]

Toward the end of the thirteenth and into the twelfth century BC, apparently in response to unsettled conditions and increasing turmoil among the cultures of the eastern Mediterranean, the number of stirrup jars crafted in 'good' Aegean clays begins to decline in eastern contexts. Evidently in response to this situation there is a corresponding increase in the number of 'derivative Mycenaean' wares, including Simple Style jars that Furumark[11] considered to have been simpler (and inferior) variants of his Levanto-Mycenaean class of pottery. The apparent shift from the importation of 'true' Aegean specialty oils to the procurement of similar products (packaged in morphologically identical vessels) from production centres closer at hand is of major importance since it seems to indicate a significant interruption in trading patterns that had existed in the eastern Mediterranean for almost four hundred years.

Also noticeable at many Near Eastern sites is an increase in the number of 'local' or 'native' stirrup jars.[12] These are vessels that exhibit all of the morphological elements of their Aegean prototypes, but are executed in clays that are often visually indistinguishable from the fabrics used in producing the more mundane elements of the local ceramic assemblage. A good example of this can be seen at Tell es-Sa'idiyeh located in the eastern Jordan Valley, an area of tremendous cultural diversity at the end of the Late Bronze Age. Here excavation has produced a group of well-crafted stirrup jars whose fabric is indistinguishable from some of the more ordinary domestic pottery at the site. In discussing the Tell es-Sa'idiyeh stirrup jars for publication,[13] important

[7] M. Ventris and J. Chadwick, *Documents in Mycenaean Greek* (Cambridge, 1959), 217, 395–6; J. Chadwick, *Linear B and Related Scripts* (Berkeley, 1987), 36.

[8] An introductory bibliography to this vast subject would include (alphabetically by author's surname): P. Åström, *The Late Cypriote Bronze Age: Architecture and Pottery, The Swedish Cyprus Expedition*, vol. iv, part 1 c (Lund, 1972), esp. 289–414; V. Hankey, 'Mycenaean pottery from the Middle East: notes on some finds since 1951', *BSA* 62 (1967), 107–47; V. Hankey and A. Leonard, jun., *Egypt and the Levant: Aegean Imports in the Second Millennium BC (A Gazeteer of Sites in the Levant, Egypt and Nubia where Aegean Pottery has been Found)*, forthcoming as *Sonderforschungsbereich* 19 of the *Tübinger Atlas des vorderen Orients*; A. Leonard, jun., *An Index to the Aegean Pottery found in Syria–Palestine* (forthcoming); T. Smith, *Mycenaean Trade and Interaction in the West Central Mediterranean 1600–1000 BC* (BAR S371, Oxford, 1987); F. H. Stubbings, *Mycenaean Pottery from the Levant* (Cambridge, 1951); W. Taylor, *Mycenaean Pottery from Italy and Adjacent Areas* (Cambridge, 1958); L. Vagnetti (ed.), *Magna Grecia e mondo miceno* (Taranto, 1982).

[9] A. Leonard, jun., 'Archaeological sources for the history of Palestine: the Late Bronze Age', *Biblical Archaeologist*, 52 (1989), 4039. For the chronology of these deposits see id., 'Some problems inherent in Mycenaean/Syro-Palestinian synchronisms', *Problems in Greek Prehistory: Papers Presented at the Centenary Conference of the British School at Athens (Manchester, April 1986), 319–31.*

[10] On the Levanto-Mycenaean style cf. Furumark (n. 2), 9–10, 680; id., *Mycenaean Pottery*, ii: *Chronology* (2nd edn, Stockholm, 1972), 116–18.

[11] For the 'Simple Style' see Furumark, *Chronology* (n. 10), 116–18; R. B. Koehl and J. Yellin, 'The origin and provenience of the Mycenaean "Simple Style"', *AJA* 86 (1982), 273.

[12] Unfortunately, most Near Eastern archaeologists publish these pieces simply as 'native' or 'local', without any indication of whether the fabric is local to the site, local to the region, or simply non-Aegean.

[13] Discussions between AL and Dr Jonathan Tubb (British Museum), the Director of the Tell es-Sa'idiyeh excavations. These pieces will be published by AL in Tubb's final publication of this important and impressive site.

questions quickly arose. Could these vessels have been manufactured at or near Tell es-Sa'idiyeh by the same (relatively local) potters who supplied the area with the pottery used at the site for domestic chores? If so, were the jars made to compete with (or augment) a continuing trade in genuine imports, or were they intended to replace a product that for some reason no longer reached these inland markets? If they were not made by potters from the area, could these stirrup jars present evidence for the presence of Aegean potters in the central Jordan Valley during the Late Bronze Age? Obviously, answers to such questions would require more than the traditional methods of study.

In the past, most studies of Aegean pottery from non-Aegean archaeological contexts that have incorporated non-traditional or scientific methods, such as neutron activation analysis (NAA), optical emission spectrometry (OES), and X-ray photoelectron spectroscopy (XPS), have concentrated on the identification of clay provenance; in other words, they attempt to answer the question of where a particular vessel was made.[14] The very valid premise in such studies is that identification of the source of the clay[15] would allow us to locate the place of manufacture of the imported vessel (and possibly also its contents), and that the combined knowledge of both the source and the destination (findspot) would identify international commercial networks. Some of the analyses carried out in the course of this project have been directed towards answering questions of this nature; but because several of the Tell es-Sa'idiyeh stirrup jars appear visually to have been manufactured from a central Jordan Valley clay source, the questions of how these pots were made, and perhaps more importantly by whom, have also been addressed.[16]

THE PROJECT

The first phase of this project may be outlined as follows.

Premise. The stirrup jar is a purely Aegean form that was used to transport olive oil products within and without the Aegean area. No matter how greatly its size and body profile may vary, certain morphological characteristics (disc, false neck, handles, and offset (true) spout) remain constant. These features caused the products to be readily identifiable in foreign markets, where they demonstrated considerable appeal for over three centuries. Towards the end of the Late Bronze Age, stirrup jars executed in vastly inferior fabrics begin to replace the true imports in the eastern markets.

Hypothesis. There is more than one way to make a stirrup jar. Individual potters or workshops can produce visually similar vessels using different manufacturing techniques. Artisans from ceramic traditions that do not include the stirrup jar might create passable

[14] For a recent and excellent summary, see R. E. Jones and H. W. Catling, 'Pottery of Aegean type in Cyprus, the Levant and Egypt', in R. E. Jones, *Greek and Cypriot Pottery: A Review of Scientific Studies* (Fitch Laboratory Occasional Papers, 1; Athens, 1986), 542–625. In such studies sherds are often selected because their Aegean appearance causes them to stand out from the other (mostly 'local') pottery in the assemblage of a given site. Except for J. B. Lambert, C. D. McLaughlin, and A. Leonard, jun., 'X-ray photoelectron spectroscopic analysis of the Mycenaean pottery from Megiddo', *Archaeometry*, 20 (1978), 107–22, little interest has been shown in applying similar tests to a corpus that included a high degree of derivative wares and other 'unknowns'; for problems with this study, see Jones and Catling, op. cit. 571.

[15] Unless one argues that the clay itself was transported.

[16] The results of a study, carried out in an attempt to answer questions concerning the identity of potters producing wares from Ashdod in the 'Mycenaean III C1' style, were presented by F. Asaro, I. Perlman, and M. Dothan, 'An introductory study of Mycenaean III C1 ware from Tel Ashdod', *Archaeometry*, 13 (1971), 169–75. They concluded that the Mycenaean style pottery was made using the same clays as local Philistine wares, but employing different techniques. The Mycenaean style wares were similar in form, design and fabric to 'Mycenaean III C' wares from other places, particularly Cyprus.

copies of the form through completely different methods. If these methods can be identified and the technical 'signatures' isolated, then individual pots, such as those from Tell es-Sa'idiyeh, should be able to be assigned to workshops, or at least workshop traditions.[17] Comparison of the method(s) of construction of the 'local' stirrup jars with the more traditional 'Made in the Aegean' imports might show sufficiently striking idiosyncrasies to allow us to postulate whether these vessels represent simple 'copies' in a local atelier or the product of an Aegean hand working with substandard clays.[18]

THE SAMPLE AND ANALYTICAL STRATEGY

The test sample. The stirrup jars from the British Museum's excavations at Tell es-Sa'idiyeh come from several of the more than two hundred late bronze age graves that had been dug into earlier (early bronze age) levels of occupation on the lower tell of this large site[19] (see PLATE 1). To these vessels was added an example from Tell Gezer in Palestine, thought to have been imported from the Aegean (see Appendix 1 for details of vessels included in the test sample).

The control sample. Thirty-four further stirrup jars were examined, ranging in date from LH III A2 to LH III C (see Appendix 2). The choice of these jars was in part determined by the material available in the collections of the Department of Greek and Roman Antiquities of the British Museum. The sample falls largely into five main groups: the Greek mainland, Crete, Rhodes, Cyprus, and Egypt, with individual examples from Aegina and Caria. Wherever possible, jars with a known excavated provenance were included. This was much easier to do with, for example, the Museum's holdings of material from Rhodes and Cyprus than it was for the mainland and Crete.

Nine jars from the Greek mainland were selected: one from Mycenae, two from Phychtia near Mycenae, one from the area of the Argive Heraion, one from Athens, and four from the Elgin collection, which have the very inexact provenance of 'probably from Athens'. The two Minoan jars are known only to be 'from Crete'.[20] Five of the jars from Cyprus are from British Museum excavations at Enkomi in 1896,[21] and the other two are from excavations at Palaipaphos in 1899. The nine Rhodian jars are from Biliotti's excavations of a cemetery at Ialysos in 1868 and 1870.[22] Four of the five jars from Egypt are from Petrie's excavations at Gurob,[23] and the fifth is known only to be

[17] A parallel case, and a classic example of such a 'signature', is the late bronze age Cypriot potters' penchant for attaching vertical handles by pushing the bottom part of the handle through the body of the vessel (Åström (n. 8), e.g. pls 42. 7 (Black Slip IV); 49. 9 (Base Ring I); 52. 1–55 (Base Ring II); 56, 'handles' (Red Slip Wheelmade); 58. 6. 7 (White Shaved); etc.). When, during the LB II period, the Cypriot potters began to imitate the (by then) centuries-old Syro-Palestinian 'dipper' juglet, whose exterior surface is shaved (or pared) vertically, they inserted the bottom of the handle through the body of the vessel. This is a technical treatment that was never done by the Palestinian potters. See R. Amiran, *Ancient Pottery of the Holy Land* (New Brunswick, 1970), 146, 173, and cf. pls 46: 15 (the local dipper juglet), 55: 15 (the Cypriot import).

[18] Jones and Catling (n. 14), pp. 542–625, esp. 593–5.

[19] J. Tubb, 'Tell es-Sa'idiyeh: A preliminary report on the first three seasons of renewed excavations', *Levant*, 20 (1988), esp. pp. 65, 75, 78 and fig. 48 *a*, no. 14. For subsequent seasons of excavation at the site, see J. Tubb, 'Preliminary report on the fourth season of excavation at Tell es-Sa'idiyeh in the Jordan Valley', *Levant*, 22 (1990), 21–42; id. and P. Durrell, 'Tell es-Sa'idiyeh: interim report on the fifth (1990) season of excavations', *Levant*, 23 (1991), 67–86. These articles give bibliography for J. Pritchard's earlier excavations at Sa'idiyeh, conducted on behalf of the University of Pennsylvania.

[20] Complete references are not given for the pottery from Mycenae, Argos, Athens, and Crete, since these vessels are not from secure archaeological contexts; some details of publication are, however, given in the catalogue (Appendix 2).

[21] A. S. Murray, A. H. Smith, and H. B. Walters, *Excavations in Cyprus* (London, 1900), 1–54, pls. 1–12.

[22] C. Mee, *Rhodes in the Bronze Age* (Warminster, 1982).

[23] W. M. F. Petrie, *Illahun, Kahun and Gurob* (London, 1891).

'from Egypt'. One jar is known to be 'from Aegina', and the final one is from a tomb at Assarlik, Caria, excavated in 1886.[24] The vessels included in the study are summarized in TABLE 1, and their approximate findspots are indicated on the map (FIG. 1).

It is surprising to note how little work has been done on how the stirrup jar was actually made.[25] Since the group of local stirrup jars from Tell es-Sa'idiyeh, as well as the

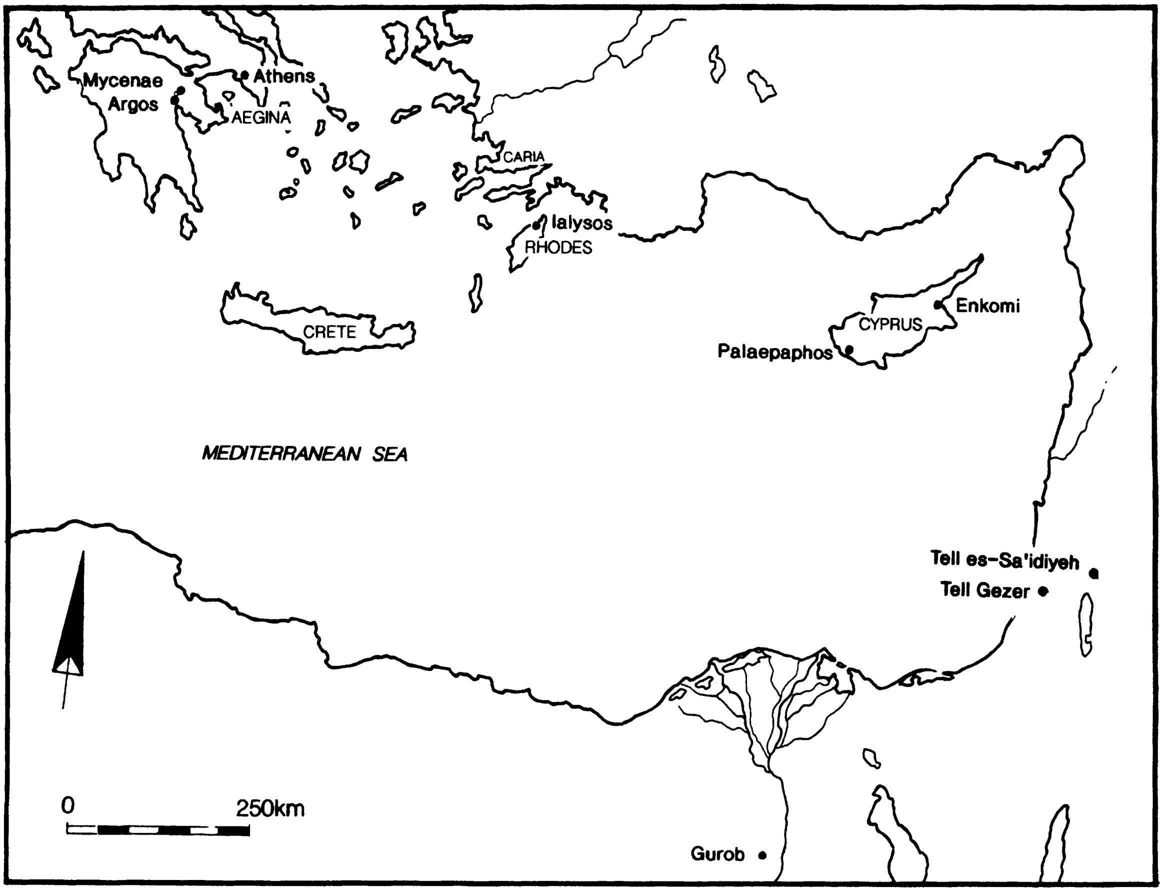


FIG. 1. Map showing approximate locations of the findspots of vessels included in the study.

[24] W. R. Paton, 'Excavations in Caria', *JHS* 8 (1887), 64–82, at p. 66.

[25] Furumark does offer some comments on how the false neck and disc developed (Furumark (n. 2), 85). For 'technical' studies that form a background to the present work, see *inter alia* D. E. Arnold, *Ceramic Theory and Cultural Process* (Cambridge, 1985); V. Hankey, 'Pottery making at Beit Shahab (Lebanon)', *PEQ* 100 (1968), 27–32; G. London, *Traditional Pottery in Cyprus* (Mainz, 1990). Also of interest are two unpublished dissertations: R. D. G. Evely, *Minoan Crafts: Tools and Techniques* (D.Phil. thesis; Univ. of Oxford, 1979), esp. pp. 397–404; H. B. Lewis, *The Manufacture of Early Mycenaean Pottery (Greece)* (Ph.D. thesis; Univ. of Minnesota, 1983; abstract only consulted). Both these authors consider the evolution of the potting techniques used by Mycenaean and Minoan artisans, in particular the relationship between the use of hand-building techniques and wheel-throwing. Evely comments directly upon the production of stirrup jars, noting that the identification of the techniques of manufacture of the kylix and of the stirrup jar causes some problems, and that 'in the case of the stirrup jar I have been unable to reconstruct the various methods used in its production' (ibid. 402). Evely also makes specific reference to the 'false' necks of the stirrup jar, noting that 'A considerable range of solid, hollow and thrown cylinders and their flat or conical caps make up the central "false" neck' (ibid.); as will be demonstrated later in the present paper the nature of the false neck is of some interest in elucidating the techniques of manufacture.

TABLE 1 Summary of stirrup jars examined and scientific observations. The vessels are grouped according to findspot.

vessel	*date*	*false neck*	*'NAA source'*
Test sample			
Tell es-Sa'idiyeh			
T 46.25	12th cent.	hollow	Local TeS
T 46.26	12th cent.	hollow	Local TeS
T 46.24	12th cent.	hollow	Cyprus?
T 222.5	12th cent.	hollow	Local TeS
Tell Gezer			
104959	13th cent.	solid	Myc/Berb main
Control sample			
Mainland			
A 1042	LH III A2	solid	Myc/Berb main
A 1054	LH III B	solid	Myc/Berb main
A 1055	LH III B	solid	Myc/Berb main
A 1057	LH III A2	hollow	Myc/Berb main
A 1085	LH III A2	semi-hollow?	Myc/Berb main
A 1094	LH III C	solid	Attic
A 1095	LH III C	solid	Attic
A 1096	LH III C	solid	Attic
A 1097	LH III C	solid	Attic
Aegina			
A 1092	LH III C	solid	Aegina
Rhodes			
A 912	LH III B	solid	Myc/Berb main
A 916	LH III A2	hollow	Myc/Berb dilut.
A 918	LH III B–C1	solid	Attic
A 922	LH III C1	solid	Rhodes
A 923	LH III A2	semi-hollow	Myc/Berb main
A 929	LH III C1	solid	Rhodes
A 930	LH III C1	solid	Rhodes
A 931	LH III C1	solid	?
A 932	LH III C1	solid	Rhodes
Crete			
A 716	LMIII B	hollow	Knossos
A 717	LMIII B	hollow	Knossos
Cyprus			
C 524	LH III A2	hollow	Myc/Berb dilut.
C 525	LH III A2	hollow	Myc/Berb dilut.
C 533	LH III A2	hollow	Myc/Berb main
C 550	LH III B	hollow	Crete?
C 553	LH III B	hollow	Myc/Berb dilut.
C 695	Cypriot 12th cent.	solid?	Cyprus
C 696	Cypriot 12th cent.	solid	Cyprus

vessel	*date*	*false neck*	*'NAA source'*
Caria (Assarlik)			
A 1101	LH III C	solid	local Caria?
Egypt			
A 984	LH III B	solid	?
A 987	LH III B	semi-hollow	Myc/Berb dilut.
A 988	LH III B	semi-hollow	Myc/Berb main
A 989	LH III B	solid	Myc/Berb dilut.
GR 1957.7-2.7	LH III B	hollow	?

'Myc/Berb main' = Mycenae/Berbati main composition group; 'Myc/Berb dilut.' = 'diluted' group of same, with reduced element concentrations (see text for discussion).

control group of more standard Aegean appearance from the collections of the British Museum, were complete or restored vessels, the project was required to find a method of examination that would not damage them. The best solution to this problem was xeroradiography. However, because it would make little sense for a group of non-potters to decide and discuss which morphological and technological features of this pottery were relevant and which were not, a 'modern ethnographic component' was added. Two professional potters, Veronica Newman and Jeremy Leach, each made a series of stirrup jars to illustrate important technological considerations. The importance of their input to the project cannot be overestimated.

In an attempt to provide some control on the original sources (as opposed to the findspots) of the vessels, most of the stirrup jars were analysed chemically using neutron activation analysis. Once again, this technique was selected as being minimally destructive; it requires only the removal of a small amount of powdered sample. The analytical techniques are described more fully below.

Scientific Methods

XERORADIOGRAPHY

As has been noted already, the nature of the archaeological material (i.e. essentially complete or fully restored three-dimensional objects) demanded the use of scientific techniques which were essentially non-destructive. X-radiography fulfils this requirement and, moreover, the technique of xeroradiography originally developed for medical purposes[26] has been found to be most useful in studies of ceramic technology.[27]

[26] J. W. Boag, A. J. Stacey, and R. Davis, 'Some clinical and experimental applications of xeroradiography', *Journal of Photographic Science*, 19 (1971), 45–8; id., 'Xerographic recording of mammograms', *British Journal of Radiology*, 45 (1972), 633.

[27] R. E. Alexander and R. H. Johnston, 'Xeroradiography of ancient objects: a new imaging modality', in J. S. Olin and A. D. Franklin (eds), *Archaeological Ceramics* (Washington, 1982), 145–54; C. Carr, 'Advances in ceramic radiography and analysis: applications and potentials', *Journal of Archaeological Science*, 17 (1990), 13–34; G. V. Foster, 'Kourion votive figures: a study using xeroradiography', *Museum Applied Science Center for Archaeology (MASCA) Journal*, 2 (1983), 179–81; S. Heinemann, 'Xeroradiography: a new archaeological tool', *American Antiquity*, 41 (1976), 106–11; A. P. Middleton, J. Lang, and R. Davis, 'The application of xeroradiography to the study of museum objects', *Journal of Photographic Science*, 40 (1992), 34–41.

Xeroradiography differs from conventional radiography in a number of respects, most notably in the sensitive medium used to capture the image. Instead of a sheet of film, an aluminium plate coated with amorphous selenium is used to record the X-ray image. Before exposure, an electrostatic charge is applied to the surface of the plate; upon exposure to X-rays this applied charge is caused to leak away differentially in proportion to the received X-ray dose. Thus a residually charged latent image remains on the plate. In a manner analogous to that of a photocopier, this latent image is then developed by exposing the plate to a cloud of finely divided charged powder and transferring the resulting toner image from the plate to a sheet of plastic-coated paper.

The images thus produced exhibit a particular feature known as 'edge enhancement'. This arises from the interaction of the charged toner particles with the charged latent image, and has the effect of emphasizing otherwise minor discontinuities in the radiographic density of the object. This feature has been found to be particularly useful in studies of ceramic materials, because it aids the recognition of voids and inclusions in the clay body. The facility with which inclusions can be recognized using xeroradiography has led to the use of the technique to study the nature, amount, and distribution of temper (i.e. opening material) in prehistoric ceramics. Recognition of this material, frequently added by ancient potters to aid in the processing of clays, can assist in the characterization of ancient ceramics.[28]

However, the area of ceramic studies in which the xeroradiographic technique has enjoyed particular success is in the investigation of forming and fabrication techniques.[29] Critical to this success is the potential of xeroradiography to provide images in which features such as the distribution and orientation of elongate voids and inclusions, and the nature and arrangement of micro-cracks, can be observed. These features are characteristic of forming techniques (e.g. slab-building, coil-building, wheel-throwing)[30] and can also yield information on construction techniques such as the application of decorative motifs, handles, spouts, and so on. It is in this area of investigation that the technique had particular application to our study of Aegean stirrup jars.

The X-ray exposures were made using a Seifert X-ray generator, generally operated with an applied voltage of 150 kV and a tube current of 2 mA. Images were recorded on to Xerox Medical Systems plates, conditioned and processed using an XMS 125 system. Exposure times were generally in the region of ten to twenty seconds.

NEUTRON ACTIVATION ANALYSIS (NAA)

This technique was used to try to find the geographical origin of each jar: did all the jars from each site have a common origin, or are some imports? Do differences in construction technique found by xeroradiography arise from different origins? Neutron

[28] Alexander and Johnston (n. 27); Carr (n. 27); Foster (n. 27); see also G. V. Foster, 'Assessment of microinclusions in ceramic ware by pattern recognition analysis of microxeroradiographs', in J. S. Olin and M. J. Blackman (eds.), *Proceedings of the 24th International Archaeometry Symposium* (Washington, 1986), 207–16.

[29] Heinemann, Foster (n. 27); see also J. A. Blakeley, R. Brinkman, and C. J. Vitaliano, 'Pompeian Red Ware: processing archaeological ceramic data', *Geoarchaeology*, 4 (1989), 201–28; W. D. Glanzman and S. Fleming, 'Ceramic technology at prehistoric Ban Chiang, Thailand: fabrication methods', *Museum Applied Science Center for Archaeology (MASCA) Journal*, 3 (1985), 114–21; P. E. McGovern (ed.), *The Late Bronze and Early Iron Ages of Central Jordan: The Baq'ah Valley Project, 1977–1981* (University Museum monographs, 65; Pennsylvania, 1986), 164–77.

[30] P. Vandiver, 'The implications of variation in ceramic technology: the forming of neolithic storage vessels in China and the Near East', *Archaeomaterials*, 2 (1988), 139–74.

activation analysis is an appropriate technique for tracing the origin of the jars. Its particular strengths include multi-element capability and high accuracy; furthermore, to the benefit of the present project, analyses of ceramics of known origin are available, against which the analyses of the jars could be compared.[31]

All the jars were analysed using the usual NAA technique adopted in the British Museum's Department of Scientific Research.[32] Samples were taken for analysis, usually from the footring, with a 2 mm diameter tungsten carbide drill. Portions of the resulting powder weighing 20–40 mg were sealed into short lengths of high-purity silica tubing, and irradiated in batches of sixty samples together with portions of an in-house standard pottery of known composition, for calibration. The samples were irradiated at the University of London Reactor Centre at Ascot, Berkshire, and were returned to the British Museum on the fourth day after irradiation, for counting on a gamma spectroscopy system. Extensive computer processing of the raw data resulted in quantitative analyses for twenty-three elements in each sample. Multivariate statistical programs for principal components analysis and cluster analysis were used to interpret the neutron activation analysis results.[33] The results are reported in TABLE 2;[34] the jars have been grouped according to the origins inferred from analysis and by reference to comparative published analyses.

VISUAL OBSERVATION

All the vessels were carefully examined visually, where appropriate also using a binocular microscope, in order to try to identify any features which might allow the characterization of particular techniques or traditions of manufacture. Particular attention was paid to body shape, character of the base, and size and proportions of the spout. On a small number of vessels, breaks in the vessel walls allowed the interior of the jar to be observed by eye and also with the aid of a deep-field video microscope (Keyence Corporation).

X-RAY FLUORESCENCE AND X-RAY DIFFRACTION ANALYSIS

The nature of the materials used to produce the decorative designs and motifs in various shades of red, brown, and black were investigated on a selection of the jars. Qualitative elemental information was obtained, using non-destructive X-ray fluorescence analysis

[31] A. M. Bieber, D. W. Brooks, G. Harbottle, and E. V. Sayre, 'Application of multivariate techniques to analytical data on Aegean ceramics', *Archaeometry*, 16 (1976), 59–74; M. J. Hughes, D. J. R. Williams, and K. Williams, 'Neutron activation analyses of ceramics from the temple of Aphaia, Aegina' (in preparation); H. Mommsen, T. Beier, U. Diehl, and C. Pozuweit, 'Provenance determination of Mycenaean sherds found in Tell el Amarna by neutron activation analysis', *Journal of Archaeological Science*, 19 (1992), 295–302; E. French, 'Tracing exports of Mycenaean pottery: the Manchester contribution', in N. H. Gale (ed.), *Bronze Age Trade in the Mediterranean* (SIMA 90; Jonsered, 1991), 121–5; F. Asaro, I. Perlman, and M. Dothan, 'An introductory study of Mycenaean III C1 ware from Tel Ashdod', *Archaeometry*, 13 (1971), 169–75; J. Yellin and A. Maeir, 'The origin of the pictorial krater from the "Mycenaean" tomb at Tel Dan', *Archaeometry*, 34 (1992), 31–6.

[32] M. Hughes, M. R. Cowell, and D. R. Hook, 'Neutron activation analysis procedure at the British Museum Research Laboratory', in iid. (eds), *Neutron Activation and Plasma Emission Spectrometric Analysis in Archaeology* (British Museum Occasional Papers, 82; London, 1991), 29–46; M. J. Hughes, M. N. Leese, and R. J. Smith, 'The analysis of pottery lamps mainly from Western Anatolia, including Ephesus, by neutron activation analysis', in D. M. Bailey, *Catalogue of Lamps in the British Museum*, iii: *Roman Provincial Lamps* (London, 1988), 461–85.

[33] Principal components: W. W. Cooley and P. R. Lohnes, *Multivariate Data Analysis* (New York, 1971). For cluster analysis the CLUSTAN program was used: D. Wishart, *CLUSTAN User Manual* (4th edn; University of St Andrews, 1987). See also Bieber *et al.*, (n. 31); and R. E. Jones (n. 14), ch. 2 *b*, 'Data analysis' (by A. M. Pollard), 56–83.

[34] Technical problems during the counting of the short-lived isotopes (about 7 of the 23 elements) led to the loss of a small amount of data. A few values are therefore missing from TABLE 2; but as these particular elements were not normally used in the subsequent multivariate statistical tests, the loss was not significant.

TABLE 2 Neutron activation analyses of stirrup jars and comparative analyses, arranged in sequence by origin (all results are given in parts per million except Na, K, Fe, and Ca in per cent)

Cat.	Findspot	Na	K	Rb	Cs	Ca	Sc	Fe	Cr	Co	La	Ce	Eu	Sm	Lu	Yb	Hf	Th	U	Tb	Ta	Ba	As	Sb
Origin = Rhodes																								
A 922	Rhodes	0.353		70.4	3.62	9.4	14.0	5.81	1044	88.7	19.2	34.0	0.799	3.23	0.221	1.29	2.04	5.73	1.5	0.40	0.61	170	13.9	0.33
A 929	Rhodes	0.425	1.20	51.0	3.05	12.2	13.1	4.92	1188	68.8	15.5	30.3	0.836	2.89	0.211	1.26	2.11	4.80	2.1			249	9.8	0.45
A 930	Rhodes	0.435	0.85	46.7	2.78	9.6	14.7	5.53	1265	73.6	17.4	32.6	0.830	3.27	0.238	1.47	2.02	5.69	1.5	0.47	0.60	225	6.8	0.24
A 932	Rhodes	0.333	0.81		4.69	7.7	14.6	5.82	1055	77.0	16.4	35.2	0.732	3.01	0.205	1.03	2.60	5.65		1.27		368	4.6	0.40
mean		0.39	0.95	56	3.53	9.7	14.1	5.51	1138	77.0	17.1	33.0	0.799	3.10	0.219	1.26	2.19	5.46	1.7	0.71	0.61	253		
s.d.		0.05	0.18	10	0.84	1.8	0.7	0.42	107	8.5	1.6	2.1	0.048	0.18	0.015	0.18	0.27	0.45	0.3	0.39	0.01	72		
Origin = Attic:																								
A 918	Rhodes	0.860		144	8.76	4.9	21.7	6.55	626	49.9	25.2	47.3	1.17	4.54	0.355	2.33	3.32	9.76	2.2	1.73	0.80	262	5.6	0.60
A 1094	Athens	0.764	2.36	143	16.9	5.0	21.1	4.87	645	39.8	27.3	59.5	1.31	5.71	0.411	2.76	4.60	10.0	1.9	0.83	0.76	513	17.6	0.76
A 1095	Athens	0.752		130	16.6	9.3	21.5	5.11	632	40.6	26.7	59.0	1.24	5.85	0.469	2.23	4.1	10.3	4.2	0.76	0.85	674	30.1	1.07
A 1096	Athens	0.762		125	14.2	7.9	19.9	4.83	587	33.1	25.4	52.5	1.17	5.44	0.404	2.38	4.51	9.24	3.2	2.02	0.68	465	30.5	0.99
A 1097	Athens	0.610		161	18.5	6.6	22.6	6.83	679	49.1	32.3	64.5	1.44	6.89	0.491	3.05	4.18	11.0	3.1	0.97	0.66	476	35.1	1.80
mean		0.78		136	14.1	6.7	21.0	5.33	623	40.9	26.2	54.6	1.22	5.38	0.41	2.43	4.13	9.84	2.9	1.34	0.77	479		
s.d.		0.05		18	3.8	1.9	0.8	0.81	25	6.9	1.0	5.8	0.07	0.59	0.05	0.23	0.58	0.49	0.9	0.55	0.06	147		
Attic B* mean		0.60	2.53	128	13.4	6.5	21.9	5.14	569	36.4	25.5	57.6	1.10			2.57	4.09	8.60			0.68	392		
s.d.		0.04	0.17	17	2.5	0.8	1.6	0.4	55	4.3	1.8	7.0	0.09			0.17	0.32	0.57			0.08	80		
Origin = Argolid (Mycenae/Berbati) main:																								
A 1054	Mycenae	1.15		135	8.31		19.2	4.92	281	36.1	32.1	63.0	1.42	6.26	0.427	2.26	4.54	12.2		0.93	1.11	407	18.9	0.53
A 1055	Mycenae	1.02		124	6.09		17.5	4.62	278	31.7	28.9	62.4	1.30	5.79	0.437	2.65	5.65	12.0	3.2	0.78	1.20	394	26.5	1.43
A 1057	Mycenae	0.674		159	9.23	11.0	19.0	4.73	239	28.6	31.2	58.2	1.27	5.84	0.416	2.33	3.43	10.9	2.4	0.70	0.90	296	6.0	0.82
A 1085	Athens	0.556		195	10.2	8.4	21.1	5.28	252	31.8	35.3	68.3	1.31	5.91	0.456	2.83	3.07	11.4		0.93		396	8.7	0.88
A 1042	Argos	1.35		98.5	9.71	8.8	20.1	5.07	260	33.2	29.8	62.2	1.24	5.76	0.432	2.72	3.86	11.6	2.8	0.72	0.96	283	33.6	0.95
A 912*	Rhodes		3.40	211	12.2	11.2	25.0	6.30	340	34.7	33.3	70.5	1.41	6.23	0.566	2.68	4.30	13.6	2.3	0.72	1.24	432	9.8	0.99
A 923	Rhodes	0.475		172	9.37	10.4	18.5	4.95	238	27.4	31.3	59.3	1.21	5.67	0.382	2.19	3.53	11.3	2.8	0.82	0.87	318	9.8	0.93
A 988	Egypt	0.926		160	9.07	10.2	18.9	5.01	250	29.4	32.5	61.6	1.26	5.83	0.445	2.47	3.81	12.0	2.8	0.81	1.02	308	9.0	0.47
C 533	Cyprus	0.765		164	9.34	7.5	20.2	5.30	253	30.8	36.1	63.6	1.29	5.72	0.508	2.52	3.77	12.7	5.2	0.69	1.12	442	13.3	1.37
104959	Gezer	0.422	2.60	161	9.51	9.5	20.0	5.38	246	31.4	32.8	62.6	1.43	6.40	0.451	2.68	3.80	12.0	2.4	0.91	0.77	939	6.4	0.68
mean		0.86		151	8.91	9.6	19.3	4.98	256	31.1	32.1	62.3	1.28	5.85	0.44	2.50	3.96	11.7	3.2	0.80	1.03	356		
s.d.		0.30		28	1.25	1.3	1.1	0.24	15	2.7	2.4	3.0	0.06	0.18	0.04	0.22	0.80	0.6	0.9	0.09	0.11	57		
MycBer** mean		0.58	2.59	157	8.95	10.3	21.5	5.20	244	29.3	31.9	63.5	1.22	5.07	0.44	2.66	3.64	11.3	2.32	0.73	0.92			
s.d.		0.23	0.38	13	0.75	2.0	0.8	0.17	26	2.6	1.3	1.3	0.08	0.21	0.03	0.10	0.46	0.7	0.12	0.07	0.10			

Origin = Argolid (Mycenae/Berbati) diluted:																								
A 916	Rhodes	0.535	2.48	157	8.72	7.7	17.8	4.49	230	25.7	29.6	53.8	1.22	5.14	0.359	2.06	3.24	10.2	2.7	0.69	1.2	301	13.8	0.75
A 987	Egypt	0.831		125	8.50	10.0	16.1	4.45	237	26.2	27.5	53.4	1.13	5.41	0.418	2.32	4.36	9.99	3.0	0.75	0.72	233	24.0	0.69
A 989	Egypt	0.738		119	7.48	10.5	14.5	3.71	208	25.3	25.6	45.4	1.09	4.73	0.358	2.00	3.62	8.78	2.5	0.61		205	6.4	0.46
C 524	Cyprus	0.785		66.9	5.72		17.8	4.74	251	15.6	28.8	58.9	1.12	5.33	0.353	2.26	3.91	11.6	6.2	0.58	0.99	768	37.7	0.75
C 525	Cyprus	0.711		69.7	4.98	5.6	17.9	4.71	261	21.4	30.8	57.3	1.30	5.80	0.414	2.04	3.95	10.8	5.6	2.18	0.66	828	28.2	0.68
C 553	Cyprus	0.899		132	6.48	8.1	16.4	4.13	260	24.7	28.6	54.9	1.22	5.24	0.410	2.19	4.4	10.2	3.0	0.70	0.90	274	3.7	7.36
mean		0.75		112	6.98	8.4	16.7	4.37	241	23.1	28.5	54.0	1.18	5.27	0.39	2.14	3.91	10.2	3.8	0.91	0.89	435		
s.d.		0.12		32	1.51	2.0	1.4	0.39	20	4.0	1.8	4.7	0.08	0.35	0.03	0.13	0.44	0.9	1.5	0.56	0.19	259		
Origin = Crete:																								
A 716	Crete	0.558		107	6.85	12.3	15.9	4.54	398	28.3	23.8	47.3	0.993	4.48	0.299	1.97	3.80	8.62	2.6	0.58	0.70	281	8.3	0.50
A 717	Crete	0.574		98.0	6.69	12.3	16.1	4.63	408	28.0	24.0	48.5	1.07	4.50	0.329	2.06	3.22	8.92	2.0	0.67		181	7.5	0.78
C 550	Egypt	0.903		86.4	5.15		17.8	4.88	496	33.7	23.4	44.2	0.948	4.08	0.344	2.02	2.91	7.86	3.1	1.68	0.97	744	19.9	0.87
A 931	Rhodes	0.861	2.57	113	7.15		19.8	5.79	560	40.4	23.9	50.0	1.09	4.50	0.370	1.96	3.27	9.91	2.6	0.63	1.11	505	16.5	0.84
Origin = Caria:																								
A 1011	Caria	0.357		68.5	6.05		26.9	6.53	826	76.1	37.6	75.6	1.61	7.60	0.547	3.73	5.02	12.9	4.8	1.04	1.07	705	37.3	0.92
Origin = Cyprus																								
C 695	Cyprus	1.04		35.6	3.32	13.0	17.9	4.22	202	24.6	20.7	29.9	0.977	3.91	0.381	2.04	2.93	4.48	3.1	0.57		199	37.7	1.88
C 696	Cyprus	1.25		36.3	2.43	13.1	22.4	5.29	255	27.4	16.3	32.9	0.996	3.40	0.338	1.76	2.60	3.64	3.1	0.64	0.40	331	7.2	0.47
T46.24	T.E.S.	0.988	1.92	55.0	3.52	15.7	13.6	3.46	388	19.0	16.4	30.8	0.955	3.77	0.267	1.94	2.51	5.02	2.2	0.56	0.55	240	10.6	1.11
Origin = Aegina:																								
A 1092	Aegina	1.00	1.79	107	31.7	15.2	17.3	4.34	531	31.9	20.0	41.4	1.03	4.05	0.346	1.85	2.86	7.06	2.7	0.63	0.46	293	25.8	1.61
Origin = Tel es-Sa'idiyeh																								
T46.25	T.E.S.	0.626	2.18	40.3	2.02	9.6	12.0	3.54	126	24.4	32.9	59.6	1.64	7.12	0.496	3.10	6.26	7.83	2.1	1.03	1.25	690	5.8	0.47
T46.26	T.E.S.	0.549	1.99	44.5	2.83	10.7	12.3	3.62	124	25.3	31.5	62.1	1.66	7.10	0.489	3.29	6.76	8.05	2.3	0.96	0.95	934	6.2	0.58
T222.5	T.E.S.	0.508	2.47	32.3	1.27	14.7	9.11	2.90	88.0	22.5	22.6	46.3	1.07	4.96	0.287	1.95	5.48	6.46	2.1	0.65	0.84	155	5.9	0.43
Origin = Unplaced:																								
A 984	Egypt	0.790		34.9	1.85	12.0	9.06	2.82	98.2	17.6	24.2	48.4	1.26	5.46	0.405	2.33	8.74	5.85	2.2	0.83	0.97	607	6.7	0.79
1957,	Egypt	0.525		46.8	3.23	22.4	8.75	2.35	135	19.6	23.5	37.2	0.964	3.86	0.260	1.52	2.59	5.61		1.34			11.9	0.93

s.d. = 1 standard deviation about the mean

Attic B* mean: from Fillieres et al (n. 37)

MycBer** mean = Mycenae-Berbati main group, from Mommsen (n. 42)

A 912*: this sample not included in the mean for this group (see n. 43)

T.E.S. = Tell es-Sa'idiyeh

(XRF). Areas of decoration a few square millimetres in size were examined in air, using a molybdenum tube. X-ray diffraction analysis (XRD) was used to determine the crystalline phases present in the coatings; very small samples were removed from a range of coatings, and their diffraction patterns recorded using Debye-Scherrer cameras.

Observations and Interpretation

NATURE OF THE COATINGS

The analytical results obtained indicated the use of several different raw materials to produce the decorative coatings but generally there did not appear to be any particular correlation with either temporal or geographical factors. For this reason the results will not be presented or discussed in detail here; but a brief summary may be given.

The qualitative XRF analyses suggested, not surprisingly, that all the red and red-brown to black coatings had been produced by the application of ferruginous materials. Many of the samples analysed by XRD were found to contain the red iron oxide, haematite. The range of colours observed probably relates in part to the use of different raw materials, but variations in firing conditions were probably of at least equal significance.

The only exceptions concern two relatively late (twelfth-century) Cypriot vessels (C 695–6). Their decorative schemes are very similar and are distinctive in two respects: the lower half of each jar is covered by a continuous coating rather than the bands normally seen; and the coatings are of a particularly dense, matt black colour. Analysis by XRF showed both coatings to be rich in manganese (in addition to iron).[35]

TECHNIQUES OF CONSTRUCTION

Examination of the vessels and the radiographs suggested that any differences in potting technique were likely to involve features such as the spouts, the handles, and the false necks. Our observations are summarized here.

Spouts. PLATE 2 (*b*) is a reproduction of a xeroradiograph of a stirrup jar from Rhodes (PLATE 2 *a*). Inspection of this image reveals a number of features which suggest that the spout of the jar was formed separately and then luted on to the (leather-hard) body of the jar. Perhaps the most obvious feature which can be seen on this radiograph, and also in radiographs of other vessels, is a misalignment of the central hole of the spout and the hole cut through the wall of the vessel. Such misalignment is difficult to reconcile with a spout which had been inserted through the wall of the jar (or which had been raised directly from the wall of the vessel). Another feature frequently observed was the presence of air gaps between the spout and wall of the vessel, again suggesting a discontinuity or join between the wall and spout. On a number of radiographs (including that in PLATE 2 *b*) areas of clay can be seen extending inwards from around the hole, through the wall and into the jar. Although these tongues of clay might be

[35] It is interesting to note that, although found elsewhere, the use of the 'manganese-black' technique for decorating ceramics was particularly popular on Cyprus. According to Noll *et al.* (W. Noll, R. Holm, and L. Born, 'Painting of ancient ceramics', *Angewandte chemie*, 14 (1975), 602–13), the 'manganese-black' technique originated in SE Anatolia in the 6th to 5th millenniums BC. Despite the local occurrence of manganese ores, the adoption of the technique on Cyprus was relatively late (*c.*1600 BC); however, it rapidly became the predominant method for the execution of black decoration on pottery, displacing the 'iron-reduction' technique used previously.

interpreted as indicating that the spout was inserted through the vessel wall, careful observation of the alignment and internal diameter of the spout shows that this was not the case; the spout was simply luted on to the body of the jar.

Direct visual confirmation of this interpretation was obtained by observation of the stirrup jar from Rhodes illustrated in PLATE 2 (*a*). This particular vessel is incomplete, allowing observation of the interior. PLATE 2 (*c*) shows a view of the interior of the spout hole, recorded using a video microscope. It can be seen that the tongue of clay around the hole (seen in the radiographs) is indeed continuous with the wall of the vessel; there is no indication that the spout on this particular vessel was inserted through the wall.

Handles. As with the spouts, there was no indication from the xeroradiographs that the handles on any of the vessels had been affixed by inserting them through the walls of the jars. In all cases it appeared that the handles were simply luted onto the exterior of the body (see PLATE 3 *a–b*). The only variant to simple luting is illustrated in PLATE 3 (*d*); here it can be seen that a small wedge of clay (arrowed) was added, to strengthen and perhaps improve the appearance of the joins on the finished vessel (PLATE 3 *c*). The question of whether the handles were applied in two parts (i.e. body to false neck/false neck to body, or as a single handle passing over the top of the false neck) was considered, but the radiographs did not yield a great deal of evidence. Any positive indications that were seen suggested that the handles were added as two separate straps; but this is not to suggest that handles were always made in this way.

False necks. The xeroradiographic observations revealed two distinct techniques for producing the false necks on the stirrup jars. The first apparently involved drawing up a hollow (PLATE 4 *a–b*) or semi-hollow (PLATE 4 *c–d*) false neck, which was integral with the body of the stirrup jar. No evidence was seen in the radiographs to suggest that these hollow or semi-hollow false necks had been formed separately and then luted onto the body of the vessel; in all cases they appeared to be integral with the body.

The second major variant which we have identified involves the production of a solid false neck. It can be seen from the radiograph of a vessel from Gurob (PLATE 5 *a–b*) that the solid post on this vessel was luted onto the outside of the (presumably leather-hard) jar. Examination of the radiographs suggests that in this instance the globular body was almost totally closed before the application of the false neck. In other examples (for instance vessel A 912 from Rhodes; PLATE 5 *c–d*) a rather larger hole was left, but again the false neck appears to have been luted onto the surface of the vessel. Direct observation of the interior of this vessel using the video microscope confirmed this interpretation of the radiograph.

ORIGINS OF THE JARS INFERRED FROM NEUTRON ACTIVATION ANALYSIS

The interpretation of the neutron activation analyses by principal components and cluster analysis showed that the jars could be divided into several composition groups (i.e. groups of samples with closely similar analyses) representing different sources, together with some outliers which did not fit into the groups. The broad sources have been identified by comparison with available neutron activation analyses of relevant ceramics of known origins, as discussed below. Further analyses (some already in progress) may lead to refinement of these source attributions, particularly those within the Argolid. The jars have been grouped in TABLE 2 by their inferred sources; the inferred sources are also given in TABLE 1.

Rhodian group. Four stirrup jars from Ialysos on Rhodes (A 922, 929–30, and 932) formed a composition group distinctively different from the rest of the samples. The very high proportions of chromium (mean 1138 ppm) and cobalt (77 ppm) suggest a local Rhodian origin.[36] There seem to be no other jars among those analysed that have a Rhodian origin.

Attic group. Secondly, there is an Attic composition group, which includes several jars found at Athens (A 1094–6 and probably also 1097), and also a single example from Rhodes (A 918). A characteristic feature of this group is the relatively high chromium (mean 622 ppm) and caesium (14.1 ppm) content. When compared to the Attic pottery analysed by Fillieres and others,[37] the stirrup jar group matches closely their Attic B group of mainly Protogeometric pottery,[38] and we conclude that both groups are the products of Attic workshops. However, the analyses given in TABLE 2 are the first published neutron activation analyses of Mycenaean period ceramics from an Attic workshop. It is perhaps interesting to note that they match in composition a Mycenaean ceramic model of a chair found at the temple of Aphaia on Aegina.[39]

Argolid groups. A third group of ten stirrup jars is of Argolid composition. Jars assigned to this composition group are of widespread occurrence, with examples from Mycenae (A 1054–5, and 1057), Athens (A 1085), Argos (A 1042), Rhodes (A 912, 923), Egypt (A 988), and Cyprus (C 533).[40] The jar found at Tell Gezer in Palestine (104959) also belongs to this composition group. An Argolid origin is concluded from the very close match between the composition of this group and a group of sherds from Mycenae and Berbati, analysed by Mommsen.[41] In an earlier paper Mommsen showed that Mycenaean pottery analysed by neutron activation analysis falls into two groups of slightly different composition, most probably representing two workshops in the Argolid. One workshop was probably in the region of Tiryns–Asine and the other near Mycenae–Berbati.[42] The

[36] Neutron activation analyses of Rhodian amphorae (G. Harbottle, Brookhaven National Laboratory, unpublished results) showed high levels of chromium, probably present as the mineral chromite. Other NAAs of Rhodian amphorae have also been made, although only for eight elements; chromium was not among them, but the analyses show general similarities to our analyses of Rhodian stirrup jars (K. Slusallek, A. Burmester, and Ch. Börker, 'Neutronaktivierungsanalytische Untersuchungen an gestempelten griechischen Amphorenhenkeln: erste Ergebnisse', *Berliner Beiträge zur Archäometrie*, 8 (1983), 261–76). R. E. Jones and C. B. Mee, 'Spectrographic analysis of Mycenaean pottery from Ialysos on Rhodes: results and implications, *JFA*, 8 (1978), 461–74, also found high levels of chromium in Ialysos Mycenaean III A–C pottery analysed by emission spectrometry, including stirrup jar A 532 (p. 466, table 1, no. 53), and attributed it to a Rhodian source, as NAA also indicates.

[37] D. Fillieres, G. Harbottle, and E. V. Sayre, 'Neutron activation study of figurines, pottery and workshop materials from the Athenian Agora, Greece', *JFA* 10 (1983), 55–69.

[38] They did not, however, analyse Mycenaean period ceramics. Inter-laboratory adjustment factors have been applied to bring the data of Fillieres *et al.* (n. 37), table 2, p. 61, onto the same standardization basis used by the British Museum.

[39] Hughes *et al.* (n. 31).

[40] Jones and Mee (n. 36) have found one Argolid sample out of five pieces of non-local Mycenaean pottery from Ialysos analysed, compared to 17 local. The other four non-local pieces could not be clearly attributed to origin; cf. NAA, which shows one Attic, one Argolid, and two unplaced among the non-local jars from Ialysos.

[41] Mommsen *et al.* (n. 31).

[42] H. Mommsen, E. Lewandowski, J. Weber, and C. Pozuweit, 'Neutron activation analysis of Mycenaen pottery from the Argolid: the search for reference groups', in R. M. Farquhar, R. G. V. Hancock, and L. Pavlish (eds), *Proceedings of the 26th International Archaeometry Symposium* (Toronto, 1988), 165–71. The unpublished NAAs of Aegean pottery made by I. Perlman have recently been studied by multivariate statistics (French, n. 31): S. M. A. Hoffman, V. J. Robinson, E. B. French, and R. E. Jones, 'The problem of the north-east Peloponnese and progress to its solution: effects of measurement error and element–element correlations defining ceramic reference groups', in D. Adan-Beyitz, M. Artzy, and F. Asaro (eds), *Nuclear Chemistry and its Influence on Modern Science* (forthcoming), are in broad agreement with Mommsen about the existence of a Tiryns group and a major group from Mycenae, but also suggest that the Mycenaean ceramics from Berbati and Zygouries can be distinguished chemically.

stirrup jars match very closely Mommsen's Mycenae–Berbati group.[43] It is interesting to note that a group of small stirrup jars found in the West House at Mycenae and analysed at Manchester[44] also belonged to a single Mycenae composition group (equivalent to Mommsen's), even though the jars are of completely different, although contemporary, types.

Six additional stirrup jars from Rhodes (A 916), Egypt (A 987 and 989), and Cyprus (C 524–5 and C 553) form a related Argolid composition group. The concentrations of elements in these jars match those of a group of Mycenaean sherds found at Tell el Amarna and analysed by Mommsen.[45] He noted that if the concentrations of all the elements were increased by a factor of 1.11, then these sherds would match the Mycenae–Berbati group discussed above. Mommsen concluded that the two groups share a common (Mycenae–Berbati) origin.[46] The present analyses have now shown that this second Mycenae–Berbati group is not confined to Amarna, but occurs elsewhere in Egypt and also on Cyprus and Rhodes.[47]

Cretan group. The two jars from Crete (A 716–17) have very similar analyses, matching closely the composition of Knossos pottery;[48] two further jars (C 550 from Cyprus, and possibly A 931 from Rhodes) may also be of Cretan origin.

Cypriot group. Comparison with existing analyses indicates that the two twelfth-century jars from Cyprus[49] (C 695–6) are of local Cypriot origin.

Aegina group. The single example available to us from Aegina appeared to be of local origin.[50]

The test sample. Of the five stirrup jars in the 'test sample', three (T 46.25, T 46.26, and T 222.5) match the local Tell es-Sa'idiyeh pottery in chemical composition;[51] these jars are also visually distinctive, as already noted in the introduction. The remaining jar found at Tell es-Sa'idiyeh (T 46.24) is thought to be non-local, and is tentatively identified as a Cypriot import. As already noted, the stirrup jar from Tell Gezer (104959) has been assigned to an Argolid source (Mycenae–Berbati).

[43] Our two laboratories have not formally compared their standardizations, but both have independently calibrated their in-house clay standard against Perlman and Asaro's standard pottery (I. Perlman and F. Asaro, 'Pottery analysis by neutron activation', *Archaeometry*, 11 (1969), 21–52), so the results of each on the same material should be broadly compatible. Jar A 912 from Rhodes has consistently higher concentrations of elements compared to the others, which is probably to be explained by its finer fabric (i.e. it includes fewer 'diluting inclusions'). This vessel was excluded when mean concentrations were calculated for the group.

[44] French (n. 31), 124.

[45] Mommsen *et al.* (n. 31).

[46] Mommsen also considered the possibility that the Amarna group may have given lower elemental concentrations because of experimental errors (e.g. different water content in the sherds), but this seems very unlikely now that we have also found the same phenomenon.

[47] Bieber *et al.* (n. 31) analysed pottery from Berbati by NAA and found three compositional groups, of which their group 1 has concentrations of elements about 1.1 to 1.2 times higher than group 2. These may represent the two Mycenae–Berbati groups of Mommsen. McGovern has analysed five Mycenaean stirrup jars found in the Baq'ah Valley (P. E. McGovern (ed.), n. 29). Two of the jars (BQ 1 and 2) were of LM III B date, and matched compositionally N. Peloponnesian pottery in the Brookhaven databank of NAA pottery analyses, including Bieber's Berbati groups 1 and 3. We have found that McGovern's data on jars BQ 1 and 2 are generally similar, for most elements, to the Mycenae–Berbati main group of Mommsen and ourselves. McGovern reported that the other three jars analysed completely lacked matches with the Brookhaven database, although some element characteristics supported a Greek mainland origin; none of the three matched any of our composition groups.

[48] Hoffman *et al.* (n. 42), unpublished analyses of 20 sherds from Knossos and 60 from Phaistos (which were chemically similar to those from Knossos).

[49] Jones (n. 14), 906–7; M. Artzy, I. Perlman, and F. Asaro, 'Alasiya of the Amarna letters', *JNES* 35 (1976), 171–82.

[50] Hughes *et al.* (n. 31).

[51] Analyses of local pottery from Tell es-Sa'idiyeh suggest that this may fall into two sub-groups, but this will not be discussed in detail here.

DISCUSSION AND CONCLUSIONS

CERAMIC TECHNIQUE

The xeroradiographic observations reported above have shown that the main variation in the techniques used to produce the stirrup jars included in our study lies in the ways in which the false neck was formed or affixed to the body of the pot. The observations suggest that in all cases the true spout was formed separately and luted onto the surface of the vessel, presumably at the leather-hard stage. No evidence was seen for the adding of the spout by insertion, although it was observed by both the professional potters involved in the study that insertion of the spout might offer a rapid and convenient method of application, since it would be easier to adjust the angle of the spout. Similarly, there was no indication that the handles were affixed by insertion through the walls of the jar.

Two essentially different methods (both identified independently by the modern potters) appear to have been used to produce the false necks. The first of these, in which the hollow or semi-hollow false neck was thrown as one with the body of the jar, would have been a very quick and efficient method for producing stirrup jars in a range of sizes. Practical experience suggested that the second method, in which the vessel was thrown to the base of the neck and a separately thrown solid false neck added, would also have provided a convenient method of production. The steps involved in the construction of stirrup jars using these two methods are illustrated by the series of photographs in PLATE 6.

It is interesting to observe that whilst the second method (solid false neck) would seem to be a technique developed specifically to make stirrup jars, the production of vessels with hollow, integral false necks involves the intermediate production of a recognizable ceramic form, namely a globular jar. This perhaps suggests that these two approaches to the making of stirrup jars represent something more than just casual differences of technique; rather, they may suggest a more fundamental difference in potting tradition. The notion that the potter's technique may be influenced by tradition receives independent support from investigations of ancient and modern pottery production carried out in Crete by Peter Day.[52] In particular, he suggests that patterns observed in techniques of clay mixing indicate 'culturally derived traditions of pottery making'. Taken with our results, this suggests that the technology of the stirrup jars may provide a key to recognizing the cultural background of the potter.

If we consider the radiographic observations on the three local Tell es-Sa'idiyeh vessels, it is immediately apparent that all were made with hollow false necks, using the 'modified globular jar' technique. Conversely, it is also apparent that seven of the nine jars from the Greek mainland (see TABLE 1) were made with solid false necks. These initial observations would perhaps offer some support for the notion of a link between ceramic technique and tradition or cultural background.

However, when the technology of the stirrup jars found at Tell es-Sa'idiyeh but attributed to other sources is considered, the putative linkage between technique and tradition is not so clear. When vessels from other sample groups are considered, the picture rapidly becomes even more confused; this is, of course, to some extent a result of the fact that these vessels were widely traded, so that their findspots do not necessarily

[52] P. M. Day, 'Ceramic production and distribution in late bronze age East Crete: a study by petrographic analysis', paper delivered at conference on Archaeometry, Los Angeles, March 1992 (abstract only).

reflect their places of manufacture. This problem is alleviated to some extent by the NAA data, which provide a 'control' on the origins of the vessels. While our observations do not provide an unequivocal answer to our original question concerning the identity of the potters who made the stirrup jars found at Tell es-Sa'idiyeh, it is nevertheless possible to make some tentative observations regarding the techniques used in ateliers in various locations. For instance, it can be observed that all the jars ascribed an Attic origin have solid false necks; all the jars belonging to the local Rhodes group also have solid false necks. On the other hand, both Cretan vessels and eleven of the sixteen jars assigned to the two Argolid (Mycenae–Berbati) groups were made using the hollow false neck technique.

PRODUCTION AND TRADE

While the information presented here on the technology and composition of the stirrup jars in our study has not allowed firm conclusions to be drawn regarding our initial hypothesis of a link between ceramic technique and cultural background, the NAA data provides information on the temporal and spatial distribution of the stirrup jars from the various sources, which is in itself of some interest. It can be observed that the earlier (LH III A and III B) stirrup jars found in Egypt, in Palestine, and on the islands of Rhodes and Cyprus were imported, mainly from the Mycenae–Berbati source. However, the later LH III C jars from Rhodes and Cyprus (no LH III C examples from Egypt were available to us) were all made from distinctive local clays. It is perhaps interesting to note that we have found no evidence among our, albeit limited, sample that stirrup jars manufactured on Rhodes were exported. Interestingly, one of our examples of later date from Tell es-Sa'idiyeh appears to have been imported (the NAA results suggest that this vessel may have originated on Cyprus); this perhaps suggests an avenue for future research.

The temporal and spatial distribution of the stirrup jars assigned to the Mycenae–Berbati groups is also of interest. While vessels from this area are of widespread occurrence in LH III A and III B, no examples of LH III C date from any site were assigned to this compositional group.

All this evidence would seem to suggest that prior to the period which saw the destruction of the palaces, most jars were produced on the mainland, particularly in the Mycenae–Berbati area; these jars were widely traded. In LH III C, however, production and use appear to have been predominantly local. This would seem to provide strong support for other archaeological evidence (alluded to in the introduction) which indicates a contraction in trade in response to the unsettled conditions prevailing in the eastern Mediterranean towards the end of the thirteenth century and into the twelfth century BC.

APPENDIX 1: CATALOGUE OF STIRRUP JARS IN TEST SAMPLE

T 46.24. BM WA 1986.6-23.69
Tell es-Sa'idiyeh, grave 46. LB III, 12th cent. BC. H. 10.1 cm.
J. Tubb, 'Tell es-Sa'idiyeh: preliminary report on the first three seasons of renewed excavations', *Levant*, 20 (1988), 23–88, fig. 48 *a*.

T 46.25. BM WA 1986.6-23.70
Tell es-Sa'idiyeh, grave 46. LB III, 12th cent. BC. H. 8.8 cm.
J. Tubb (ibid., fig. 48 *a*).

T 46.26. BM WA 1986.6-23.71
Tell es-Sa'idiyeh, grave 46. LB III, 12th cent. BC. H. 9.5 cm.
J. Tubb (ibid., fig. 48 *a*).

T 222.5. BM WA 1987.7-27.129
Tell es-Sa'idiyeh, grave 222. LB III, 12th cent. BC. H. 11.9 cm.
J. Tubb (ibid. 78).

104959. BM WA 1912.10-12.60
Gezer. LB II–III, 13th–12th cent. BC. H. 9.6 cm.
This piece was not from Macalister's excavations, but was purchased from villagers who had further 'investigated' the site after the completion of the official campaign in 1909.

Appendix 2: Catalogue of Stirrup Jars in Control Sample

MAINLAND

A 1042. BM GR 1912.6-26.102
Argos, Heraion. FS 171/FM 64. LH III A2. H. 8.9 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 26.

A 1054. BM GR 1905.6-10.8
Said to have been found in a tomb at Phychtia, near Mycenae. FS 180/FM 51. LH III B. H. 10.9 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 35.

A 1055. BM GR 1905.6-10.9
Said to have been found in a tomb at Phychtia, near Mycenae. FS 180/FM 42. LH III B. H. 10.2 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 29.

A 1057. BM GR 1912.6-26.30
Mycenae. FS 177/FM 18 C. LH III A2. H. 10.2 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 30. E. French, 'Late Helladic III A2 pottery from Mycenae', *BSA* 60 (1965), 161.

A 1085. BM GR 1842.7-28.833
Athens. FS 171/FM 18 C. LH III A2. H. 7.6 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 34.

A 1094. BM GR 1978.7-1.2
Probably from Athens. FS 175/FM 43 + 61 A. LH III C. H. 24.2 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 7.

A 1095. BM GR 1978.7-1.3
Probably from Athens. FS 175/FM 71 + 61. LH III C. H. 22.2 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 11.

A 1096. BM GR 1978.7-1.4
Probably from Athens. FS 175/FM 43. LH III C. H. 17.2 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 8.

A 1097. BM GR 1978.7-1.5
Probably from Athens. FS 175/FM 72. LH III C. H. 19.7 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 10.

AEGINA

A 1092. BM GR 1893.7-12.6
Aegina. FS 175/FM 71 + 43 + 42. LH III C. H. 25.4 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 9. S. Hiller, *Alt Ägina* iv. 1 (Mainz, 1975), no. 374.

RHODES

Abbreviation. Rhodes = C. Mee, *Rhodes in the Bronze Age* (Warminster, 1982)

A 912. BM GR 1870.10-8.89
Ialysos. FS 173/ FM 18 and 64. LH III B. H. 13.4 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 6. 20. Rhodes, 23.

A 916. BM GR 1872.3-15.147
Ialysos, tomb 37. FS 171/FM 19. LH III A2. H. 8.8 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 8. 19. Rhodes, 13.

A 918. BM GR 1872.3-15.145
Ialysos, tomb 35.
FS 173/FM 58. LH III B–C1. H. 14 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 8. 1. Rhodes, 13.

A 922. BM GR 1870.10-8.84
Ialysos, tomb 12. FS 176/FM 58. LH III C1. H. 8.8 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 8. 5. Rhodes, 30.

A 923. BM GR 1978.7-7.17
Ialysos, tomb 31. FS 171/FM 64. LH III A2. H. 10.8 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 7. 23. Rhodes, 13.

A 929. BM GR 1870.10-8.95
Ialysos, tomb 12. FS 176/FM 43 + 61 A. LH III C1. H. 21 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 7. 11. Rhodes, 30.

A 930. BM GR 1872. 3-15.149
Ialysos, tomb 14. FS 176/FM 51 and 61 A. LH III C1. H. 26.1 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 7. 24. Rhodes, 30.

A 931. BM GR 1870.10-8.97
Ialysos. FS 176/FM 17 and 53. LH III C1. H. 21.5 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 7. 22. Rhodes, 30.

A 932. BM GR 1870.10-8.96
Ialysos, tomb 10. FS 176/FM 21. LH III C1. H. 22.3 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 7. 16. Rhodes, 30.

CRETE

A 716. BM GR 1875.8-25.2
Crete. LM III B. H. 11.4 cm.
J. L. Benson, 'A Mycenaean vase in Toronto', *AJA* 72 (1968), 204, pl. 67.

A 717. BM GR 1875.8-25.1
Crete. LM III B. H. 11.4 cm.

CYPRUS

Abbreviation. Excavations in Cyprus = A. S. Murray, A. H. Smith, and H. B. Walters, *Excavations in Cyprus* (London, 1900).

C 524. BM GR 1897.4-1.940
Enkomi, tomb 45. FS 171/FM 19. LH III A2. H. 10.9 cm.
Excavations in Cyprus, 45, fig. 71, no. 940. *CVA* GB, BM i. 2 C (*b*) (1925), pl. 2. 4.

C 525. BM GR 1897.4-1.941
Enkomi. FS171/FM19. LH III A2. H. 9.2 cm.
Excavations in Cyprus, 45, fig. 71, no. 941. *CVA* GB, BM i. 2 C (*b*) (1925), pl. 2. 1.

C 533. BM GR 1897.4-1.1160
Enkomi, tomb 83. FS 171/FS 18 C. LH III A2. H. 8.9 cm.
Excavations in Cyprus, 35, fig. 63, no. 1160. *CVA* GB, BM i. 2 C (*b*) (1925), pl. 2. 2.

C 550. BM GR 1897.4-1.969
Enkomi. FS 180/FM 44. LH III B. H. 10.9 cm.
Excavations in Cyprus, 48, fig. 73, no. 969. *CVA* GB, BM i. 2 C (*b*) (1925), pl. 3. 30.

C 553. BM GR 1897.4-1.1012
Enkomi. FS 181. LH III B. H. 9.5 cm.
Excavations in Cyprus, 35, fig. 63, no. 1012. *CVA* GB, BM i. 2 C (*b*) (1925), pl. 3. 36.

C 695. BM GR 1899.12-29.17
Palaipaphos. Cypriot, 12th cent. H. 11.4 cm.
CVA GB, BM i. 2 C (*e*) (1925), pl. 1. 11.

C 696. BM GR 1899.12-29.18
Palaipaphos. Cypriot, 12th cent. H. 12 cm.
CVA GB, BM i. 2 C (*e*) (1925), pl. 1. 19.

CARIA (ASSARLIK)

A 1101. BM GR 1887.5-2.86
Caria (Assarlik), tomb O. FS 177/FM 43. LH III C. H. 14.6 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 11. 5. W. Paton, 'Excavations in Caria', *JHS* 8 (1887), 66.

EGYPT

A 984. BM GR 1890.11-7.1
Gurob. FS 173/FM 64. LH III B. H. 11.4 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 20. W. M. F. Petrie, *Illahun, Kahun and Gurob, 1889–90* (London, 1891), 17, pl. 17. 3.

A 987. BM GR 1912.2-5.293
Gurob, tomb 23. FS 171. LH III B. H. 12 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 17. W. M. F. Petrie, *Kahun, Gurob and Hawara* (London, 1890), 39, 42, 45, pl. 28. 1.

A 988. BM GR 1912.2-5.292
Gurob. FS 180. LH III B. H. 8.9 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 21. W. M. F. Petrie, *Illahun, Kahun and Gurob, 1889–90* (London, 1891), 19, pl. 20. 7.

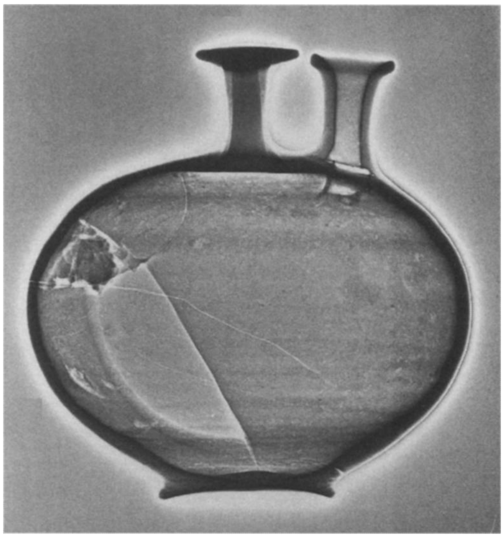
A 989. BM GR 1912.2-5.294
Gurob. FS 183. LH III B. H. 8.3 cm.
CVA GB, BM i. 3 (*a*) (1925), pl. 10. 15.

BM GR 1957.7-2.7
Egypt. FS 171. LH III B. H. 9.5 cm.

University of Arizona A. LEONARD
British Museum M. HUGHES
British Museum A. MIDDLETON
British Museum L. SCHOFIELD

A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
Western (head) end of grave 46 at Tell es-Sa'idiyeh, showing one of the stirrup jars from this study together with other grave-goods.

(a)

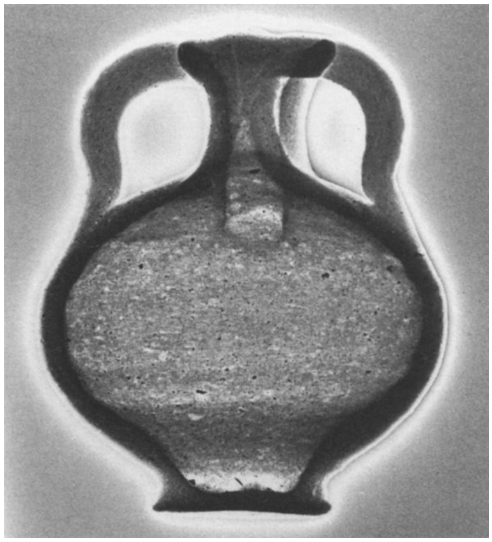


(b)

(c)

A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
(*a*) Stirrup jar A 912, from cemetery at Ialysos, Rhodes. (*b*) Xeroradiograph of jar A 912, showing method of affixing spout. (*c*) Photomicrograph taken using videomicroscope of interior of jar A 912 in region of spout hole.

(a)



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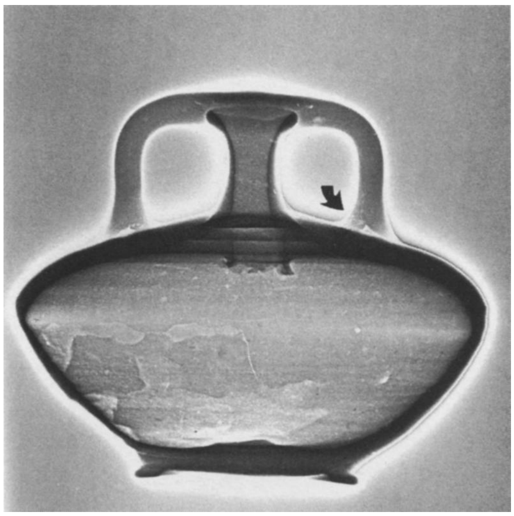
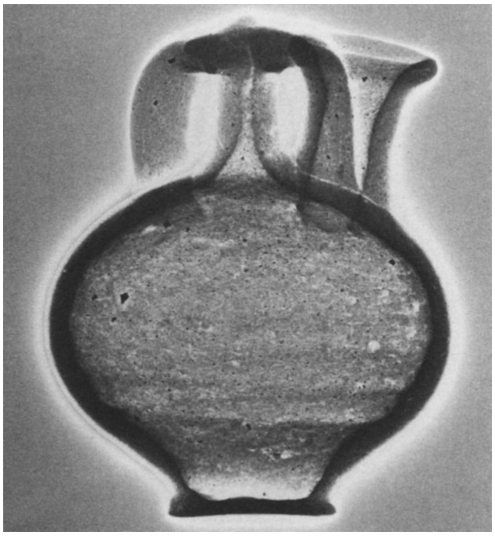
(c)



(d)

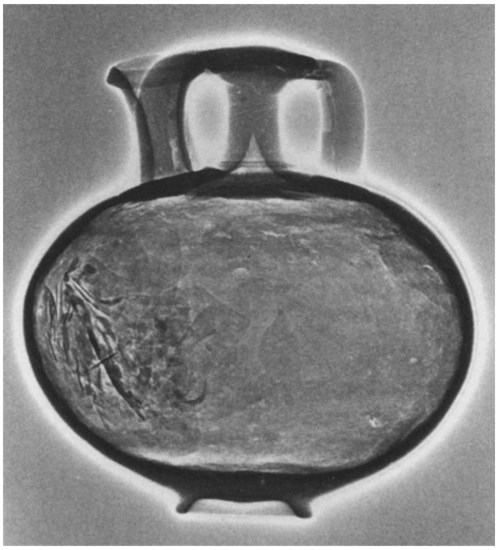
A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
(*a*) Stirrup jar T 46.25, from Tell es-Sa'idiyeh. (*b*) Xeroradiograph showing method of affixing handles. (*c*) Stirrup jar A 1054, said to be from tomb at Phychtia near Mycenae. (*d*) Xeroradiograph of jar, showing method of affixing handles.

(a)



(b)

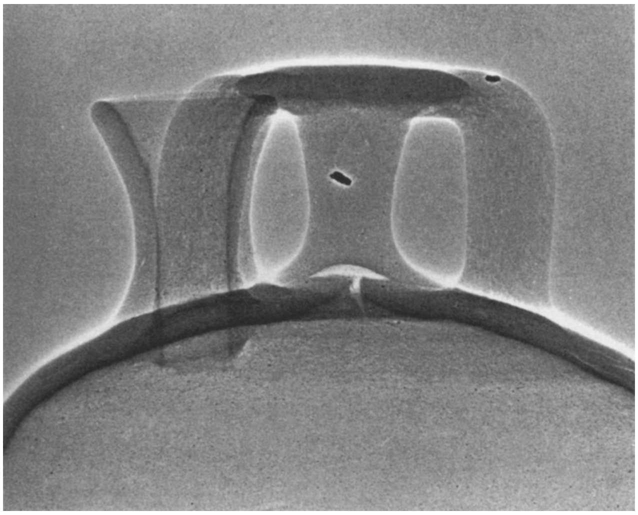
(c)



(d)

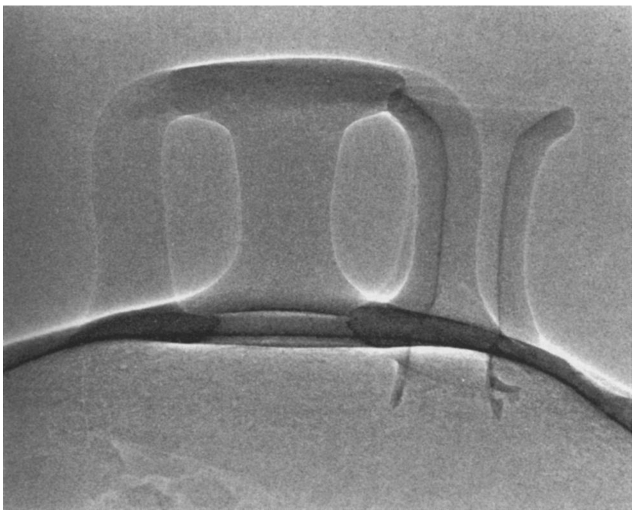
A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
(*a*) Stirrup jar T 46.26, from Tell es-Sa'idiyeh. (*b*) Xeroradiograph showing hollow false neck. (*c*) Stirrup jar A 923, from cemetery at Ialysos, Rhodes. (*d*) Xeroradiograph showing 'semi-hollow' false neck.

(a)



(b)

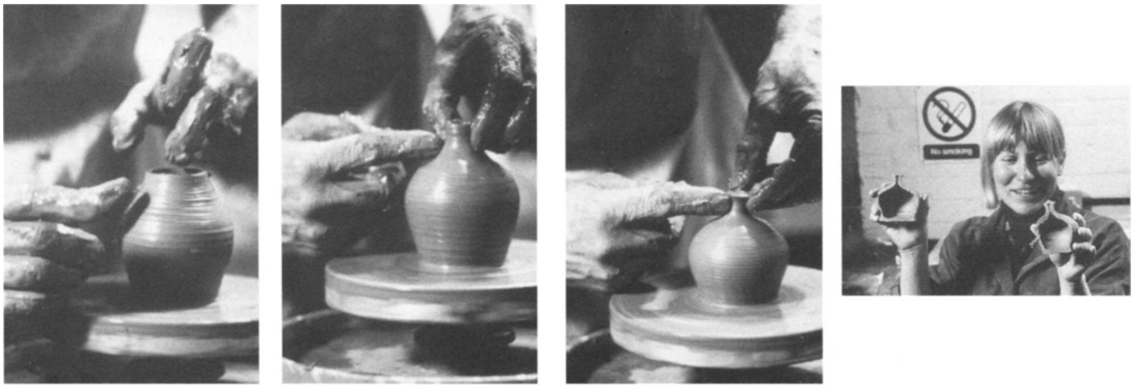
(c)



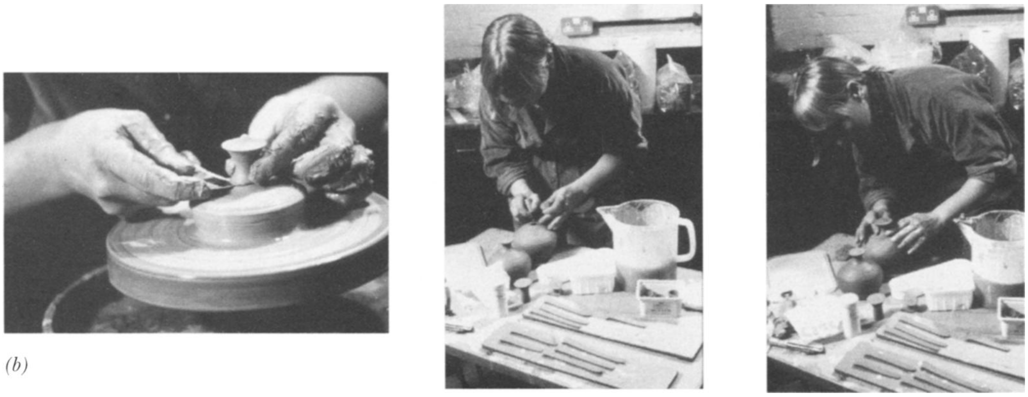
(d)

A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
(*a*) Stirrup jar A 984, from Gurob, Egypt. (*b*) Xeroradiograph showing solid false neck. (*c*) Stirrup jar A 912, from cemetery at Ialysos, Rhodes. (*d*) Xeroradiograph showing solid false neck.

PLATE 6

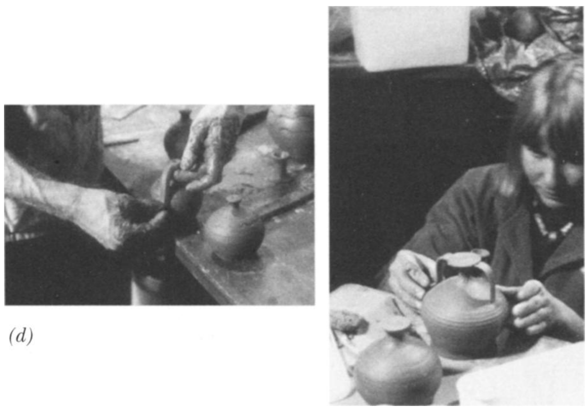


(a)



(b)

(c)



(d)

A. LEONARD *ET AL.*
THE MAKING OF AEGEAN STIRRUP JARS
Stages in manufacture of stirrup jars with hollow and solid false necks, as inferred from radiographic observations and executed by J. Leach and V. Newman. (*a*) Throwing body with hollow false neck. (*b*) Throwing solid false neck and adding it to body of vessel. (*c*) Adding pre-thrown (hollow) true spout to body. (*d*) Adding strap handles and disc to body.