GEOPHYSICAL AND SURFACE SURVEYS IN THE BYZANTINE FORTRESS AT ISTHMIA 1985–1986

(Plates 73–78)

In 1985 and 1986, the University of California–Los Angeles and The Ohio State University excavations at Isthmia conducted geophysical and surface surveys in the Early Byzantine Fortress (Fig. 1).[1] The purpose of this work was to gather evidence concerning the configuration of features in the Fortress in order to assess the level of cultural activity at Isthmia in Late Antiquity and the Mediaeval period. The present investigation makes use of surface survey more intensively than is usual in the Mediterranean area: most surveys have a regional focus, while our work applied survey techniques to the interior of a single site.[2] Geophysical prospecting, by contrast, has been applied sparingly and with varying success in the Aegean;[3] our particular contribution is the intensity of the investigation and the application of several survey techniques, each of which can compensate for the limitations of the other methods.

The work in the Fortress is one phase of the ongoing investigation of Isthmia. Although efforts at the site have concentrated on locating and exposing the various parts of the classical Sanctuary, examination of the Byzantine remains has been more extensive than at most other major sites in Greece. The earlier work, however, was undertaken to address

[1] The project operated under a permit granted by the Greek Archaeological Service, with the Sixth Byzantine Ephoreia as the supervising agency in the field. The work was conducted under the auspices of the American School of Classical Studies at Athens and received generous support from The Ohio State University, which provided financial assistance for the field work and computer facilities for analysis. Professor Ralph von Frese, Department of Geology and Mineralogy, Ohio State University, provided the magnetometer and electrical resistivity meter, and Professor Stavros Papamarinopoulos, Department of Geophysics, University of Patras, furnished the soil resistance meter. James Foradas conducted the self-potential survey and has graciously consented to the publication of some of the results in this context. Students from Ohio State University (1985 and 1986) and Kenyon College (1985) served as field crews. Special thanks go to Peter Cole, Mette Korsholm, A. Charles Mastran, Caroline Seymour, and Marianne Urse. The Media Center at Youngstown State University drafted or photographed all the figures except Figure 1.

Works frequently cited are abbreviated as follows:

Gregory = T. E. Gregory, *Isthmia*, V, *The Hexamilion and Fortress*, Princeton, in preparation

Pringle = D. Pringle, *The Defence of Byzantine Africa from Justinian to the Arab Conquest*, BAR International Series 99, Oxford 1981

Webster = G. Webster, *The Roman Imperial Army of the First and Second Centuries A.D.*, 3rd ed., London 1985

[2] For a good discussion of regional survey in Greece, see T. H. van Andel and C. N. Runnels, *Beyond the Acropolis*, Stanford 1987.

[3] D. G. Lyness and B. A. Hobbs, "A Magnetic Survey of the Roussolakhos Site, Palaikastro," *BSA* 79, 1984, pp. 149–155; S. Papamarinopoulos, G. N. Tsokas, and H. Williams, "Magnetic and Electrical Measurements on the Island of Lesbos and the Detection of Buried Ancient Relics," *Geoexploration* 23, 1985, pp. 483–490; H. Williams, "Investigations at Mytilene and Stymphalos, 1983," *Classical Views* 28, 1984, pp. 169–186.

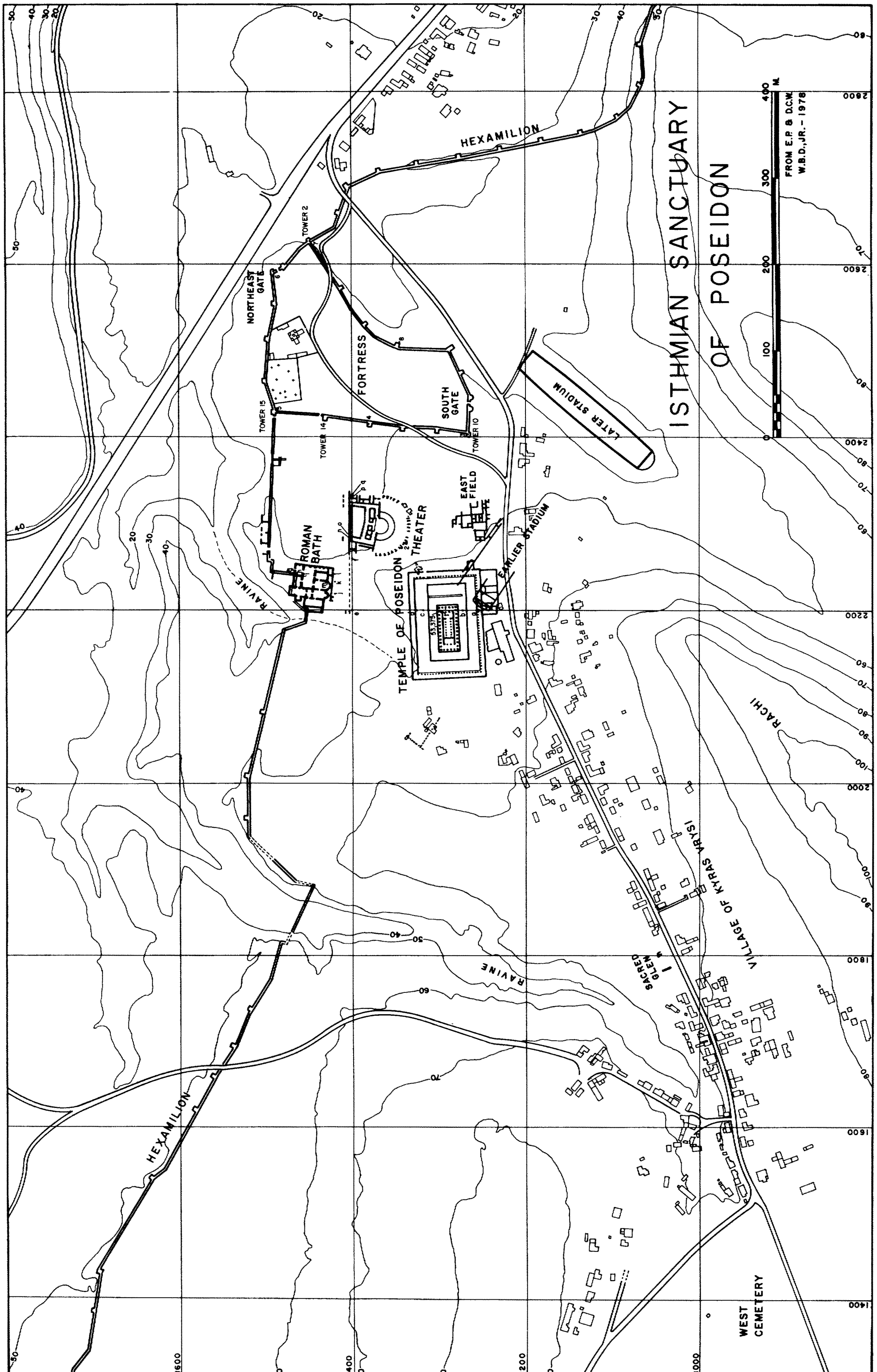

FIG. 1. Site Plan of the Isthmian Sanctuary of Poseidon

only a few particular questions about Mediaeval occupation at the site, such as the date of the fortifications. The results of the present examination provide the foundation for dealing with problems at both site-specific and general levels. The site-specific questions concern changes in site usage through time. At the general level Isthmia can serve as a barometer to gauge the degree to which urban institutions survived the end of antiquity.

Systematic archaeological investigation of the Isthmian Fortress began with Paul Monceaux's excavation of the Northeast Gate in 1883.[4] This and other early efforts were attempts to uncover the classical Sanctuary and were based on the mistaken assumption that the Fortress wall was the ancient temenos. Monceaux exposed the Gate down to its marble pavement, correctly identified the arch as Roman in date, and assigned the flanking towers to the 3rd century after Christ. In 1903, E. Staïs of the Greek Archaeological Service excavated a series of trial trenches in the interior of the Fortress to evaluate Monceaux's claims that no ancient (i.e., pre-Roman) buildings existed in the enclosure. Staïs found a total of nine Byzantine structures and one ancient foundation of indeterminate function.[5] Fowler's description of Isthmia in his survey of Corinthian sites perpetuated the misidentification of the Fortress as the classical peribolos.[6] Jenkins and Megaw of the British School finally rectified this error.[7] In 1931 and 1932 they dug a series of exploratory trenches and as a result assigned all sections of the fortifications (Hexamilion and Fortress), with the exception of the arch, to the 6th century after Christ. Several house foundations *ca.* 10 meters west of Fortress Tower 5 indicated occupation in the Early Roman period on the unfortified slope; Jenkins and Megaw concluded that Byzantine military engineers brought in fill to level the ground in the eastern half of the enclosure and buried these structures under four meters of overburden.

Oscar Broneer initiated long-term excavation at Isthmia in 1952.[8] Although most of his work focused on the Sanctuary proper, Broneer did excavate the South Gate, Towers 6 and 8, and along portions of the exterior Fortress wall.[9] Paul Clement extended this investigation; he cleared the Northeast Gate and explored in and around Towers 2, 10, 14, and 15.[10] Clement provided conclusive proof that the Fortress and Hexamilion date to the early 5th century after Christ.[11] The present report adds to and integrates much of the prior work at the site.

[4] P. Monceaux, "Fouilles et recherches archéologiques au sanctuaire des jeux isthmiques," *GazArch* 9, 1884, pp. 273–285 and 354–363; *idem*, "Fouilles et recherches archéologiques au sanctuaire des jeux isthmiques," *GazArch* 10, 1885, pp. 205–214 and 402–412.

[5] E. Staïs, «*Ἀνασκαφαὶ ἐν Ἰσθμίᾳ*», *Πρακτικά* 1903, pp. 14–17.

[6] H. N. Fowler and R. Stillwell, *Corinth*, I, [i], *Introduction, Topography, Architecture*, Cambridge, Mass. 1932, pp. 60–67.

[7] R. J. H. Jenkins and A. H. S. Megaw, "Researches at Isthmia," *BSA* 32, 1931–1932, pp. 68–89.

[8] O. Broneer, "Isthmia Excavations, 1952," *Hesperia* 22, 1953, pp. 182–195.

[9] O. Broneer, "Excavations at Isthmia, Third Campaign, 1955–1956," *Hesperia* 27, 1958, pp. 1–37; *idem*, "Excavations at Isthmia, Fourth Campaign, 1957–1958," *Hesperia* 28, 1959, pp. 298–343.

[10] P. A. Clement, "Isthmia 1967," *Δελτ* 23, 1968, B′ 1, *Χρονικά* [1969], pp. 137–143; *idem*, "Isthmia Excavations 1969," *Δελτ* 25, 1970, B′ 1, *Χρονικά* [1972], pp. 161–167.

[11] P. A. Clement, "The Date of the Hexamilion," in *Essays in Memory of Basil Laourdas*, Thessaloniki 1975, pp. 159–164.

TABLE 1. Area covered by geophysical techniques in the Fortress

Method	m^2
Magnetometry: 1985 and 1986	14,700
Electrical resistivity: 1985	5,632
Soil resistance: 1985	1,120
Self-potential: 1986	60

Today the interior of the Fortress can be divided into three zones, from north to south. The northernmost zone is occupied by the modern cemetery of the village of Kyras Vrysi and the church of St. John Prodromos; with the exceptions noted below, this zone is unavailable for archaeological study. The middle zone of the Fortress is covered with brush and is presently disused and unplowed; the surface of the ground is hard packed. The southernmost zone is covered with rows of olive trees; the area is frequently plowed and the soil is normally loose (Pl. 73:a, c). The entire surface of the interior is strewn with rubble, loose mortar, and other archaeological material, which are the remains of buildings and activity within the Fortress. Fragments of walls, most of them oriented along the cardinal axes, are visible at several points, especially in the southern zone, but they nowhere allow reconstruction of an entire building (Fig. 2, Pls. 73:b, d, e, 77:a).

FIELD METHODS AND ANALYTICAL PROCEDURES

Field work was conducted at Isthmia for a total of six weeks in the spring and summer of 1985 and seven weeks in the summer of 1986. A grid, with datum (0,0) at a benchmark on the northwest corner of Tower 5, was established inside the Fortress using a transit and metric tapes; wooden stakes marked grid points at 10-meter intervals. Tapes stretched between the stakes provided station locations for the geophysical and surface collection surveys. The station interval was 1 meter for magnetic and soil-resistance readings and 2 meters for electrical resistivity readings; all readings were taken in large square or rectangular sections or areas. The self-potential survey covered six 10-meter lines with readings at every meter. Magnetometry was carried out in both seasons, the electrical techniques only in 1985, and the self-potential survey only in 1986. Table 1 indicates the coverage of each method. Magnetic readings were stored temporarily in the memory of the magnetometer and transferred to a personal computer at the end of the survey of each area. All readings were also recorded by hand on special forms as a safeguard, as were records of all other geophysical field data.

A surface collection preceded the geophysical work in both field seasons. In each season the total area available for surface collection was *ca.* 21,000 sq.m. (2.1 ha.). This constitutes 77.5 percent of the total area of 2.71 ha. (27,000 sq.m.) enclosed by the circuit walls. A systematic sampling procedure was employed in which a series of 1-sq.m. units was marked out at 10-meter and 5-meter intervals in 1985 and 1986, respectively. Within each sampling

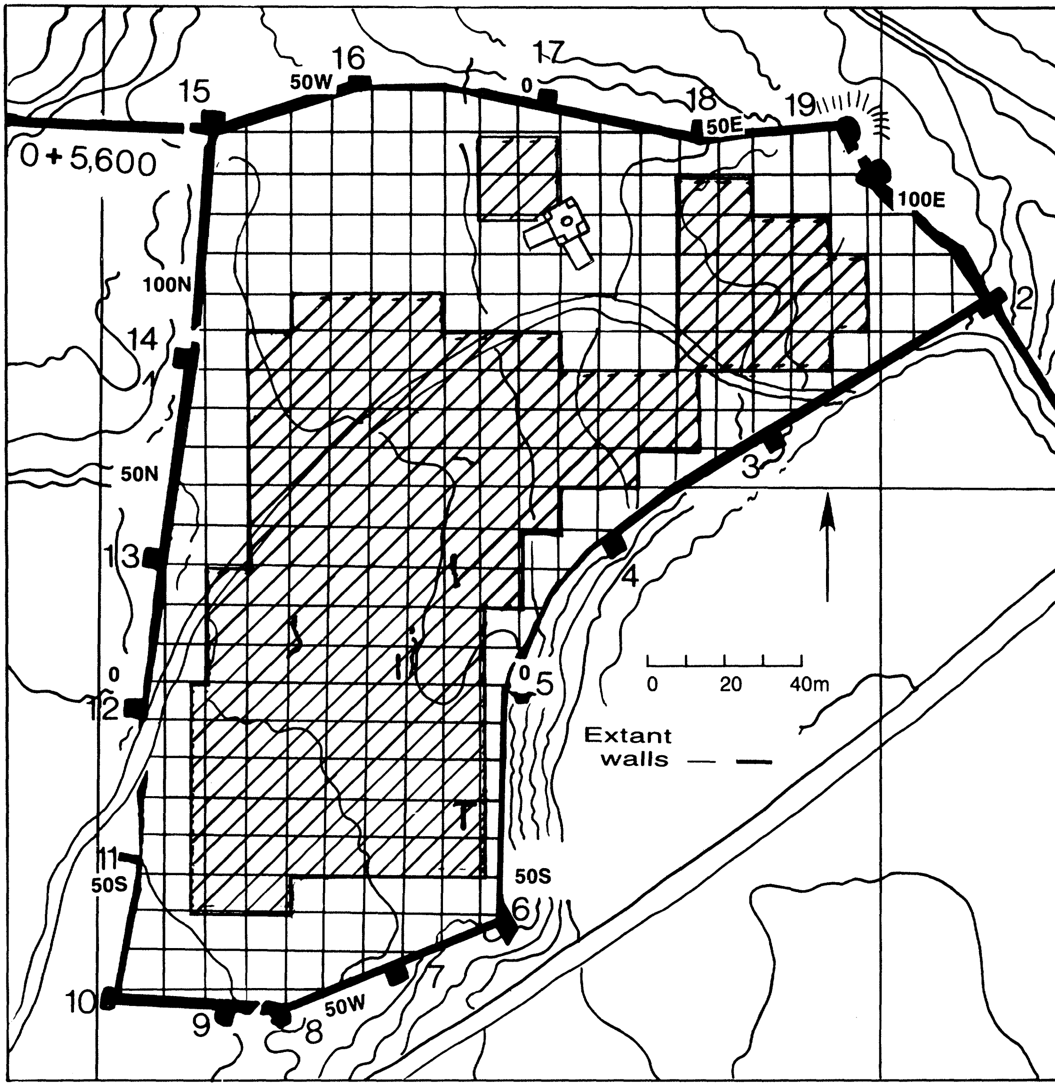

FIG. 2. Plan of the Fortress showing area covered by magnetometry in 1985 and 1986

square (a total of 391 in 1985 and 725 in 1986), all artifacts were collected, counted, and recorded according to categories within each material type. For example, for ceramic materials we made distinctions between bricks, roof tiles, loom weights, ceramic beehives, and pottery. The pottery was further divided into fine and coarse wares and assigned approximate dates when possible. Only the pottery lent itself to such detailed classification. The subdivision of other ceramics remained necessarily at a relatively gross level, and this was generally true of other categories of material. Stone could be subdivided into building material and ground and flaked lithics, with only the few decorative architectural members affording any relatively secure date. Because of the more exhaustive nature of the 1986 surface collection, it will be the subject of detailed analysis.[12]

GEOPHYSICAL SURVEYS

Geophysical methods used in the Fortress include magnetometry, electrical resistivity, soil resistance, and self-potential.[13] The purpose of using these techniques was to obtain information about the size, configuration, and orientation of subsurface features. Cultural features create disruptions or anomalies in natural electrical and magnetic fields. The various instruments we employed are capable of detecting such anomalies and provide powerful tools for assessing the nature of the remains without excavation.[14] The use of different methods permitted an assessment of the efficacy of each in the examination of a structurally complex site. In addition, each procedure has its own limitations; the use of several in the same area would help to overcome the constraints of any single method.

Magnetic prospecting was the most extensively applied of the four geophysical techniques, covering an area of 14,700 sq.m. inside the Fortress (54.2 percent of the interior area of 2.71 ha.; see Fig. 2), 58 sq.m. near the Roman Bath, and 300 sq.m. at the eastern terminus of the Hexamilion (Pl. 75:b). Only the work in the Fortress provided positive results. Metal in a sprinkler system distorted readings in the field east of the Roman Bath, and the overburden on the Hexamilion is probably too thick to be penetrated by our near-surface approach. The primary targets in the Fortress were buried stone walls, the limestone of which provides a significant magnetic contrast with the ferruginous soil matrix. Readings were taken every meter in a series of 36 adjoining grids. To monitor the diurnal fluctuation in the local magnetic field, the operator returned to a base station every 20 to 30 minutes and recorded three readings that were used to reduce, or standardize, the data.

[12] Analysis of the geophysical and surface-collection data was facilitated by a variety of computer programs. Magnetic maps were plotted using the MAGPAC software provided by Geometrics, Inc. and the PLTCON FORTRAN program devised by Professor Ralph von Frese. The latter program also served to plot electrical readings. Artifact distributions were plotted by hand on maps of the Fortress and then shown as contours using the PLTCON program and TOPO (Golden Software), and in a three-dimensional representation by SURF2 (Golden Software); the TOPO and SURF2 maps are not included in this report. MAGPAC, TOPO, and SURF2 all operated on IBM or IBM-compatible personal computers. STATVIEW, a statistical program for Macintosh personal computers, provided profiles and regression analysis of the self-potential data. The IBM mainframe computer and Versatec printer at Ohio State University produced the PLTCON contour maps.

[13] The geophysical principles behind the various methods and the basic field procedures are described in M. Aitken, *Physics and Archaeology*, Oxford 1974; W. M. Telford, *Applied Geophysics*, New York 1976; M. S. Tite, *Methods of Physical Examination in Archaeology*, London 1972; J. Weymouth, "Geophysical Methods of Archaeological Site Surveying," in *Advances in Archaeological Method and Theory* IX, M. Schiffer, ed., New York 1986, pp. 311–395; J. C. Wynn and S. I. Sherwood, "The Self Potential (SP) Method: An Inexpensive Reconnaissance Archaeological Mapping Tool," *JFA* 11, 1984, pp. 195–204.

See Glossary, pp. 510–511.

[14] For the magnetic survey, we used a Geometrics G-856 Proton Free Precession Magnetometer with a storage capacity of 1225 readings. A Strata Scout R-40 Resistivity Meter and a Bradphys MK 4 Earth Resistance Meter provided electrical resistivity and soil-resistance measurements, respectively. Self-potential readings were taken with a Radio Shack Volt Meter attached by electrical wire to copper terminals in porous pots cast from plaster of Paris and a solution of copper sulfate poured into plastic cylinders.

Plate 74 presents a dot-density image of the total geomagnetic intensity for all areas surveyed within the Fortress. Regional field strength is 45,000 nT. Darker areas on the image represent higher readings, while lighter areas with lower readings indicate walls and other anomalies. Those anomalies that are the result of modern construction (asphalt road, power lines, churchyard) are designated. The most uniform readings come from a stretch of 70 meters along the southwest and west-central part of the site and may provide the best example of the natural magnetic field within the Fortress because of the lack of subsurface features; these sectors can act as a baseline against which to assess the magnitude of anomalies in the east-central and southeast sectors. In general, the interior of the Fortress presents a very complex magnetic picture because of the amount of cultural activity, past and present.

There are, however, five anomalies of clear archaeological significance. These anomalies are interpreted as walls on the basis of 1) a drop in magnetic-field strength due to contrast with the surrounding soil matrix; 2) orientation along the cardinal directions, on which the Fortress as a whole seems to have been laid out; 3) rectilinear shape; and 4) alignment with visible wall fragments.

Magnetic Anomaly 1 is a composite of smaller linear anomalies clustered together in the southeast corner of the site where there are visible walls of large ashlar blocks (Pls. 73:b, e, 74). The magnetic data indicate that the east–west portion of the T-shaped extant wall extends some 20 meters to the west and that a parallel wall of approximately the same length lies 18 meters to the south. Other linear features between these two long anomalies suggest crosswalls that divided the structure into small rooms. These linear features do not exhibit consistently straight edges; the image probably reflects structural collapse with blocks scattered unevenly along both sides of the wall, or there may have been some deflection of the magnetic signal by the considerable amount of surface rubble. The combined evidence of visible walls and magnetic data indicates the presence of at least three and probably four east–west walls and two or three north–south crosswalls. This configuration reveals six small compartments (identified by Roman numerals in Plate 75:a). The size of Anomaly 1 and the arrangement of compartments within it suggest that the structure is the remains of a barracks. In their studies of military camps, Webster and Pringle[15] both present archaeological evidence that the living quarters of soldiers in Roman and Byzantine fortresses were large structures subdivided into a number of small rooms. Room I in Anomaly 1 may be a corridor, and each of the remaining rooms, the sleeping quarters of a mess unit or *contubernium*. In North African Byzantine forts, barracks were often two stories tall; the men slept on the upper floor, and the ground level was used for storing supplies or as stables. The barracks at Isthmia may also have been of the two-story variety, although the evidence is uncertain.

Magnetic Anomaly 2 is a large (21 meters northeast–southwest by 10 meters northwest–southeast), cigar-shaped, dipole anomaly in the east-central part of the Fortress (Pl. 74). The magnitude of the readings indicates either a large deposit of iron or a substantial thermoremanent feature. Since the feature lacks the characteristic hexagonal shape of many iron anomalies, it is tentatively identified as thermoremanent in origin, probably a

[15] Pringle, p. 86; Webster, pp. 184–195.

forge or kiln. The material evidence for either a forge or kiln is sparse. We recorded some ceramic wasters and slag debris during the surface collection, but this material is not concentrated near Anomaly 2. Circumstantial evidence suggests the likelihood of a forge: a facility could provide crucial armaments and metal tools for a military installation. The odd, elongated shape of the anomaly may reflect the presence of metal spill or a casting floor, rather than the furnace proper.

Just to the east of the probable forge is a large square anomaly (Anomaly 3) measuring 6 meters on a side (Pl. 74). Von Frese and Noble[16] assert that monopole anomalies exhibiting radially symmetric amplitudes are often indicative of wells or deep pits. Anomaly 3 (radially symmetric, but a dipole rather than a monopole) may have a direct functional association with Anomaly 2: the feature may be a cistern to store water for the adjacent forge and the manufacturing activity associated with it. The dipolarity of the anomaly would be accounted for if such a cistern had been filled with metal debris at some point. An alternative explanation is that this anomaly is simply an extension of the one to the west (Anomaly 2). The problem is difficult to resolve.

The fourth major magnetic anomaly signals a large rectangular feature located near Tower 4, to the northeast of Anomalies 2 and 3 (Pl. 74). This large dipole anomaly measures 4 meters north–south and 6 meters east–west, narrowing somewhat to the west. The magnitude of the dipole contrast indicates a significant thermoremanent anomaly, although not so large or intense as Anomaly 2. Its more regular shape and its magnitude suggest a metallic source, oriented on an east–west axis. The precise nature of this source cannot be determined but would bear investigation should excavation be undertaken within the Fortress.

Magnetic Anomaly 5 is a low-intensity, linear dipole *ca.* 3 meters long; it runs north–south just north of a large wall lying south of the road in the west-central part of the Fortress (Pl. 74). The preserved wall has a facing of large ashlar blocks and a cemented-rubble interior; it is identical in construction to the circuit walls of the Fortress and thus suggestive of a similar date (*ca.* A.D. 410–420). A narrow band of higher readings, indicating a gap of some sort, separates Anomaly 5 from the wall proper; the hiatus may reflect a door or a robbed section of wall. There are no anomalies that clearly indicate crosswalls, even though on the south end of the extant wall a corner and part of a return are visible. Several meters to the north of Anomaly 5 there is an area of low readings, but these are not tightly defined and may be due to the proximity of electrical power lines that disrupted the magnetic signal. The size of the wall and associated anomaly and the fine masonry technique reflect the presence of a well-constructed monumental building. Its central location suggests that it may have been part of the praetorium complex.

The most numerous magnetic anomalies are small but intense dipoles scattered throughout the interior of the Fortress. Such anomalies with large amplitudes and distinct geometries tend to characterize thermoremanent sources such as baked clay or iron objects.

[16] R. von Frese and V. Noble, "Magnetometry for Archaeological Exploration of Historical Sites," *Historical Archaeology* 18, 1984, p. 42. Monopole anomalies have single peaks that represent high readings, while dipoles have twin peaks.

The most likely interpretation of these small anomalies in the Fortress is as either concentrations of ceramics or iron artifacts. Examination of Plate 74 reveals that the distribution of these anomalies is not random. There are few in the southeast and east-central part of the site where the major structural anomalies are found. There are five such anomalies along the western edge of the site south of the paved road, four in the field immediately south of the church enclosure, and another four in the northeast sector. These anomalies may represent iron artifacts or clusters of ceramics, perhaps roof tiles, that were discarded by Fortress residents or that accumulated from the collapse of tiled roofs. If these objects are pre-modern iron tools, the distribution suggests use or discard throughout the site and indicates that loci of similar activity occurred throughout the Fortress.

The PLTCON program provided an enhanced image of the 1985 magnetic-survey data. The image is more precise than that of the dot-density map because outlines of anomalies can be approximated more accurately. Plate 76 represents an area of 4,700 sq.m. in the east-central and southeastern parts of the Fortress (northwest corner at 40N-60W, southeast corner at 50S-10W). With this map, the key anomalies discussed above can be viewed in greater detail, and amplitudes (range in nT from highest to lowest readings associated with an anomaly) can be readily determined. Structural anomalies can be identified as elongated clusters of contour lines. Small dipoles appear as pentagons, with the apex of the anomaly indicating the orientation of the target in the ground. Anomaly 1 in the southeast corner has an amplitude of 8 nT, the suspected forge (Anomaly 2) over 1700 nT, Anomaly 3 east of the kiln 80 nT, and some of the iron or ceramic features 12–20 nT. Only this area was mapped with such contours, because the surrounding sections lack the major cultural anomalies that benefit from this type of enhancement.

Magnetometry proved to be a viable technique at the Isthmian Fortress. There are problems with interpreting the small anomalies because of the amount of debris on the surface and the uncertainty as to how this material affected readings in some areas. Major subsurface features are easily detected, however, when they are not deeply buried. The method is especially valuable in tracing the extent of structures that are partially visible on the surface.

Investigation by electrical resistivity was confined to the Fortress and conducted during part of the 1985 field season. Equipment failure limited the area examined to 5,632 sq.m. (20.8 percent of the Fortress; see Fig. 3), and subsequent work was not feasible. Nonetheless, the sections surveyed form an important sample from the site; only the north-central and northeast areas received no coverage. The data have been plotted as a contour map using the PLTCON program and the Versatec Printer (Fig. 4).

The use of the Wenner array with an a-spacing of 2 meters between the electrical probes allowed the signal to penetrate *ca.* 3 meters into the ground. Excavation by Jenkins and Megaw indicated that the depth to bedrock is *ca.* 1.5–2 m. in the western part of the Fortress but increases to as much as 4.5 m. in the far part of the eastern section owing to filling and leveling operations by the Byzantine military engineers. Therefore, the readings do not reflect the full depth of cultural materials in the east-central part of the Fortress. Enlarging the a-spacing would have provided greater depth penetration, but at the expense of signal clarity.

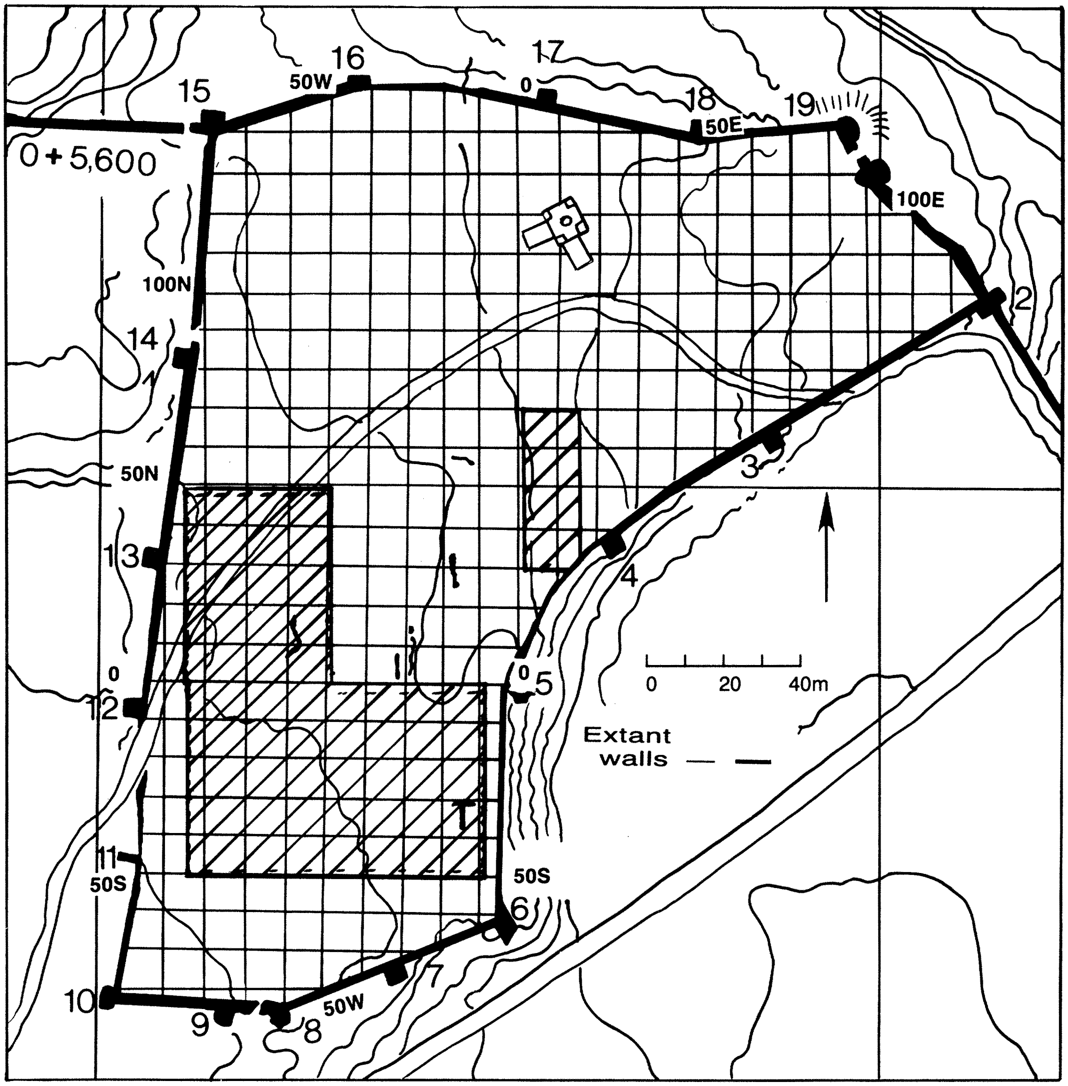

FIG. 3. Areas covered by electrical resistivity survey in the Fortress in 1985

Major targets for this electrical survey were walls and other large structural elements. Such features inhibit the flow of electrical current through the ground and are thus indicated by high resistivity values. Since the current is assumed to pass through a homogeneous natural layer, most disturbances in current flow can be attributed to projecting areas of bedrock or to cultural features.

Figure 4 is a contour map of apparent resistivity values plotted at a contour interval of 50 ohm-meters. The large blank area in the upper right was not surveyed because of equipment failure. The three straight lines that neatly outline this section on the west and south result from an edge effect and do not reflect real anomalies. The most prominent anomalies

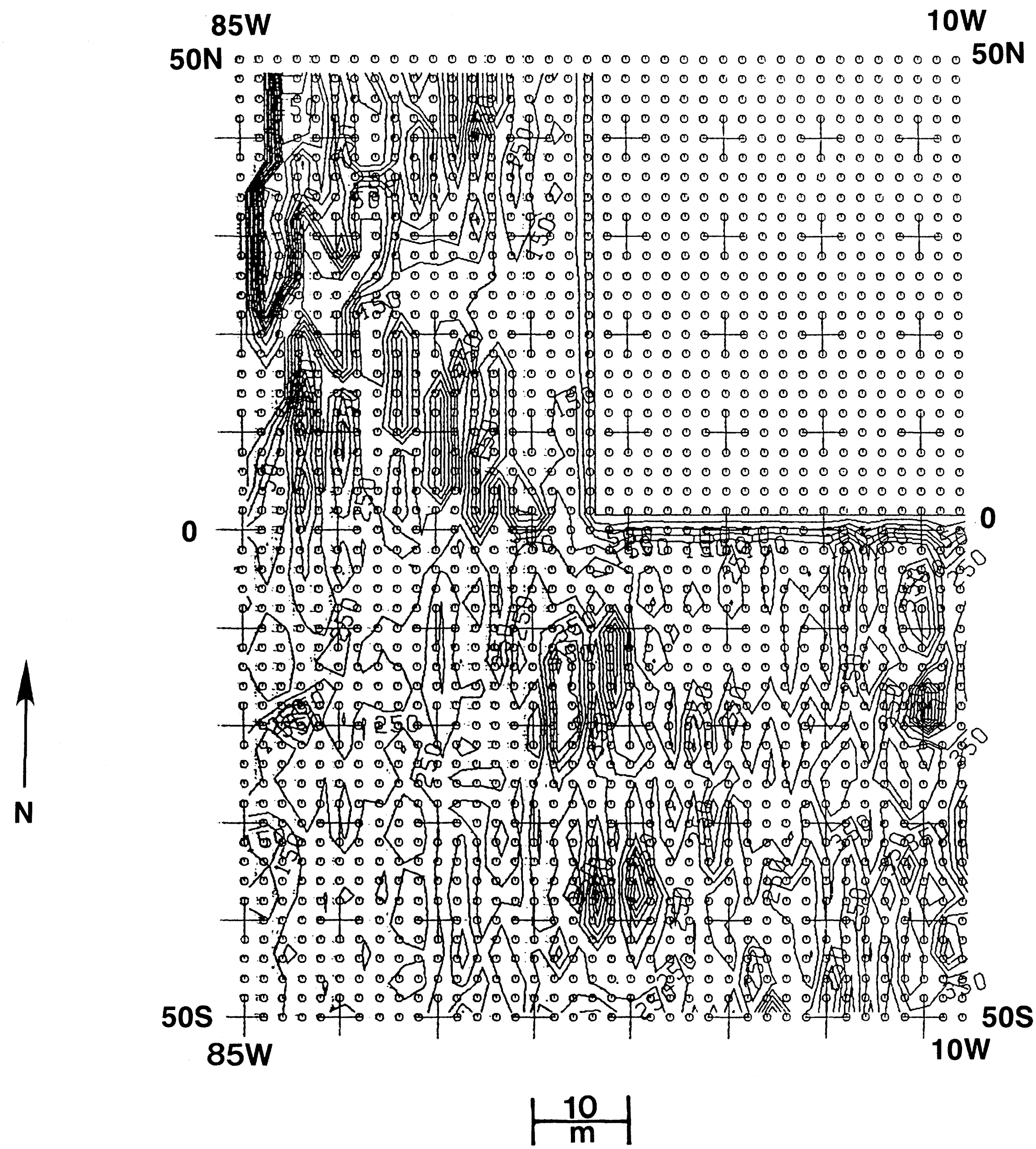

FIG. 4. Contour map of electrical resistivity readings in the Fortress, 1985. Contour interval = 50 ohm-meters

are a series of linear features, trending north–south, that are concentrated in the south-central and northwest sections of the image. These anomalies are intermediate in strength, ranging in magnitude from 150 to 500 ohm-meters, and are from 8 to 20 meters in length. Although it is tempting to view them as indicating a series of walls, they may also be caused by the considerable stone rubble on the ground surface. This explanation, however, does not account for the lack of such anomalies in the southwest sector, where the quantity of stone rubble is approximately the same as elsewhere. Furthermore, the amount of rock in the northwest section is no greater than in other areas, yet it has most of these anomalies. The most prudent course in analyzing these data is to consider only those anomalies with the highest values as candidates for cultural features. In their examination of a Mediaeval fortress at Mytilene, Papamarinopoulos and his collaborators considered values of 200–400 ohm-meters as moderate to high.[17] Adopting 250 ohm-meters as a cutoff point eliminates all the anomalies except for two in the central part of the image and one along the northwest edge. These anomalies are identified as walls. The last coincides generally with magnetic Anomaly 5. The two anomalies in the center of the image are located in an area with an extremely heavy concentration of stone rubble that may represent structural collapse; they may pinpoint a subsurface alignment of the original wall from which this rubble derived. Another possibility is that the anomalies in the center of the image are the result of electrical current being channeled into linear shapes by the abundance of surface debris, but even if this is the case, the amount and direction of the rubble can be used to argue for the presence of a substantial wall.

Two other anomalies of interest are located in the southeast section of Figure 4. Both follow a sinuous east–west course. The more southern includes the section of visible foundations noted near magnetic Anomaly 1. The electrical anomaly is 25 to 30 meters long (including the visible part of the wall) and provides some corroborating evidence for the magnetic data. The other anomaly, 10 meters to the north, parallels the first, but there is no evidence of any feature such as a crosswall connecting them. At the western end, however, each of these long anomalies abuts on one of the north–south electrical features, creating right angles opening in opposite directions, like the exterior corners of buildings that face each other across an intervening space. If these anomalies do indeed represent different structures, there would be two large buildings in close proximity to one another, perhaps forming a complex, e.g., two barracks, or a barracks and a storehouse.

By following the outlines of these U-shaped anomalies, the size of the suggested structures can be estimated. The east–west anomalies are 35 to 40 meters long. Making allowances for collapsed walls and scattering of debris, a conservative estimate for the length of these walls is 30 meters. The anomalies trending north–south that define the width of these structures are 22 meters long for the southern structure and 18 meters for the northern, but neither has a complete width since no corner is indicated; a compromise figure of 20 meters for the width of each structure seems reasonable. The thickness of the walls was probably under 1 meter.

The southeastern part of the Fortress was also scanned with a soil resistance meter, which in its turn detected a series of large anomalies (Fig. 5). In Figure 6 a linear feature is clearly visible running east–west across the entire 20-meter breadth of the survey area. This

[17] Papamarinopoulos *et al.* (footnote 3 above).

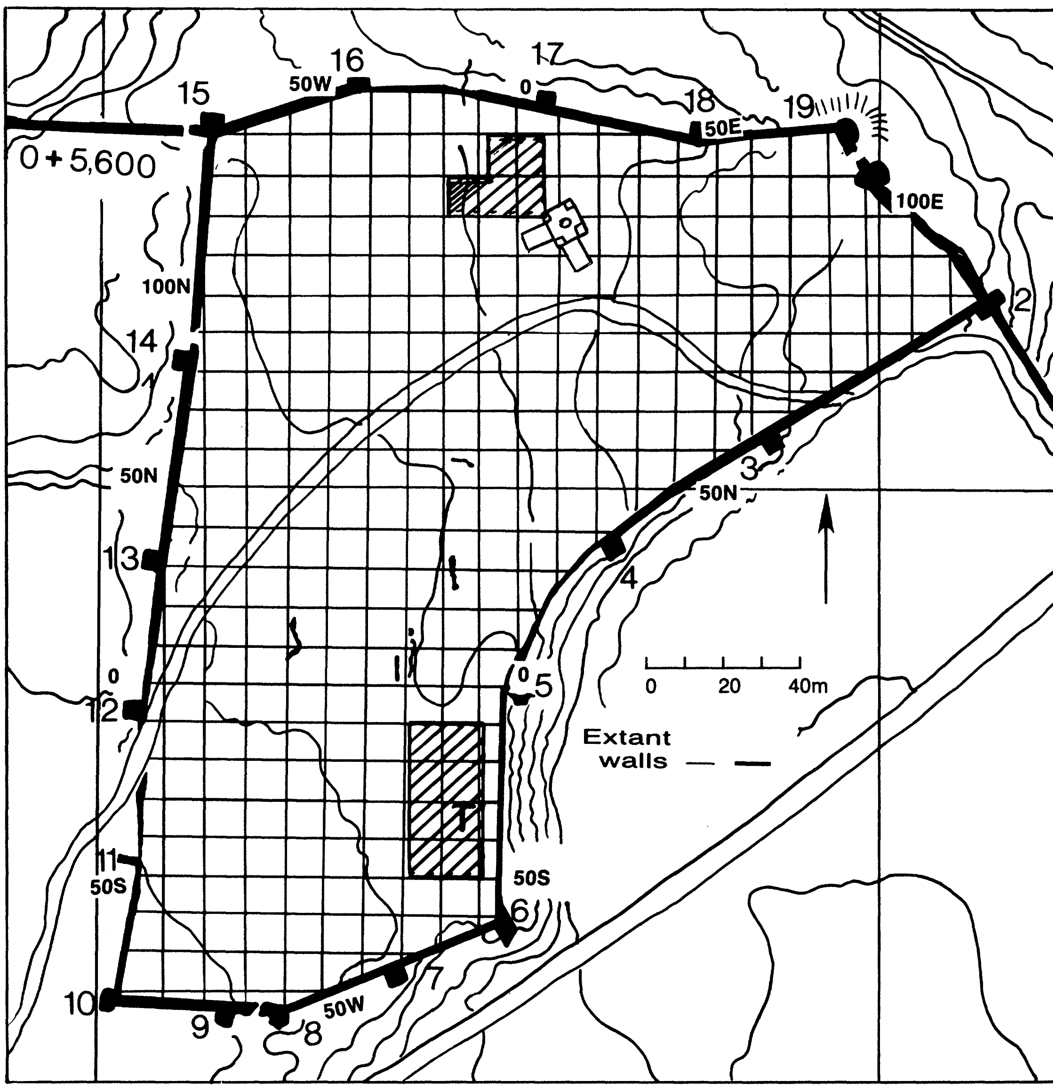

FIG. 5. Areas covered by electrical resistance survey in the Fortress in 1985

corresponds to the extant wall and its presumed subterranean extension detected by magnetics and resistivity. To the south of and perpendicular to this feature at least two anomalies indicate possible crosswalls. Two other similar north–south anomalies are evident to the north of the wall. All these anomalies have amplitudes in a range from 310 to 410 ohms. The dark lines indicating a strictly linear anomaly along the northwest edge of the survey unit reflect a section where no readings registered and not a cultural feature.

The anomalies detected by the two electrical meters in this sector correspond rather closely. The major exception is the one east–west anomaly along the 20S line noted in the

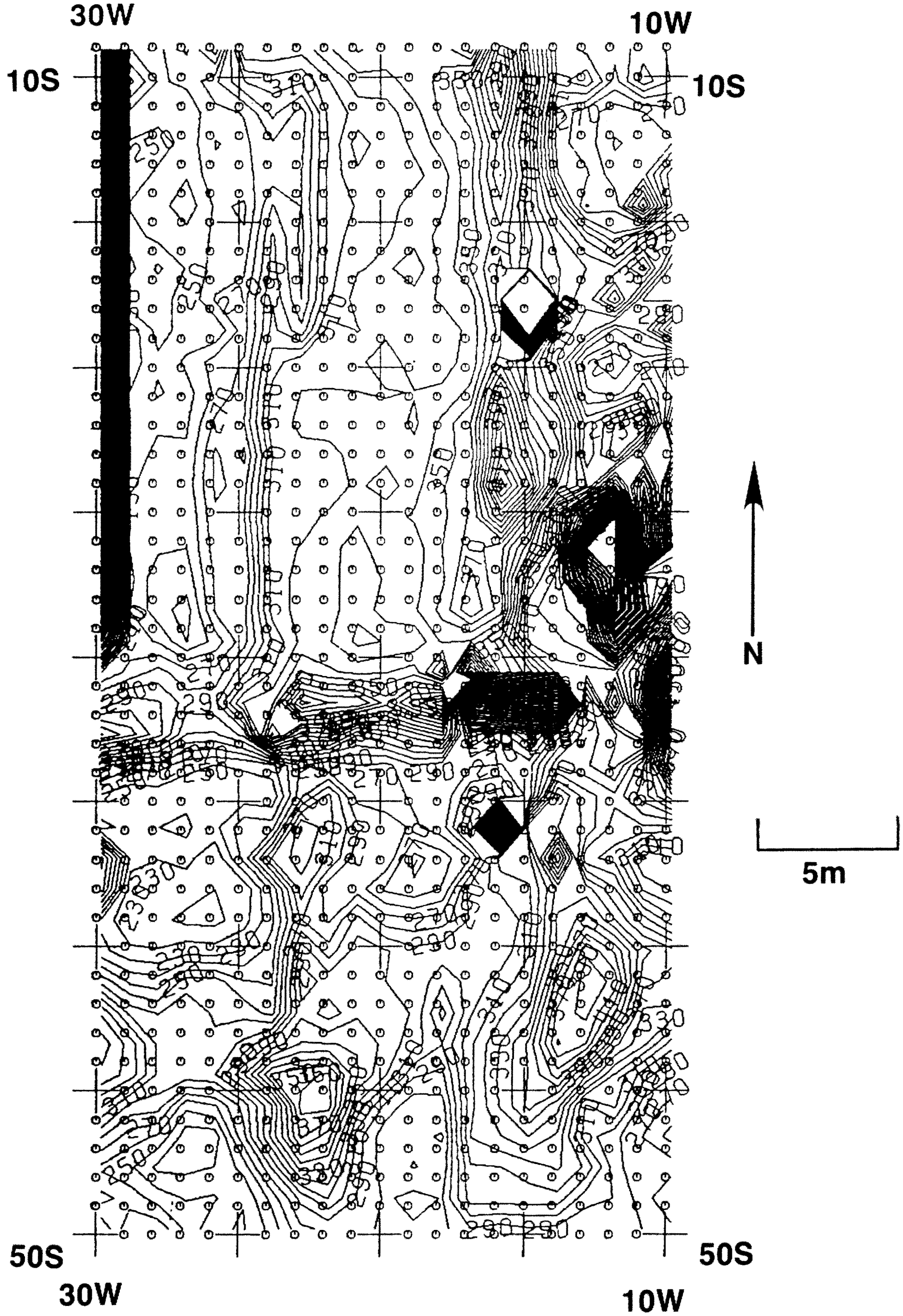

FIG. 6. Contour plot of electrical resistance readings, 1985. Contour intervals = 50 ohms

resistivity survey. No such anomaly was recorded by the soil resistance meter. There is undoubtedly one large structure in this southwest corner, but it is not clear whether the walls to the north indicated by large anomalies are part of the same building or not.

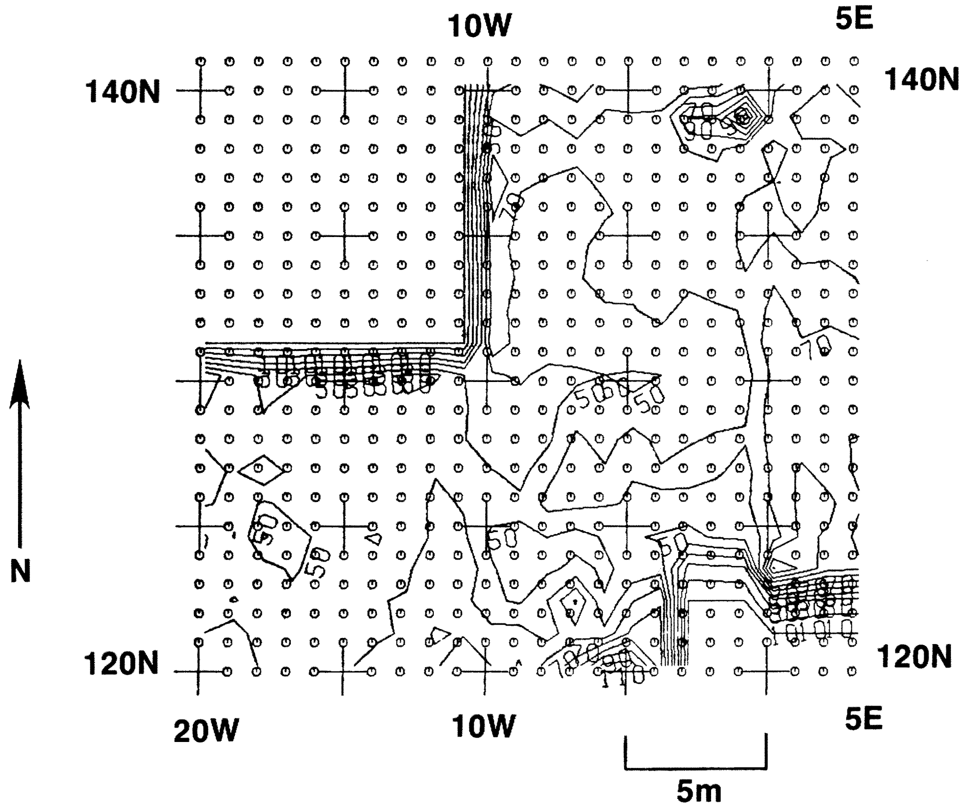

FIG. 7. Contour plot of electrical resistance readings in the churchyard. Contour interval = 50 ohms

The examination of the churchyard revealed no significant anomalies in electrical resistance (Fig. 7). The consistently low readings indicate a non-resistant medium free of large stones. The soil in this area is highly compacted, probably from recent activity within the compound. The area has been leveled by heavy machinery as can be seen by an island of raised soil left around a tree near the interior face of the Hexamilion. This activity may have removed evidence of earlier buildings and thus constitutes a continuation of site formation process; that is, it is cultural activity subsequent to the deposition of the material of interest to the archaeologist.

The self-potential method has only recently been applied to archaeological problems, and so our effort was conceived as a further test of its viability. For this reason, the transects ran across known targets (visible stone foundations) to evaluate how well the technique detects large features (Fig. 8). Thus no new information about sub-surface structures at the site was expected or obtained.

The readings from the self-potential survey have been plotted as profiles. Figures 9 and 10 present the profiles derived from data in the southeast part of the site. Examination of these profiles reveals considerable fluctuation in the readings but no discernible pattern that can be identified as a characteristic signature for the stone walls. This situation points out

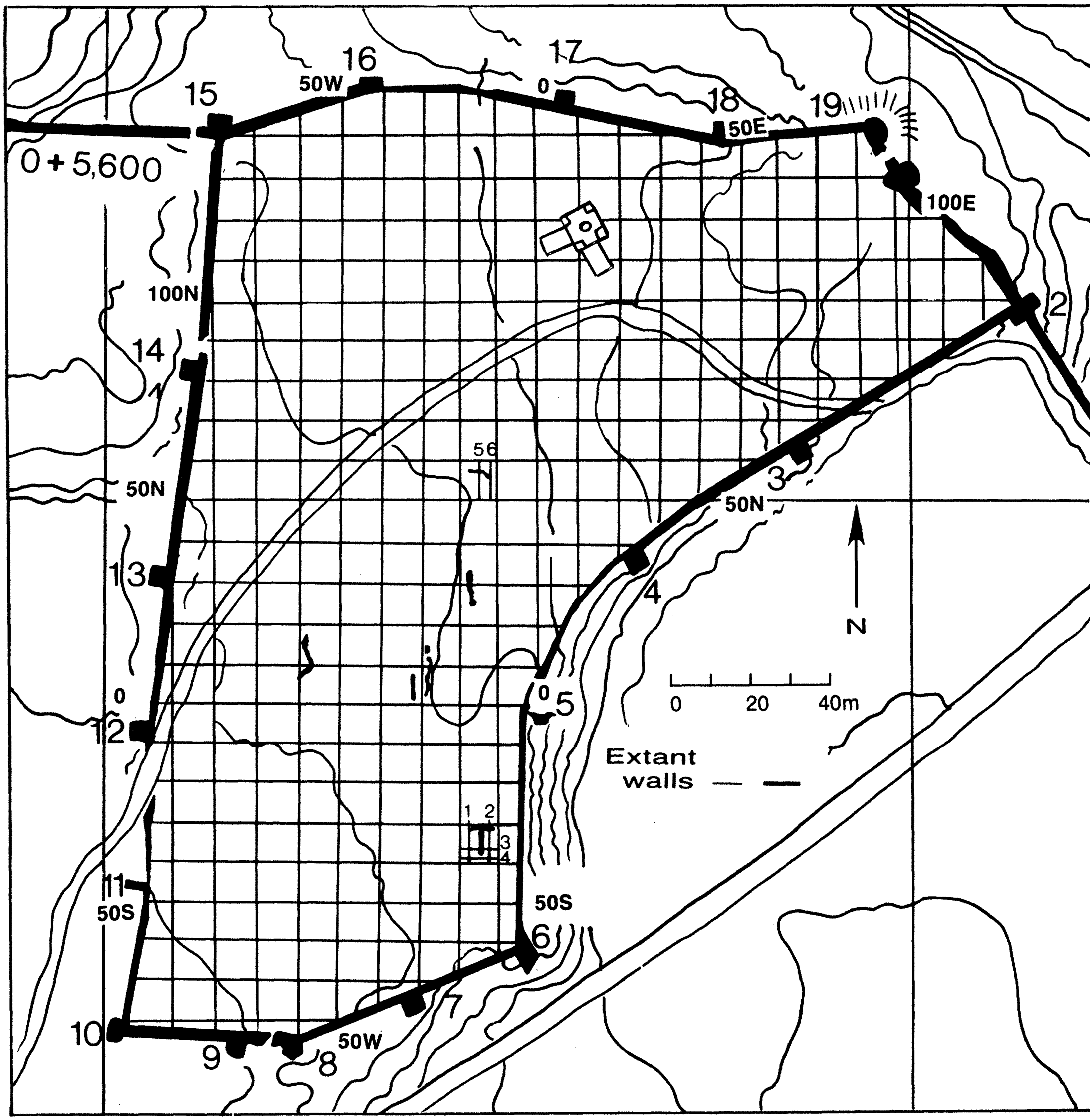

FIG. 8. Location of self-potential profiles in the Fortress in 1986

one of the key problems with the method. Although it is evident that the earth generates natural electrical currents, it is extremely difficult to discriminate among the various sources from which these signals emanate.[18] The lack of recognizable patterns in the profiles shows what a complex property the self-potential phenomenon is. There is no easy way to determine what impact cultural features have on the complex patterns of natural current.

The profiles from the central area of the site exhibit the same lack of patterning (Figs. 11 and 12). As a further test of the method in this area, Line 5 was surveyed three

[18] Telford (footnote 13 above), p. 458.

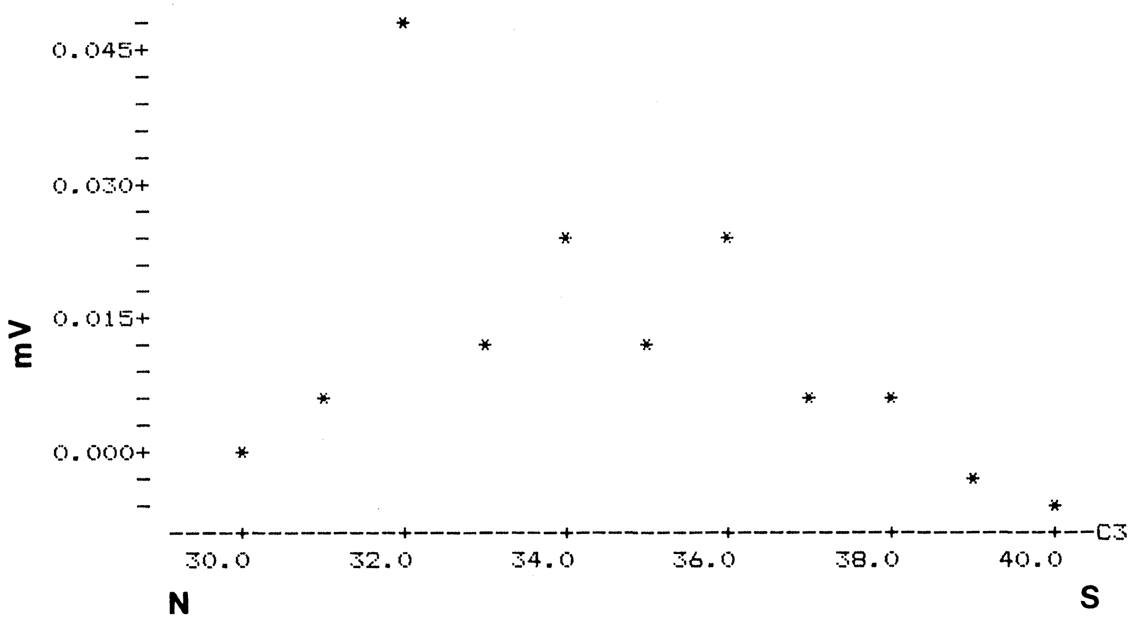

FIG. 9. Self-potential of Line 1

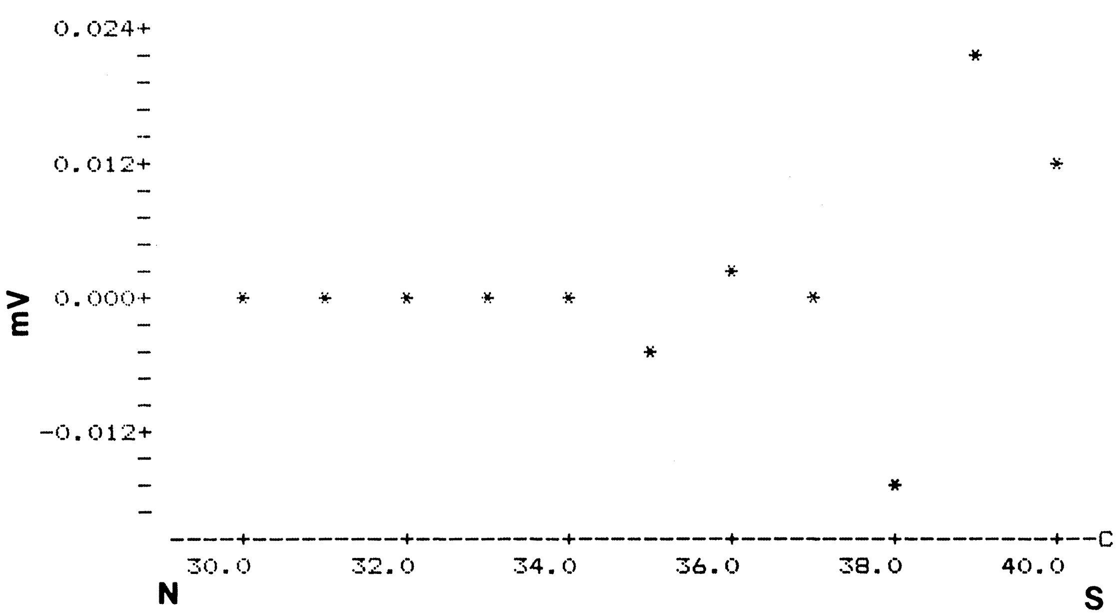

FIG. 10. Self-potential of Line 2

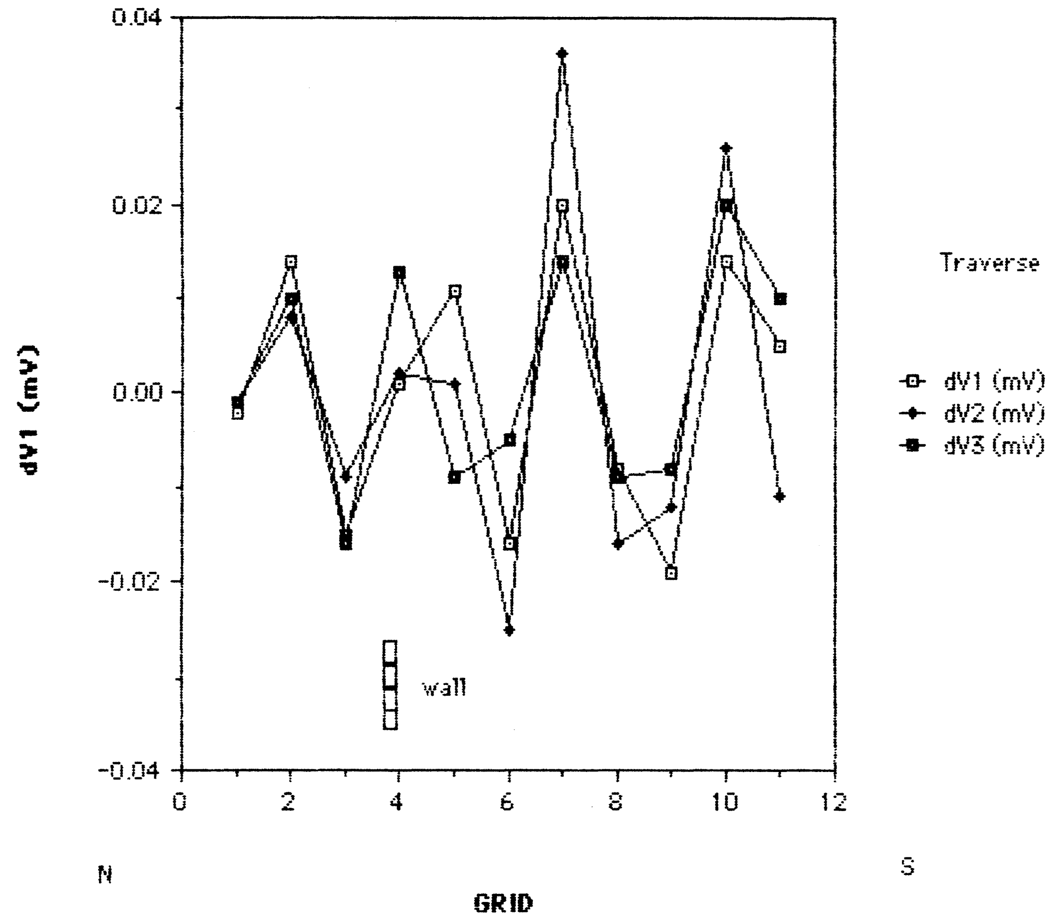

FIG. 11. Self-potential profile of Line 5 showing 3 sets of readings for test of replicability

times to check on the replicability of results. Obviously, if readings are not consistent in one area over time, interpretation is further complicated. The three sets of readings were compared on scattergram plots: Figure 13 compares the first and third sets, which have a very low correlation of 0.34; the second and third sets have a correlation factor of 0.417 (Fig. 14). These results suggest that the self-potential method is not reliably replicable, at least in this area of the site. Further tests of this sort should be conducted, however, before the technique is completely dismissed by archaeologists. In light of the availability of other geophysical techniques of proven utility, the self-potential method does not provide an appropriate option in terms of efficient use of field time or results.

SURFACE COLLECTION SURVEY

Artifact density on the surface has customarily been used as an indicator of subsurface concentrations of cultural material and as a demarcator of activity foci within sites. Some

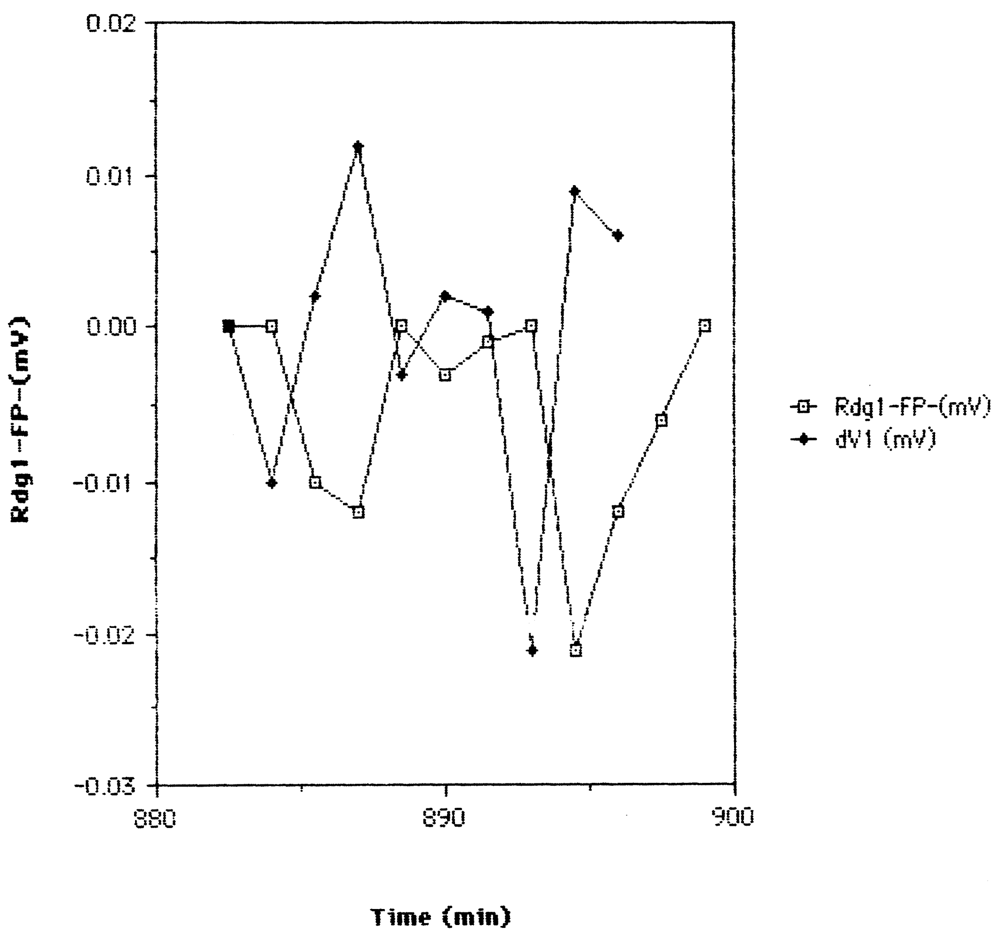

FIG. 12. Self-potential of Line 6

empirical substantiation for this intuitive assumption has been provided by Redman and Watson, who demonstrated that the horizontal spatial attributes of artifacts on the ground are rather well correlated with the distribution of artifact clusters and features beneath the surface.[19] There are three key attributes of surface artifacts. The *absolute frequency* (total raw count) of the different artifacts by category may suggest the relative importance of the activities associated with those items. The *ubiquity* of various artifacts measures the degree of areal spread over the site and may be an index of generalized as opposed to specialized function. *Artifact density* refers to the degree of concentration of material at particular loci and can be a measure of the intensity of activity over space.

The various permutations and intensity levels of these attributes are tied to certain basic assumptions about the relative significance of the artifacts. Those objects that exhibit high

[19] C. L. Redman and P. J. Watson, "Systematic Intensive Surface Collection," *American Antiquity* 35, 1970, pp. 279–291.

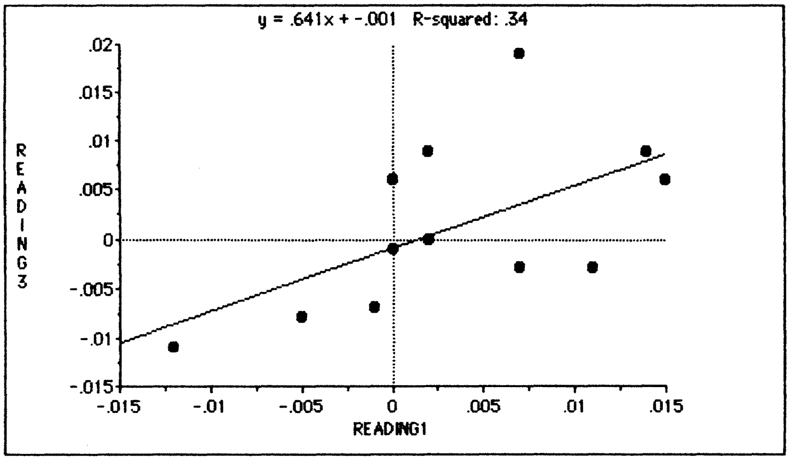

FIG. 13. Linear regression comparison of first and third sets of self-potential readings for Line 5. Correlation coefficient (r2 = 0.34) is very low

frequency, high ubiquity, and high density would represent the largest and in many ways the most important categories, since they dominate the inventory; this combination can also reflect the most mundane, utilitarian types. A combination of low frequency and low ubiquity could express one of several extremes. 1) If it is prosaic material, a low level of use might be indicated, due to insignificant contribution to the total lifestyle of site occupants; alternatively, such circumstances may reflect a temporal problem, with low frequency perhaps indicating earlier deposits of which only a small portion find their way to the surface. 2) If it is finer material, perhaps this distribution represents an unequal low-level spread owing to its scarcity, suggesting privileged access and hierarchical distinctions among occupants of the site. 3) It may also be the result of limited occupation of the site in certain periods.

In addition to such basic assumptions, a series of second-order behavioral correlates can be derived from the various combinations. For example, a high frequency, high density, low ubiquity distribution may indicate locations of specialized activity. Categories exhibiting high frequency and high ubiquity (most notably roof tiles) reflect the most common material elements and undifferentiated activity, at least in a general sense (e.g., widespread distribution of roof tiles at a high frequency suggests a number of roofed structures throughout the Fortress but does not necessarily reveal the functions of such buildings).

A complicating factor that undoubtedly affects the nature of the surface-artifact assemblage at Isthmia is the use of fill from elsewhere at the Sanctuary to level the ground at the eastern edge of the Fortress at the time the latter was constructed. This activity introduced a set of intrusive artifacts with no direct link to the functioning Fortress. It constitutes an important formation process that will be considered both in its own right and in terms of how it affects the interpretation of the results from the surface survey.

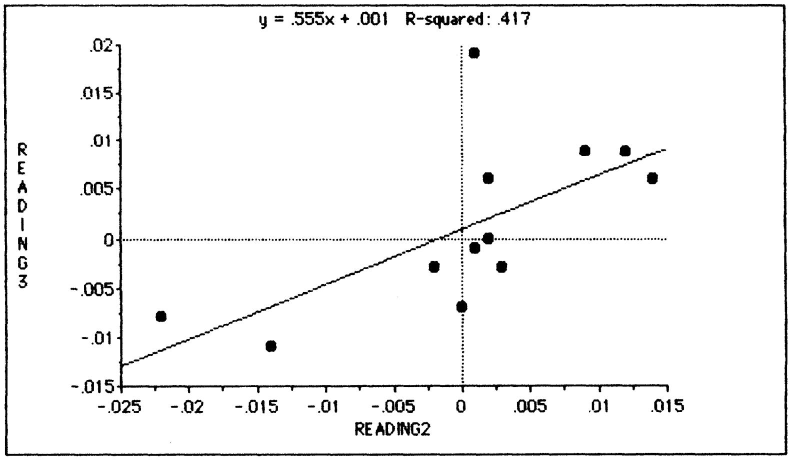

FIG. 14. Linear regression comparison of second and third sets of self-potential readings for Line 5. Correlation coefficient ($r2 = 0.417$) is again low and suggests the two sets of readings are independent, i.e., results are not repeatable

One of the problems in interpreting the archaeological record is the need to draw behavioral or dynamic implications from a static set of remains.[20] It is therefore critical to understand how the record came to have its present form, i.e., to comprehend the nature of site-formation processes. A range of diverse factors creates the artifact distribution on the ground noted by field workers during surface collections. Michael Schiffer was one of the first archaeologists systematically to discuss use and discard behavior, which he called c- (for cultural) transforms, and the impact of such activities on the nature of the material record.[21] Other important activities that should leave characteristic indications are production and transport. For example, if production occurs on the site, more than one element of the manufacturing sequence should be evident, including raw materials, transforming agents (e.g., manufacturing tools, fuels, workshops), and intermediate and finished products. If no production facilities can be distinguished, importation of finished or semi-finished products is implied, with all the attendant activities of physical transfer and exchange.

A sequence of events, including production, importation, use, discard, re-use, loss, and abandonment, influences the character of the archaeological record, both its contents and the distribution of those objects. Although this sequence is commonly considered in horizontal terms, both spatially and temporally, there are diachronic and vertical displacement factors to consider. Once the archaeological record is deposited it can be disturbed by

[20] L. R. Binford, "General Introduction," in *For Theory Building in Archaeology*, L. R. Binford, ed., New York 1977, pp. 1–10.

[21] M. Schiffer, "Archaeological Context and Systemic Context," *American Antiquity* 37, 1972, pp. 156–165; *Behavioral Archaeology*, New York 1976; "Toward the Identification of Formation Processes," *American Antiquity* 48, 1983, pp. 675–706; and *Formation Processes of the Archaeological Record*, Albuquerque 1987.

subsequent human activity at a much later date. Such disturbance is often unintentional, as is the case with plowing or the digging of foundation footing trenches. In the case of large features, there may be intentional re-use even at a later date which may require disturbing the archaeological record by, for example, clearing away accumulated debris or gathering material to use in a different manner than originally intended. A considerable amount of this sort of activity characterizes the Fortress at Isthmia. For example, large ceramic fragments were used in wall construction. More significant was the use of the ancient monuments of the Sanctuary as sources of worked blocks for both the Hexamilion and Fortress. The Northeast Gate, for example, incorporates spolia (column drums, voussoirs, and inscribed blocks) in both the superstructure and the roadway.[22]

In addition to these cultural factors, a range of natural forces (n-transforms, in Schiffer's terms) have an incessant impact on the archaeological record. At Isthmia, erosion would have been significant in the eastern and northeastern sections of the Fortress where the ground slopes down dramatically to the east. The construction of the fortifications and the subsequent filling would have restricted erosional washoff along most of the eastern edge and stabilized that area. The land still sloped down towards the Northeast Gate, however, and erosional runoff contributed to the accumulation of soil and artifacts behind the walls in that area, eventually covering significant portions of them. An understanding of the roles played by various formation processes is vital to explaining the distribution of surface artifacts in the Fortress.

The 1986 surface collection sampled 2.7 percent of the Fortress interior. In all, 27,199 artifacts were collected and recorded in the 725 1-sq.m. sample units (Table 2). The mean artifact density is 37.51 artifacts/sq.m., a figure two to four times higher than that recorded in other parts of Greece (*e.g.*, Boiotia, Thisbe Plain)[23] and in neighboring areas of the Corinthia.[24] The material from the surface collection provides data at three levels:

1) Chronological. Diagnostic pottery, coins, and some worked stone blocks provide temporal parameters for occupation of the Fortress.

2) Extent of site usage. Spatial distribution of the artifacts indicates differential occupation of the enclosure in various periods.

3) Functional. The different material categories suggest domestic, storage, production, and transport contexts.

The oldest datable artifact that appears within the Fortress is an Archaic body sherd. There are a few pieces of flaked stone, including a prismatic blade core that may be Bronze Age in date, and some fragments of ground stone, but the small number precludes any clear-cut temporal assignment. The lack of definite prehistoric artifacts in the Fortress suggests that this part of Isthmia was occupied only later in the sequence.

[22] T. E. Gregory and H. Mills, "The Roman Arch at Isthmia," *Hesperia* 53, 1985, pp. 407–445.

[23] T. E. Gregory, "Intensive Archaeological Survey and Its Place in Byzantine Studies," *Byzantine Studies/Études byzantines*, in press; J. Bintliff and A. Snodgrass, "The Cambridge/Bradford Boeotian Expedition: the First Four Years," *JFA* 12, 1985, pp. 132–133.

[24] T. E. Gregory, "An Early Byzantine Complex at Akra Sophia near Corinth," *Hesperia* 54, 1985 (pp. 411–428), p. 421.

TABLE 2. Breakdown of material from 1986 surface collection. Sample unit size 1 sq.m., sample interval 5 m. north–south and east–west.

Transects:	1	2	3	4	5	6	Total
Total Squares	122	172	198	77	32	124	725
Material							
Ceramic							
Fine	109	109	120	40	30	14	422
Coarse	1173	1957	2356	1015	470	388	7359
Body sherds	1194	1921	2302	965	457	361	7200
Rim sherds	36	71	87	56	23	22	295
Handle	40	54	61	24	15	14	208
Base	12	20	26	10	5	5	78
Diagnostic							
Prehistoric	0	1	1	0	0	0	2
Archaic	0	0	0	1	0	0	1
Classical	3	3	8	6	3	0	23
Classical/Hellenistic	0	2	8	3	3	2	18
Hellenistic	1	6	3	1	1	0	12
Early Roman	39	48	48	17	8	1	161
Late Roman	161	232	253	112	58	68	884
Slavic	2	3	2	0	5	1	13
Early Byzantine	4	6	14	1	2	4	31
Late Byzantine	29	50	82	26	24	17	228
Early Modern	0	1	1	0	2	1	4
Tile	2562	4937	4992	3242	4323	2073	19129
Miscellaneous							
Water pipe	0	2	3	0	0	0	5
Beehive	3	8	3	2	1	0	17
Lamp	2	2	1	0	0	0	5
Waster	0	0	1	0	0	0	1
Kiln support	0	1	0	0	0	1	2
Brick	0	1	0	0	0	1	2
Lid	0	0	0	1	0	0	1
Stone							
Tessera	3	3	1	5	0	0	12
Marble	22	52	17	24	10	16	141
Revetment	1	0	12	20	2	3	38
Cut block	1	7	3	1	0	2	14
Mortar	0	1	0	0	0	0	1
Slate	1	0	1	0	0	0	2
Flaked stone	0	3	3	1	0	3	10
Ground stone	2	3	1	0	0	0	6
Miscellaneous Material							
Coin	0	0	2	1	0	0	3
Iron	1	0	0	0	0	0	1
Bronze	0	0	1	0	0	0	1
Nail	0	0	0	0	1	0	1
Slag	1	3	1	0	0	0	5
Glass	6	7	6	2	0	1	22
	3887	7095	7525	4354	1837	2501	27199

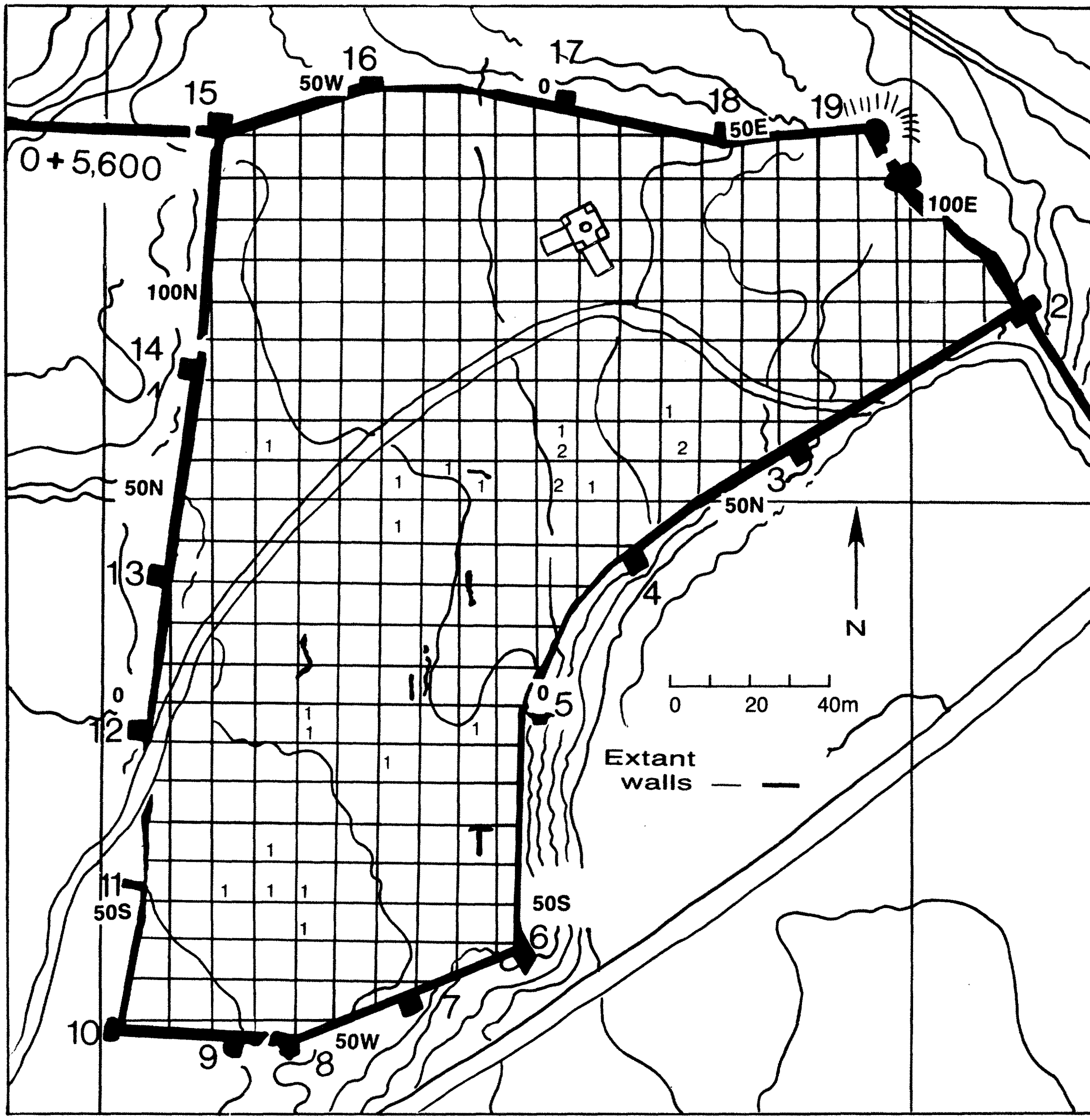

FIG. 15. Distribution of Classical pottery in the Fortress. N = 23

Twenty-three Classical (Fig. 15) and 18 Classical-Hellenistic (Fig. 16) sherds constitute the earliest substantial body of diagnostic material. A key aspect of their distribution is the small number of sherds in the eastern half of the Fortress south of 45N and east of 50W, the area of the deep fill brought in to level the ground inside the east curtain wall. The lack of early material in the area of this fill suggests that the soil was not brought in from the Sanctuary proper, or at least from Classical or earlier levels.

The Early Roman pottery (161 sherds, Fig. 17; Catalogue: **1**) exhibits higher frequency and density than material from previous periods and may represent a sudden increase in site

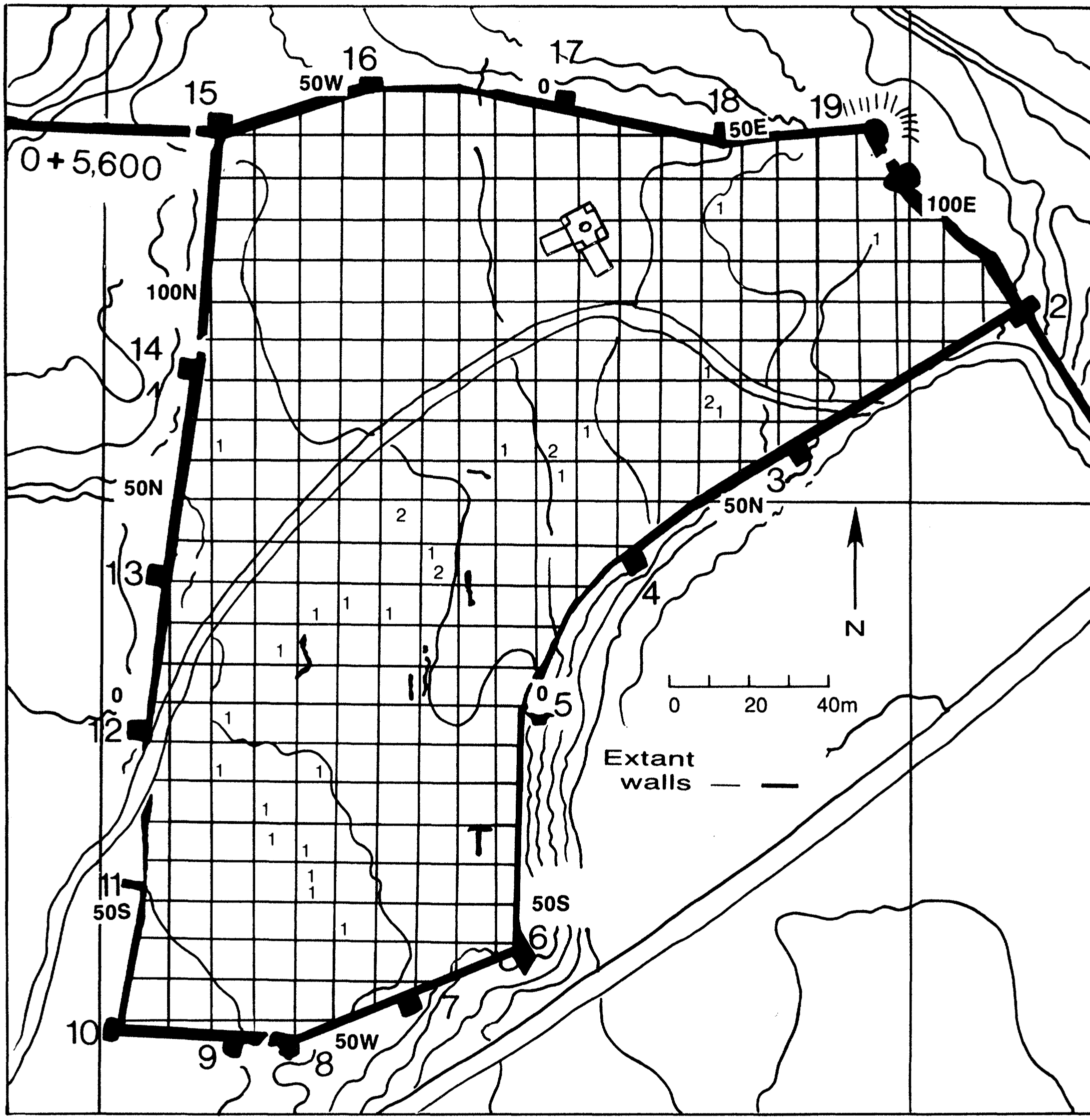

FIG. 16. Distribution of Classical/Hellenistic and Hellenistic pottery in the Fortress. N = 30

usage. The main cluster of material is in the east-central part of the Fortress near Tower 5. The fact that Jenkins and Megaw found several Early Roman structures in this area suggests that much of this pottery reflects habitation, but some of the sherds probably were transported here in the leveling fill brought in by Byzantine military engineers.

The pattern of more intense occupation reached an apex in the Late Roman period (4th to 7th centuries after Christ), for which the pottery count is 884 (64.2 percent of all diagnostic pieces). The distribution of Late Roman pottery is more extensive (high ubiquity) than that of any other period (Fig. 18). Both the northwest and northeast sections of the

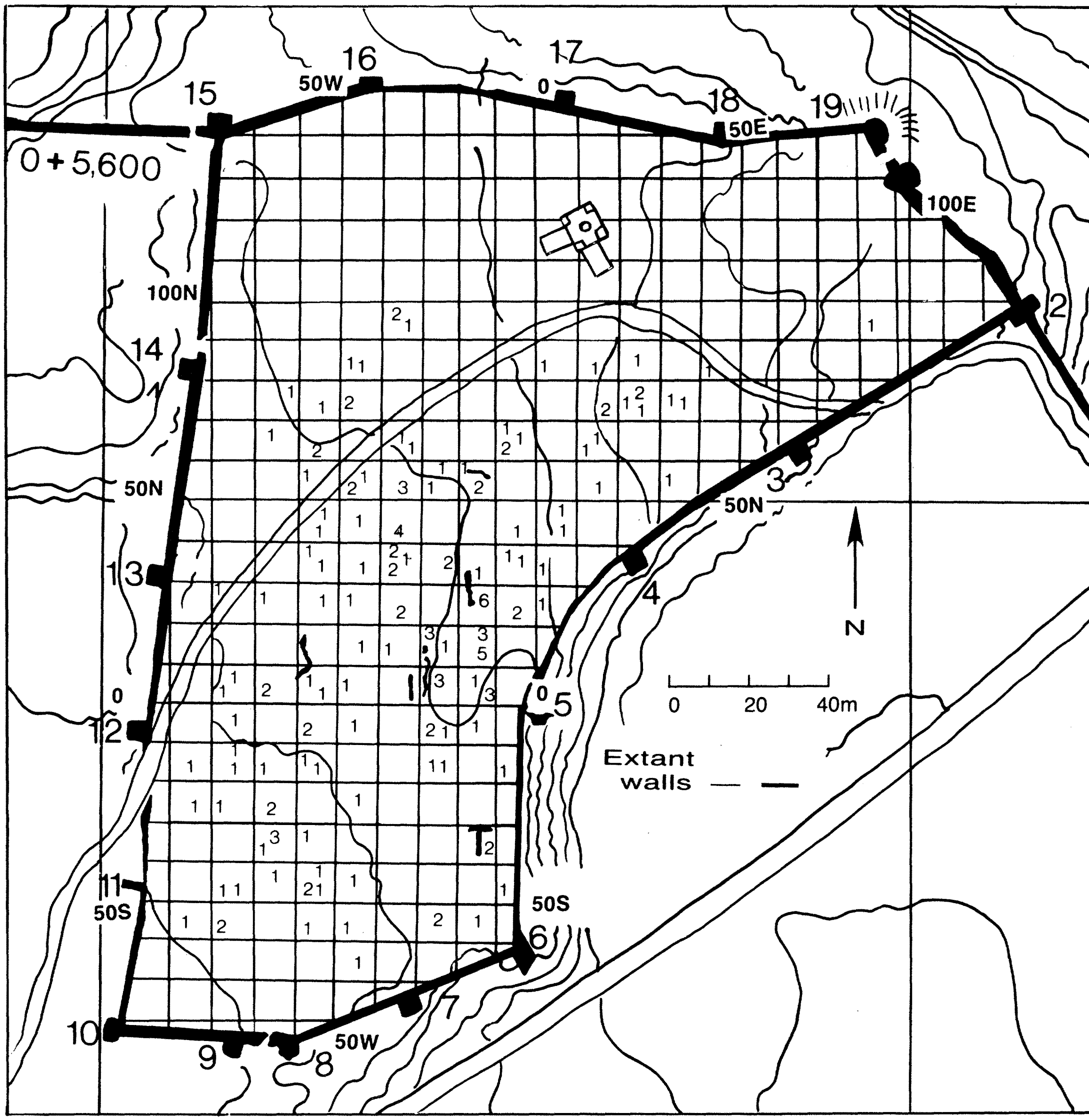

FIG. 17. Distribution of Early Roman pottery in the Fortress. N = 161

Fortress contain significant amounts of material; this is true for no other era. The presence of Late Roman material in all areas surveyed within the Fortress is precisely what one would expect if this period reflects the time when the fortifications were constructed and initially garrisoned. It was then that the entire enclosure would have been utilized in some fashion. The range of pottery types (amphoras, jugs, pitchers, plates, various bowls) in the sample suggests a variety of activities, from importation and storage to on-site consumption. The only subsequent period represented by substantial pottery is the Late Byzantine (228 sherds; Fig. 19), which may coincide with another major military occupation after the

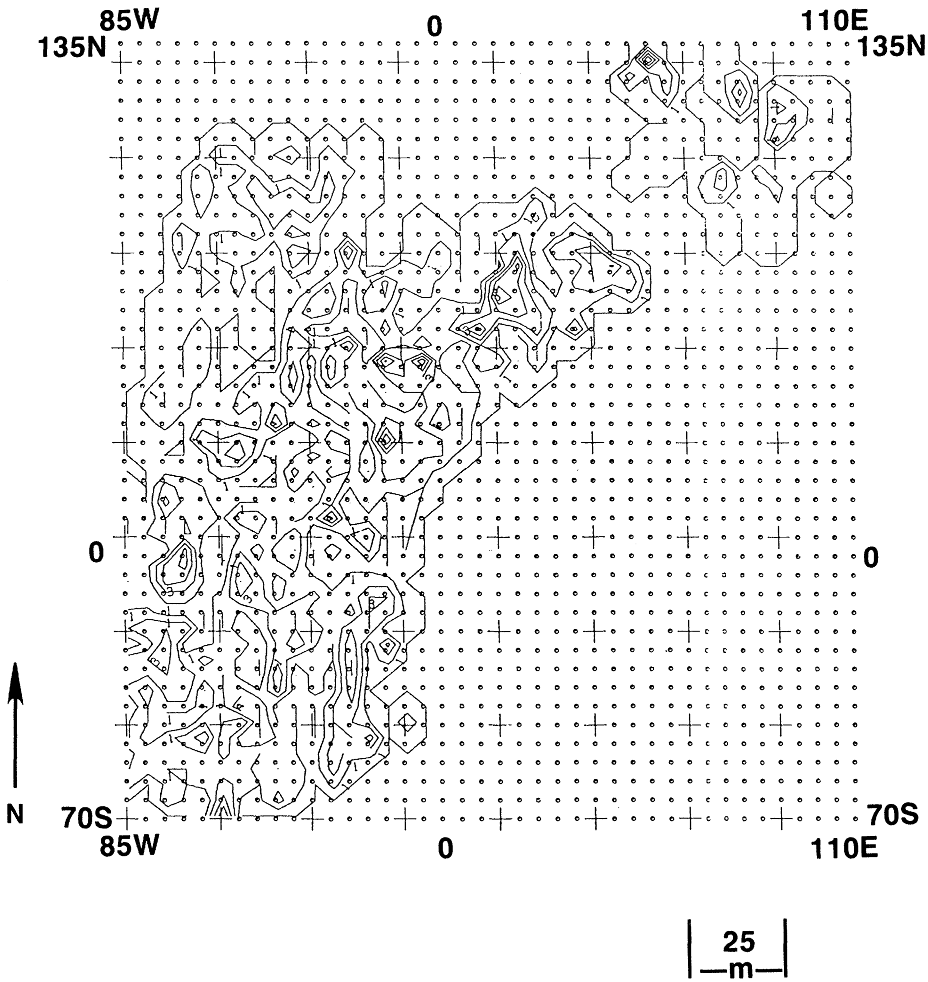

FIG. 18. Distribution of Late Roman pottery in the Fortress presented in contour format. N = 884

reconstruction of the fortifications ordered by Manuel II. Of importance is the presence of Slavic pottery (Catalogue: **4**) dating to the 6th and 7th centuries after Christ. This material does not appear in a destruction context in the Fortress and may not be the definitive marker of invasion that some believe it to be.[25]

A major working assumption of this study is that diagnostic pieces can be a guide to determining the date of other surface material. In the Fortress, the greatest amount of diagnostic pottery is Late Roman in date, followed by Late Byzantine and Early Roman. Excavations in and around the Fortress indicate that although the Early Roman presence was

[25] P. Aupert, "Céramique slave à Argos (585 ap. J.-C.)," *Études argiennes* (*BCH-Suppl.* 6), Paris 1980, pp. 373–394.

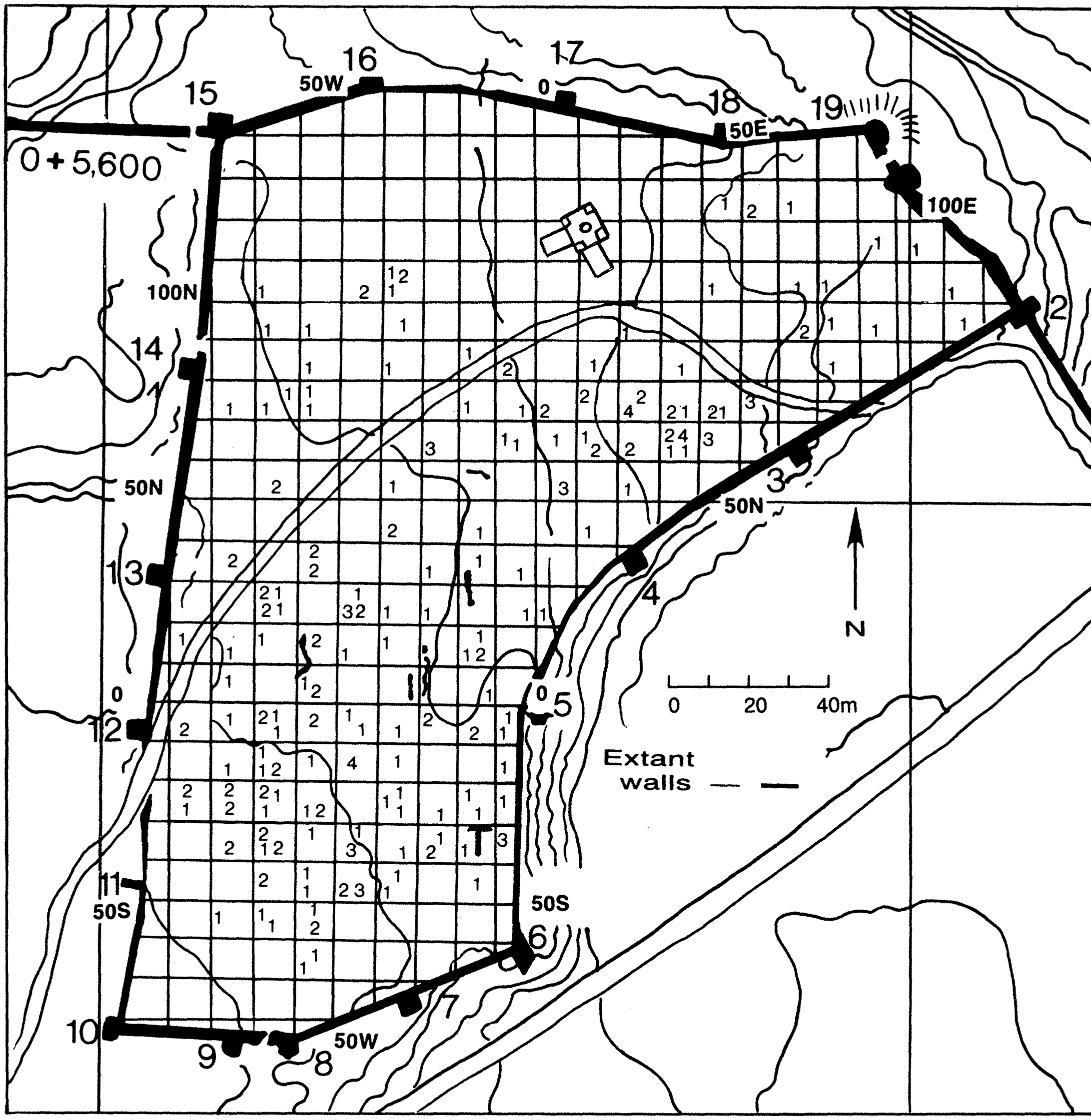

FIG. 19. Distribution of Late Byzantine pottery in the Fortress. N = 228

significant, it was not so pronounced as Late Roman and Late Byzantine occupation. Therefore, the surface collection seems to reflect accurately the intensity of occupation as indicated in previous investigations. A key assumption is that the Late Roman component encompasses approximately 64 percent of the entire surface collection.

The ability to discriminate among certain functional categories within the surface assemblage presents the possibility of distinguishing certain specialized activities. In addition, these artifacts also enhance understanding of the diversity of material present, thus providing insights into the population structure of the residents of the site and their relationship to

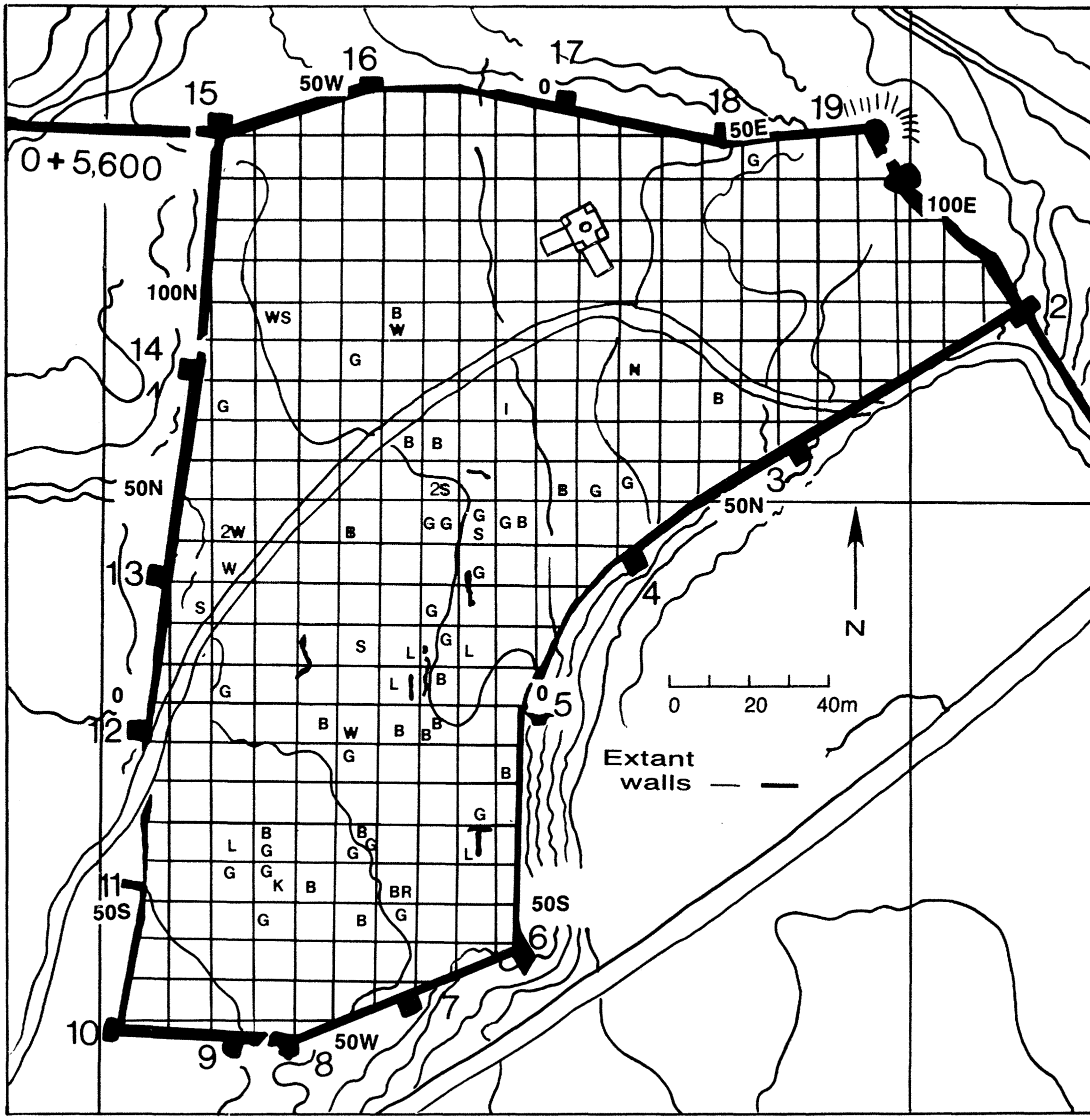

FIG. 20. Distribution of beehive fragments (B), glass (G), water pipe (W), slag (S), lamps (L), bronze (BR), nails (N), kiln support (K), and waster (WS) in the Fortress. All symbols indicate single specimens except where preceded by a number.

other occupants of the area. The ceramic materials in question include fragments of beehives, water pipes, a kiln waster, a kiln support, bricks, industrial waste, and lamps. Glass forms another category.

The materials recovered (Fig. 20) suggest a considerable range of activities. In terms of production, the fragments of ceramic beehive (Catalogue: **3**) indicate an attempt to provide one special item in the diet, but the noise, dust, and lack of vegetation within the Fortress may not have been conducive to honey production. The ceramic beehives may belong to the period before construction of the fortifications, or to a time when civilian squatters inhabited the Fortress.[26] The kiln waster, support, and industrial waste indicate pottery production, but the locations of these objects do not correlate with the suspected furnace revealed by magnetometry. As suggested above (pp. 473–474), perhaps the furnace was for metalworking. The one piece of bronze discovered is a dripping or spill from the manufacturing process. The discovery of substantial foundry debris in dumps near the Temple of Poseidon[27] suggests that at least some of the metal objects dating to the Hellenistic period and earlier found at the Sanctuary may have been cast and finished near by. The metal debris in our sample may thus be dumped material brought in from elsewhere at Isthmia. The same may be true of the lamps (Catalogue: **2**),[28] kiln support, and diamond-shaped floor tiles (Catalogue: **6**). A number of kiln supports and unfired and overfired ceramics have recently been identified from the destruction deposits in the Roman Bath; there may have been a kiln in or near the Bath after its abandonment. Diamond-shaped tiles line the floor of a Late Roman cistern *ca.* 50 meters east of the Temple of Poseidon[29] and of another Late Roman structure just north of the Roman Bath; one similar tile was also found in the debris of the Bath itself.

The water pipes and glass represent efforts to provide certain amenities. Although there is some leeway in assigning dates to these materials, they would not be out of character in a Late Roman to Early Byzantine context and may therefore have been used by occupants of the Fortress in the 5th century after Christ. The northeast sector of the Fortress yielded almost none of this material, which suggests that it did not function in the same capacity as other parts of the site. It may have been a specialized area, perhaps one that stressed a more purely military purpose, such as a muster area for troops near the main gate facing the oncoming enemy. That only a limited degree of positive locational correlation exists among the various classes of artifacts is to be expected, since the categories tend to reflect different types of activities and should be spatially distinct.

Another possible indicator of functional differences is the distribution of fine wares (Fig. 21). Assuming that the difference in social class between officers and common soldiers was reflected in the types of artifacts used by each group, there should be distinct spatial segregation of such material if the two groups had separate quarters. Clusters of Late Roman fine wares in the central and south-central parts of the Fortress are taken to be areas probably occupied by officers and senior non-commissioned officers. These concentrations coincide with the expectation that the largest contingent of officers in a Roman or Byzantine army would be found in the center of the camp, the characteristic location of the headquarters or *principia*.[30]

The third problem the surface assemblage can address is the location of structures. Surface surveys in various parts of Greece have noted the close relationship of roof-tile

[26] The beehive fragments are difficult to date; they might be assigned to the middle of the 6th century after Christ, perhaps reflecting occupation of the enclosure by squatters or a different military use of the Fortress.

[27] W. Rostoker and E. R. Gebhard, "The Sanctuary of Poseidon at Isthmia: Techniques of Metal Manufacture," *Hesperia* 49, 1980, pp. 347–363.

[28] The lamps can be closely dated to the 1st to 3rd centuries.

[29] O. Broneer, *Isthmia*, II, *Topography and Architecture*, Princeton 1973, p. 96.

[30] Webster, pp. 171, 184.

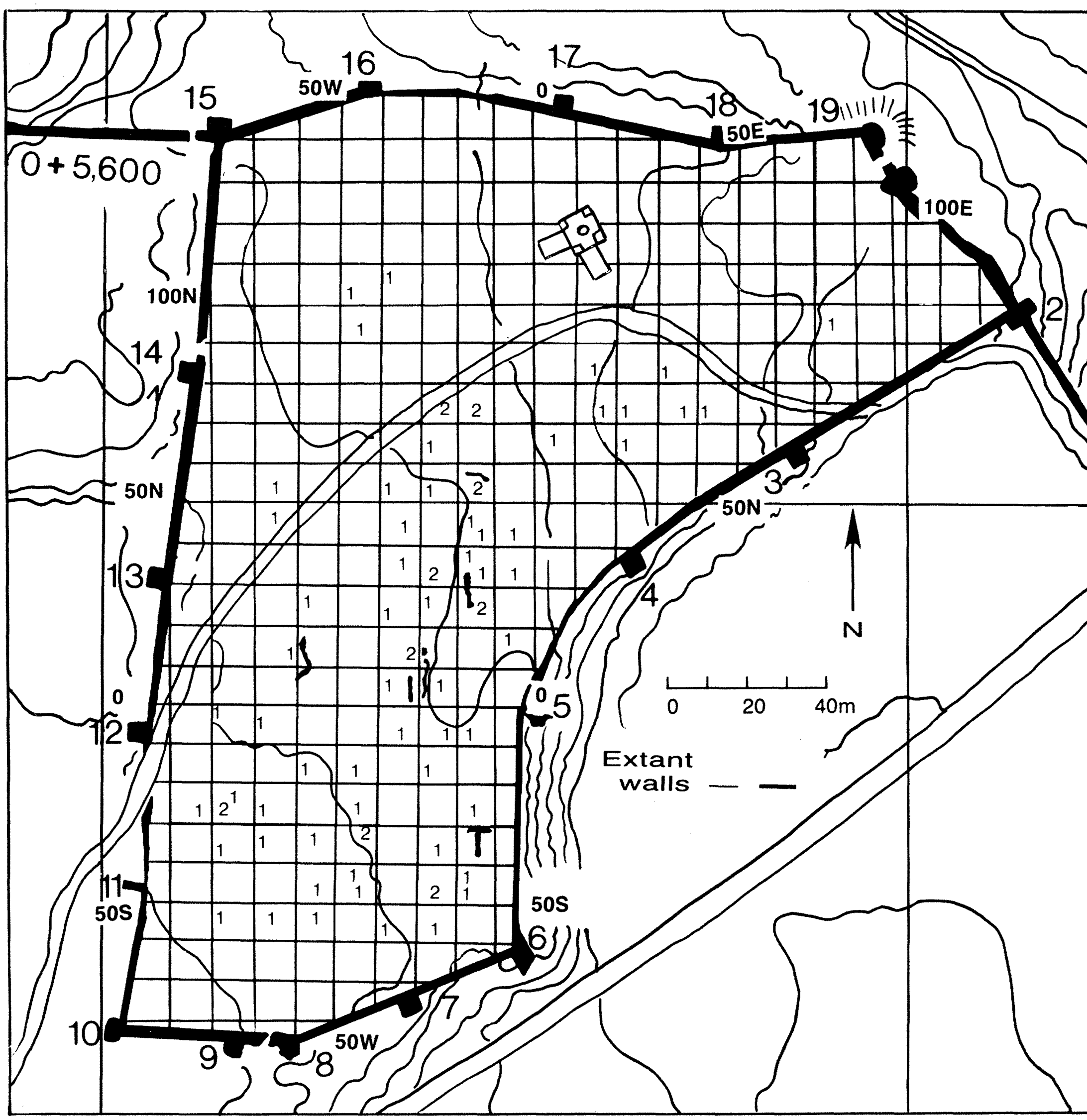

FIG. 21. Distribution of Late Roman fine ware in the Fortress. N = 80

scatters to the location of ancient structures. It is assumed that a similar relationship holds in the Fortress. Because of the confined space and the considerable density of occupation in the enclosure, however, it is not clear how strong this connection is. In addition, inward and outward roof collapse would leave different patterns on the ground. Roof tiles can also be collected and stored for later re-use. The 19,129 roof-tile fragments form the largest single category of surface artifact (Fig. 22). The highest densities appear in the south and east sectors, but with substantial concentrations elsewhere. Roof tiles represent a high-frequency, high-ubiquity, high-density artifact type. With so much material, there is the problem of determining the threshold that separates background scatter from culturally

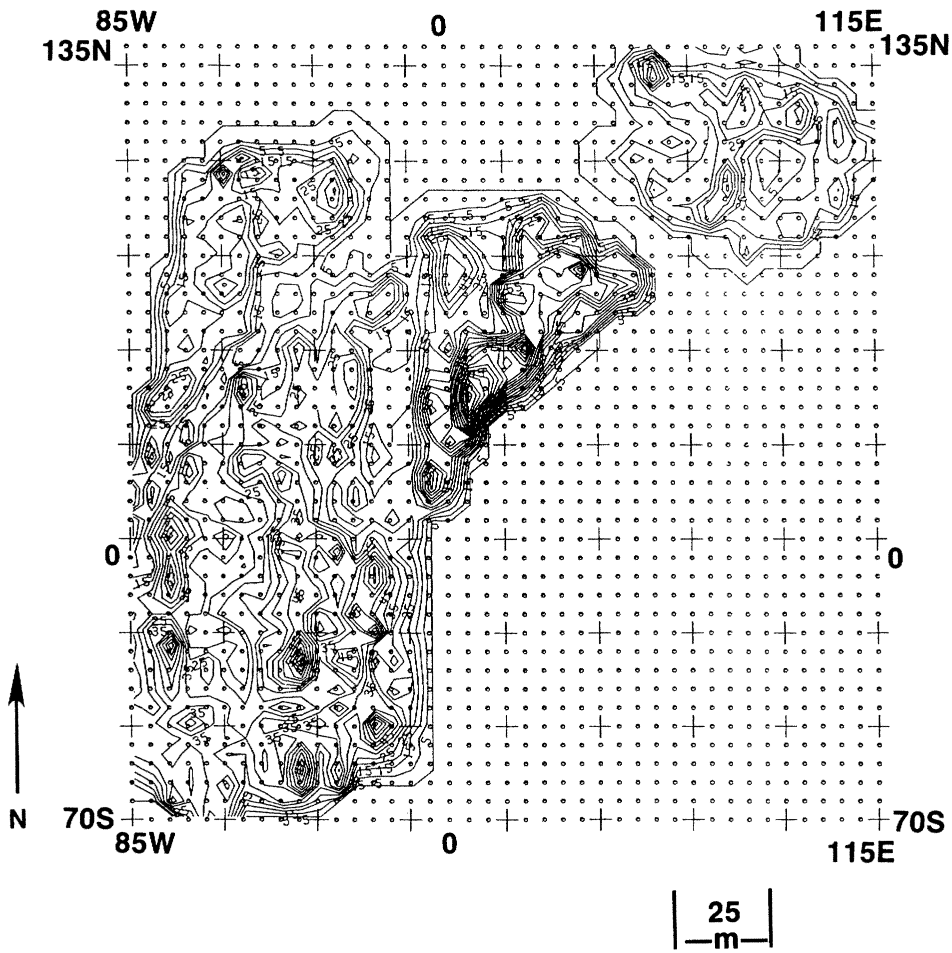

FIG. 22. Distribution of roof tiles in the Fortress presented in contour format. N = 19,129

meaningful concentrations. In examining the frequency distribution, there are 305 sample squares with roof-tile counts of 1–20 pieces, 308 with counts of 21–40, 80 with 41–60, 23 with 61–80, and 9 with 81–109. If an arbitrary contour threshold of 35 roof-tile fragments is adopted as a possible indication of a structure, the southeast corner of the Fortress has several significant clusters, as do the far western fringe and the area between Towers 3 and 4. The concentration in the southeast corner coincides with the structures indicated by magnetic and electrical surveys. The two other high-density areas, however, lack extant walls and geophysical structural anomalies. The roof-tile distribution may suggest either the presence of substantial buildings or dumping.

Architectural stone is another category with the potential of indicating the presence of structures. Included in this category are worked blocks, pieces of revetment, marble fragments, and tesserae (Fig. 23). The largest cluster of marble, revetment fragments, and tesserae is in the center of the Fortress, where the command post may have stood. Although no

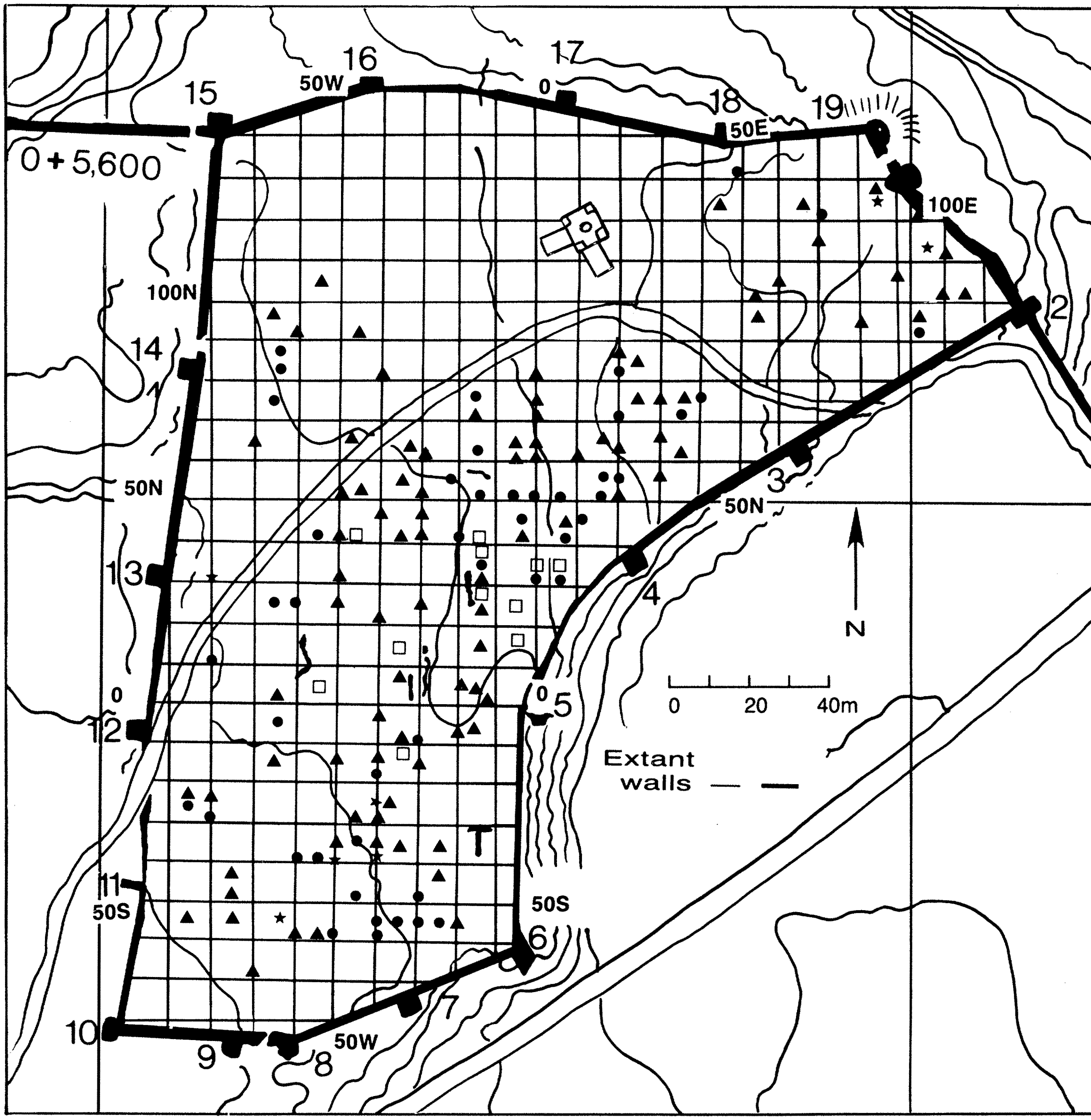

FIG. 23. Distribution of architectural stone in the Fortress. Triangles represent marble (N = 140), circles are revetment (N = 70), squares are tesserae (N = 13), and stars are worked blocks (N = 7). With the exception of worked blocks, the symbols only represent presence, not frequency.

individual worked blocks were found in any sample units, there are several walls in this area. Several other smaller concentrations of architectural stone are located in the northwest and south sectors, where they may reflect residue from construction of the Fortress wall. The marble and pieces of revetment in the southeast sector, however, correspond moderately well to the major structural anomaly detected by the geophysical techniques. Some of the revetment fragments are decorated with vertical flutes; they appear to be segments of decorative antae or pilasters (Catalogue: 7). Perhaps they came from the Bath, where similar, but not identical, pieces are abundant. These fragments may have been stripped from the Bath to decorate some of the Fortress residences, or these items may be part of a fill deposit dumped into the compound. Such alternative explanations of origins also apply to the tesserae (Catalogue: **5**). Though few in number, the tesserae are indicators of wealth, since these decorative pieces were commonly used in elaborate mosaic floors such as might grace the commander's quarters.[31] If the tesserae were brought from the Sanctuary, either for decorative purposes or mixed in with fill dirt, the Roman Bath, with its extensive mosaic floors, might be thought a likely source, but the Bath tesserae are considerably larger than those found in the Fortress. Whatever the explanation, the architectural stone was clearly brought into the Fortress after construction of the fortifications, because the Early Roman structures excavated by Jenkins and Megaw apparently lacked such architectural embellishment.[32]

The surface collection survey thus provides some control over the interpretation of geophysical anomalies as well as being an independent data-gathering technique. The surface assemblage offers both chronological and functional information that is important in making sense of the sub-surface features. The surface collection and geophysical techniques together formed an integrated strategy for understanding the site layout at the Fortress. Undertaken in conjunction, surface survey and geophysical methods offer results that can aid in interpreting a site and can guide future excavation.

CONCLUSIONS

The field research yielded an abundance of information useful in determining the size and variety of structures within the Fortress and in gauging the intensity of cultural activity through time. Analysis of the surface-collection and geophysical data reveals the presence of a number of structures within the Fortress enclosure. Most of the suggested features are directly associated with visible walls. Figure 24 presents the visible walls and the extensions associated with them that were revealed by fieldwork. In addition, the research produced evidence of possible structures with no visible remains; these hypothesized buildings are also shown in Figure 24.

The dotted lines representing suggested walls (except Structures 7, 8, 9, and 10) in Figure 24 were drawn primarily on the basis of the correlation of visible walls and geophysical anomalies. For example, Structure 1 is represented by two adjoining sections of visible walls (Pl. 73:b, e). Magnetic and electrical readings indicated the continuation of a visible east–west section of wall 25 meters further to the west. The slight displacement of magnetic anomalies to the south has been compensated for in the north wall of Structure 1 by placing the proposed wall *ca.* 1 meter north of the line indicated by the magnetic survey. The electrical surveys provide substantiation for this adjustment: the resistivity and resistance anomalies continue due west from the visible wall. The north–south width of the structure was estimated from linear anomalies that seem to represent crosswalls. These anomalies reach to the southern boundary (50S) of the surveyed area, *ca.* 18–20 meters from

[31] Suetonius reports that Julius Caesar had a mosaic floor in his command tent in Gaul (*Caesar* 46).
[32] Jenkins and Megaw (footnote 7 above), p. 81.

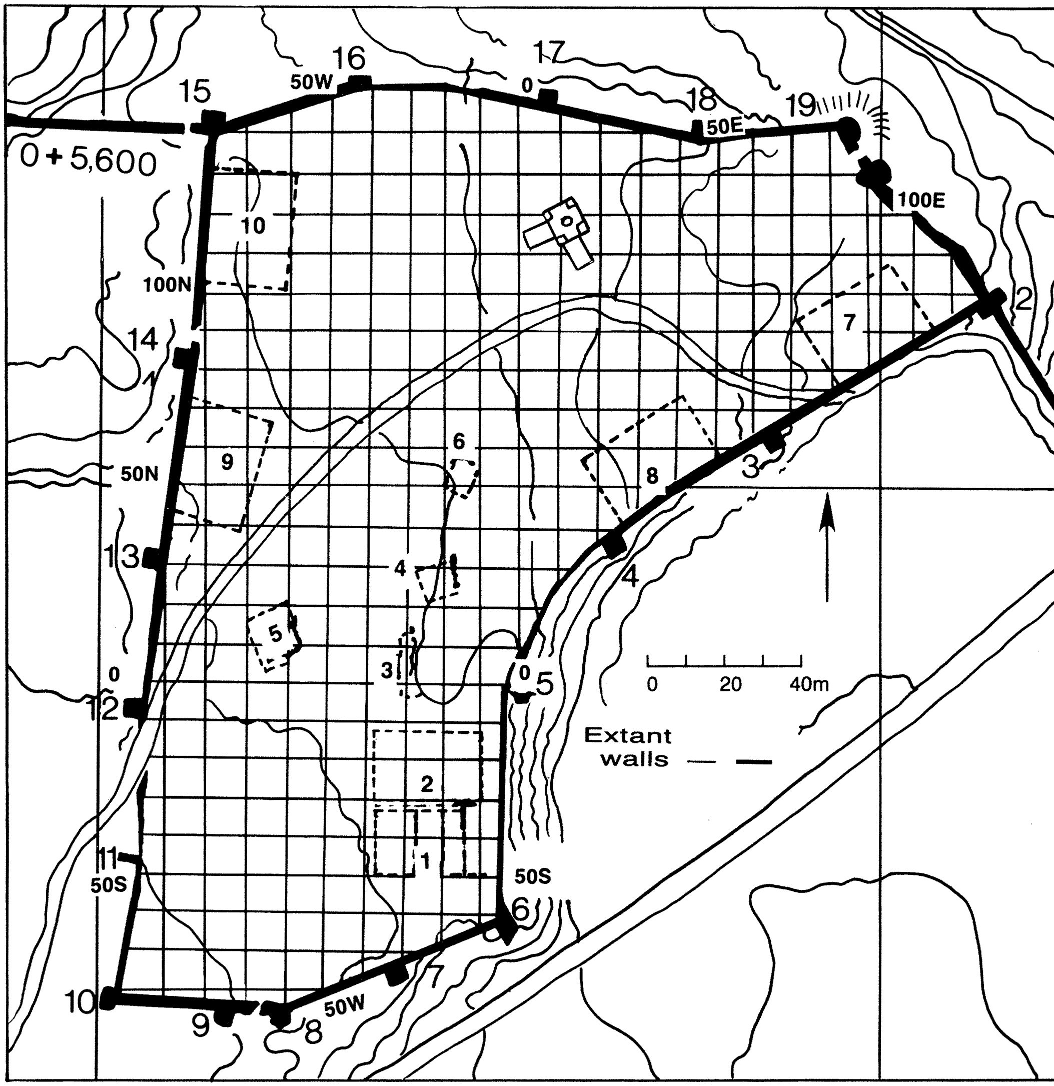

FIG. 24. Plan of the Fortress showing extant Mediaeval walls and restored layout of buildings (indicated by dotted lines and identified by numbers) for military occupation in Late Roman and Early Byzantine periods

the north wall. These east–west and north–south measurements are taken to be maximum dimensions, and so the area of the structure is derived by multiplying these two figures (Table 3). A similar approach has been used in estimating the size of Structure 2, but with only one small section of visible wall, there is greater reliance on the geophysical, especially the electrical, anomalies. The dimensions of Structures 7, 8, 9, and 10 have been estimated on the basis of a suggested identity in function with Structures 1 and 2.

The layout of the site in the 5th century after Christ can now be discussed in light of this restoration. A massive building, Structure 1, dominates the southeast sector. The size and

TABLE 3. Population estimates for the Isthmian Fortress in Late Roman to Early Byzantine period

Structure	Approximate size m. × m.	Available space in sq.m.		Number of people		
				Naroll coefficient	Pringle coefficient	
		Total floor*	Sleeping**	10 sq.m.	2.7 sq.m.	1.8 sq.m.
1	30 × 20	1200	500	120	185	278
2	30 × 20	1200	500	120	185	278
3	12 × 5	60	60	6	22	33
4	5 × 5	25	0	3	0	0
5	15 × 10	150	150	15	3	3
6	6 × 6	36	36	4	13	20
7	20 × 30	1200	500	120	185	278
8	20 × 30	1200	500	120	185	278
9	20 × 30	1200	500	120	185	278
10	20 × 30	1200	500	120	185	278
		7471	3246	748	1148	1724

*Structures 1, 2, 7, 8, 9, and 10 are assumed to have been two stories tall. Total floor space for these buildings is obtained by doubling the area from the dimensions indicated. Used in conjunction with Naroll coefficient.

**Sleeping space includes only available area on the second story of Structures 1, 2, 7, 8, 9, and 10. 100 sq.m. is subtracted to account for verandas and intervening walls. Used in conjunction with Pringle coefficients.

location of this structure suggest that it may be a barracks. Several walls just to the north of this building seem not to be connected to it and are designated Structure 2. The presence of two barracks in the same area would suggest that this was a key residential part of the Fortress. This southern area would have been one of the most protected in the enclosure, since attacks were anticipated from the north. The descriptions of fortresses provided by Webster and Pringle together provide the basis for understanding the size and form of barracks in the Isthmian Fortress. Since Pringle specifically discusses Early Byzantine fortresses, some of the particulars of his study are more appropriate in the context of Isthmia. Barracks in North Africa were commonly two stories tall,[33] and so the crosswalls indicated by geophysical techniques in Structure 1 may reflect dividers that separated rooms by military unit and supported an upper floor of similar layout.

Other barracks may have existed in the Fortress, but the lack of other large linear anomalies makes pinpointing the location of such structures difficult. One possible spot is the northwest area, south of the cemetery, where there is open ground and a substantial scatter of surface artifacts. Such positioning of barracks would have spread out forces within the Fortress. An alternative explanation is suggested by Pringle's observation that in North

[33] Pringle, p. 86.

African Byzantine forts, additional barracks were often built against the defensive walls.[34] Because obstacles such as fences and recently constructed walls prevented us from examining strips abutting on the circuit walls, the presence of such barracks remains an open question. There may, however, be an independent indicator that such structures did abut on the Fortress walls. The barracks area in the southeast sector lies between Towers 5 and 6, a distance of 50 meters. There are several other locations in the Fortress with similar long stretches of wall between towers: in the northeast, between Towers 2 and 3 and between Towers 3 and 4; and in the northwest, between Towers 13 and 14 and Towers 14 and 15. These four stretches could accommodate long buildings (Structures 7, 8, 9, and 10, respectively, in Figure 24) without interfering with activities in the towers.

The evidence points to considerable use of the central zone of the Fortress, in addition to the southeast area. In the east-central area, two parallel walls, with a curved, apselike appendage on the north end, constitute Structure 3 (Pl. 77:a).[35] This building may be related to the large anomaly immediately to the northeast (Anomaly 2). The forge or forge debris that this anomaly may represent indicates specialized economic activity and an effort to make the garrison self-sufficient in this respect. A structure of some sort would have housed this enterprise, but none of the visible walls lines up with the magnetic Anomaly 2. The closest association is with Structure 4, a narrow, 4-meter-long section of wall with its north end at 30N-20W, and with Structure 3. None of these walls has the appearance of a forge, but perhaps the single wall of Structure 4 is a remnant of a storage building associated with manufacturing activity. A forge may have been situated in the eastern half of the Fortress to take advantage of prevailing winds to prevent noxious fumes flowing across the inhabited part of the compound.

No other areas of such industrial activity are evident. The scattered pieces of metal and ceramic waste, kiln wasters, and melted bronze suggest specialized production, but the small sample is insufficient to indicate patterning, and as we have seen, this material may be in secondary deposit. Supplying water must have been a key concern. No wells or cisterns are evident inside the Fortress walls. The few pieces of water pipe suggest the channeling of water. The stream to the south and east and the North Drain to the west could have provided abundant water in the rainy season, but storage in cisterns or large pools would have been necessary in the summer. The location of such water-storage features, however, is not clear from the results of the current fieldwork.

To judge from the distribution of certain artifact classes, such as architectural stone and Late Roman fine ware, the headquarters or *principia* seems to have been located near the center of the enclosure, perhaps in the zone between 20N and 60N. With one exception

[34] Pringle, p. 86.

[35] This may be one of the buildings described by Monceaux (footnote 4 above) and Staïs (footnote 5 above) as a chapel. Chapels were certainly important elements of Early Byzantine military installations, in which they often housed a shrine to the Virgin Mary as Protectress of the Empire and served as a storehouse for the military standards of the unit (Pringle, p. 164). The problem with identifying Structure 3 as a chapel is that the apse would be on the north end of the building instead of on the east. No chapel has been identified yet in the Fortress; perhaps there are such remains under the present church of St. John at the north end of the enclosure.

there are only a few small extant wall fragments in this area, and the geophysical evidence for the presence of a large structure here is ambiguous. This exception is a fragment of a thick wall near 10N-60W with a facing of fine ashlar blocks and a rubble core (Structure 5); this structure may be part of the headquarters complex, although it is slightly west of the central area and the heaviest concentration of surface materials. This wall, however, does exhibit the level of workmanship one might expect in the commander's compound.

Since the walls of the Isthmian Fortress do not form a neat square or rectangle, some of the symmetry visible in other Roman and Byzantine camps is absent. There probably was only one road, connecting the two gates along a curving route. The disposition of the various buildings described above may not be so regular as elsewhere because of the unusual shape of the enclosure. The orientation of most structures along the cardinal directions and the size of the buildings, however, do indicate considerable organization. The command center seems to have been situated in the heart of the enclosure, equidistant from either gate. The supposed forge in the southeastern part of this complex might be associated with an arsenal. The amount of high-quality material in this central zone (35 = 43.8 percent of all Late Roman fine ware discovered, 11 = 50 percent of all glass, 70 = 50 percent of all marble, 11 = 84.6 percent of all tesserae) suggests the presence of elaborate structures to house and serve officers. Distortion of geophysical readings by stone rubble, metal scrap, and the bell tower may have obscured the presence of other features, such as a chapel. It must also be kept in mind that the presence of the modern church and cemetery prohibited examination of the far northern zone.

The size and organizational structure of the Fortress garrison can be estimated by using several different approaches. Some require estimates of available roofed floor space in buildings.[36] Table 3 presents the area and floor space for the buildings discussed above, including the hypothetical barracks abutting on the Fortress walls. The available floor-space figure assumes that all barracks had two stories, the lower for storage or stables, the upper occupied by soldiers. Buildings represented by one wall are assumed to be square in plan and one story in height.

An initial population estimate rests on Naroll's figure of 10 sq.m. per person of floor space.[37] This floor space includes all roofed areas, e.g., sleeping quarters, storage areas, corridors, and non-residential space. The population figure derived from the Naroll coefficient must be viewed as conservative. Perhaps more appropriate in this context is the approach followed by Pringle. He proposes 1.8 to 2.7 sq.m. of floor space per man in the sleeping compartments, on the basis of evidence from the Early Byzantine fortress at Thamugadi in North Africa.[38] The occupants per building and totals for the whole Fortress at Isthmia based on the various coefficients are also presented in Table 3.

[36] R. Naroll, "Floor Area and Settlement Population," *American Antiquity* 27, 1962, pp. 587–588; F. Hole and R. F. Heizer, *An Introduction to Prehistoric Archaeology*, New York 1969, p. 307; S. LeBlanc, "An Addition to Naroll's Suggested Floor Area and Settlement Population Relationship," *American Antiquity* 36, 1971, pp. 210–211.

[37] Naroll (footnote 36 above), pp. 587–588.

[38] Pringle, p. 86.

Other population estimates are based on the total area of the enclosure.[39] The Isthmian Fortress, at 2.71 ha., falls in the intermediate range of Pringle's list that ranks all the Byzantine North African forts.[40] On the basis of this ranking and several related factors, including proximity to but not incorporation into a large population center, Gregory suggests that the Fortress may have held a maximum force of 2000 men.[41] This number yields a density of 738 people per hectare (2000 ÷ 2.71), far beyond the range of estimates for even large historic settlements.[42] To judge from the evidence of Roman camps in Europe, however, troops were housed in much more crowded conditions than were civilian populations. For example, Webster notes that a legion, which had at that time an operational strength of 5000 men, often camped in an area of *ca.* 8 hectares, as at Reycross in England;[43] such conditions yield a density figure of 625 people per hectare. On this basis, the Fortress could have held 1694 soldiers (625 × 2.71). This number corresponds closely to the figure of 1724 men derived by using the Pringle coefficient of 1.8 sq.m. per man for sleeping area and can be taken as a reasonable upper limit that probably would have been reached only when a significant threat to the security of the Peloponnesos was imminent. The presence of cavalry would have lowered troop strength, since a detachment of horsemen required about twice as much space as an equal number of infantry, primarily to shelter their mounts.

The preceding computations suggest that the garrison in the Fortress in the 5th century consisted of at least four, and perhaps as many as eight, *tagmata*, of the size current in this period, *ca.* 250 men. With four *tagmata* (totaling *ca.* 1000 men) to the contemporaneous legion, there may have been one or two legions stationed at Isthmia.[44] As to the composition of the troops, Procopius[45] states that the soldiers who manned the fortifications at Thermopylai prior to Justinian's reign were local farmers who proved to be incapable of checking the advance of various invaders and so were replaced by *comitatenses*. Gregory believes that the situation was similar at Isthmia in the 6th century.[46] One can argue that it would not have made much sense for the state to undertake expensive projects such as the construction of the Hexamilion and Fortress, only to leave defense of these fortifications in the hands of local militias. We suggest that in the 5th, 6th, and perhaps in the 7th centuries, when southern Greece faced invasions or raids in force by formidable barbarian groups, the task

[39] S. F. Cook and R. F. Heizer, "The Quantitative Approach to the Relation between Population and Settlement Size," *Reports of the University of California Archaeological Survey* 64, 1965, pp. 1–97; *eidem*, "Relationships among Houses, Settlement Areas, and Population in Aboriginal California," in *Settlement Archaeology*, K. C. Chang, ed., Palo Alto 1968, pp. 79–116; P. Weissner, "A Functional Estimator of Population from Floor Area," *American Antiquity* 39, 1974, pp. 343–350.

[40] Pringle, pp. 126–127.

[41] Gregory.

[42] J. C. Russell, "Late Ancient and Medieval Population," *TAPS* 48, no. 3, presents a detailed demographic survey of Europe and circum-Mediterranean regions in Late Antiquity and Mediaeval times. He estimates population densities of 160 people per hectare for Pompeii, 250–350 people per hectare for Imperial Rome, and 200 people per hectare for Constantinople in the 5th century.

[43] Webster, p. 171.

[44] Gregory.

[45] *Buildings* 4.2.14.

[46] Gregory.

of holding the key defenses along the Isthmus was entrusted to contingents of *comitatenses* aided by locals. At other times, when threats to security were less severe, the locals could probably have defended their territory alone.

The *comitatenses* would have required substantial support from surrounding communities to fulfill their needs. The soldiers could provide some of their own food by farming the surrounding fields south of the Hexamilion, keeping domestic animals and bees and gardening inside the Fortress, but when a full complement of up to 1700 men was stationed at Isthmia, such efforts would not have sufficed. Local farmers would have had to provide food, while merchants, artisans, and workmen offered other necessary products and services such as pottery, metal artifacts, leather and wood materials, and labor for various projects. Facilities and personnel at Corinth and other towns probably supplied a considerable share of these goods and services. A system of rural villas, such as the one at Akra Sofia,[47] could also have provided a substantial number of goods, especially agricultural items. Such *villae rusticae* were an important part of the economic exchange system elsewhere in the Empire,[48] and there is some evidence for a similar phenomenon in Greece in Late Roman and Early Byzantine times.

The demands made on the countryside by troops in the Fortress would have been a drain on the local economy, but the needs of the garrison for a variety of products could also have acted as a catalyst for economic intensification. Just as the ancient Sanctuary had been an economic boon because of the demands of visitors for food, drink, lodging, and animals for sacrifice, so, too, the stationing of troops could stimulate local production. The effect of the garrison on the local economy would have been cyclical, since the Fortress was probably not occupied continuously. The Sanctuary had had a similar impact, since the number of visitors would rise and fall according to the calendar of festivals. In some basic ways, then, Isthmia continued to serve the surrounding area in a similar fashion, both when the Sanctuary was the focus of activity and when the Fortress became the key part of the site.

The larger issue surrounding the archaeological data from this study is the nature of social change. Discontinuity and continuity have been presented by scholars as competing paradigms to explain the transition from Late Antiquity to the Middle Ages in the Aegean region. The matter is not simply a semantic disagreement. Those who espouse discontinuity believe that a fundamental cultural and socio-economic break occurred in this region at some time between the 4th and 9th centuries. Some scholars who adopt this perspective see an abrupt break due primarily to human action (e.g. invasion), while others stress a more gradual but no less definitive change from earlier classical civilization resulting from an accumulation of social and environmental problems. A unifying theme among all the theorists of discontinuity is agreement over the decline of urban life as constituted in the classical polis. The adherents of continuity, in contrast, emphasize the perpetuation of many aspects of ancient society during this period of stress. They see cities maintaining a vital social, political, and economic role into the Early Byzantine period and beyond.

[47] Gregory (footnote 24 above).

[48] H. Schutz, *The Romans in Central Europe*, New Haven 1985, p. 139. S. Dyson, "New Methods and Models in the Study of Roman Town-Country Systems," *Ancient World* 2, 1979, pp. 91–95.

The major theorists of discontinuity include Foss[49] and Kazhdan and Cutler,[50] all of whom concentrate on the decay of city life in Anatolia. In Foss's view the immediate cause of this decline is the Persian invasions of the 7th century, while Kazhdan and Cutler offer a gradualist, multi-variate explanation in which increasing rurification, a decline in social complexity, and a drop in literacy eroded the urban base of ancient society. Scholars who advocate continuity include Ostrogorsky[51] and Gregory,[52] but such a perspective is also implied in the work of many others.[53] Advocates of continuity do not deny the fact that some significant changes characterize Early Byzantine society, but they point out that many important institutions survived the upheavals of the 4th through the 7th centuries.

In their efforts to resolve this debate, scholars on both sides have had recourse to archaeological as well as historical evidence; these efforts have focused largely on Anatolia. Isthmia provides a Greek setting for the examination of the problem of social change. Despite its lack of civic status, certain characteristics of Isthmia make it an appropriate case for examining how urban culture fared in the transitional phase. Both as a sanctuary and as a fortress, Isthmia was an urban apparatus. In both periods it reflected and was sensitive to the shifting nuances of the larger society, some of whose important needs the site reflected. At no time could the site stand in isolation. Corinthian officials directed the Sanctuary and regulated its festivals, construction, and maintenance to enhance their personal status and that of their city. Later, the Fortress was an important cog in Imperial military strategy, which covered all the Balkans. In many ways Isthmia was always dependent on connections to a larger urban system for its prosperity. If that larger system was disrupted and cities declined, as the discontinuity thesis holds, a site such as Isthmia should be among the first to suffer. As cities turned in upon themselves, halted the construction of large public projects, and became isolated settlements, urban outliers such as Isthmia should have felt the impact of the changes. Isthmia should thus be as good or better than a city as a measure of urban vitality and the direction of social change during the period in question.[54]

[49] C. Foss, "The Persians in Asia Minor and the End of Antiquity," *The English Historical Review* 90, 1975, pp. 721–747; *Byzantine and Turkish Sardis* (Archaeological Exploration of Sardis, Monograph 4), Cambridge 1976; "Archaeology and the 'Twenty Cities' of Byzantine Asia," *AJA* 81, 1977, pp. 469–486; and *Ephesus after Antiquity: A Late Antique, Byzantine and Turkish City*, New York 1979.

[50] A. Kazhdan and A. Cutler, "Continuity and Discontinuity in Byzantine History," *Byzantion* 52, 1982, pp. 429–478.

[51] G. Ostrogorsky, "Byzantine Cities in the Early Middle Ages," *DOP* 13, 1959, pp. 45–66.

[52] T. E. Gregory, "Cities and Social Evolution in Roman and Byzantine South East Europe," in *European Social Evolution: Archaeological Perspectives*, J. Bintliff, ed., Bradford 1985, pp. 267–276.

[53] P. Charanis, "The Significance of Coins as Evidence for the History of Athens and Corinth in the Seventh and Eighth Centuries," *Historia* 4, 1955, pp. 163–172; F. Trombley, "The Decline of the Seventh-Century Town: The Exception of Euchaita," in *Byzantine Studies in Honor of M. V. Anastos*, S. Vryonis, Jr., ed., Malibu 1985, pp. 65–90; W. E. Kaegi, Jr., "Variable Rates of Seventh-Century Change," in *Tradition and Innovation in Late Antiquity*, F. M. Clover and R. S. Humphreys, edd., Madison 1989, pp. 191–208. R. Hodges and D. Whitehouse (*Mohammed, Charlemagne and the Origins of Europe: Archaeology and the Pirenne Thesis*, London 1983) argue that the collapse came in the 5th century. For a recent survey of the whole question see S. J. B. Barnish, "The Transformation of Classical Cities and the Pirenne Debate," *JRA* 2, 1989, pp. 385–400.

[54] P. N. Kardulias (*The Byzantine Fortress at Isthmia, Greece and the Transition from Late Antiquity to the Medieval Period in the Aegean Region*, diss. Ohio State University 1988) explores this idea in detail.

The historical and archaeological evidence from Isthmia suggests the continuation of important elements of the Imperial urban system in Late Antiquity. Various contemporary historians, most notably Procopius, refer to the rebuilding of the Hexamilion and Fortress under the auspices of the Imperial government as part of a larger plan for defending the southern Balkans.[55] The size and extent of the fortifications at Isthmia and the evidence for their integration into a regional strategy strongly indicate the continuation of the Imperial system into the 5th and 6th centuries at least.

That Isthmia was intimately tied into this defensive network is demonstrated by similarities in the construction techniques used in the Fortress and Hexamilion with structures as far away as Constantinople and Resafa (Sergioupolis) in Syria.[56] In addition, there is evidence for a monetary economy in the period of transition in the form of coins and substantial amounts of imported pottery collected during the surface survey. At present, there is no way to know what role Corinthian officials played in the administration of the Fortress, but some of the financial burden may have been borne by locals. The fortifications at Isthmia represent a massive public project and continuation of a tradition of defensive construction often treated as characteristic of urban culture in the region. As an urban outlier, Isthmia continued to serve a variety of functions, the key one being defensive rather than ritual. Neither the Fortress nor the Sanctuary could have existed in isolation. The complex social hierarchy that characterized antiquity was also a feature of Late Antique society. Social differentiation is evident in the Fortress in the variety of prestige items from the surface collection; these data imply not just discrepancies in military rank but also in social station, since it was the officers who could afford such material. All these indicators point to certain crucial similarities in the social, political, and economic milieux at Isthmia in the Classical and the Late Antique periods. There are differences as well, but we believe the weight of the evidence compels acceptance of a position viewing social complexity as a continuing feature at Isthmia, and perhaps in the Aegean area as a whole, throughout the period of transition. Obviously, the case of Isthmia by itself does not settle the issue at a regional level, but it at least demonstrates the need to consider the range of possible variation.

An important consideration, but one we cannot presently answer with certainty, is the fate of the site in the 7th century. The evidence as we have presented it seems to show continuity at Isthmia into the 5th and 6th centuries, well beyond the date at which the site underwent its most important formal transformation from religious sanctuary to military fortress. Nevertheless, the near absence of material from the Byzantine "Dark Ages" of the 7th and 8th centuries and the paucity of evidence until the Late Byzantine period might suggest that a significant break in continuity occurred in the 7th century, a date that is increasingly favored by scholarship on other parts of the Empire. Indeed, this may well be the case. One of the weaknesses of the geophysical techniques, of course, is that they cannot allow clear chronological distinction. Further, the surface evidence of just this period is, unfortunately, susceptible to serious distortion of interpretation, largely because of our poor

[55] *Buildings*, 4.2.1–28.

[56] F. E. Winter (*Greek Fortifications*, Toronto 1971, p. 203) notes the characteristic use of rectangular towers, similar to those of the Fortress and Hexamilion, in Byzantine fortifications in the 5th and 6th centuries.

knowledge of the ceramic chronologies. As Russell has noted for southeastern Asia Minor, we may fail to identify the pottery from the "Dark Ages" simply because we do not know what it looks like. The issue of the so-called Slavic pottery (Catalogue: **4**) is a special case in point. Chronological evidence for this ware at Isthmia is slight, but it suggests a date in the mid-7th rather than the 6th century, as argued by Aupert for Argos.[57] In the Isthmian Fortress it is perhaps significant that the Slavic pottery was encountered broadly throughout the area, suggesting that whoever brought the pottery made use of the whole of the Fortress: the distribution as we have it does not concentrate along the walls, nor is there any reason to think that it came from a cemetery, as is common from elsewhere in the Balkans. The people who used this pottery may or may not have been invaders, and the issue must presently remain open. The current evidence does not contradict the hypothesis that they (i.e., the users of the Slavic pottery) continued to use the Fortress in the same way as their predecessors, but this is an issue that will require further investigation.

Catalogue

1 (86-FS-7) Stamped Roman plate fragment — Pl. 77

Pres. L. 0.037, pres. W. 0.028 m.
Fine, reddish yellow clay (5YR 7/8) with tiny grits. Traces of red slip on interior.

On interior, stamp in shape of a foot: inscription preserves ΘΥΠ, ΘΥΝ, or ΝΛΘ.
1st–2nd century after Christ

2 (86-FS-2 a–c) Lamp fragments — Pl. 77

a. Pres. H. 0.030, pres. L. 0.028, pres. W. 0.040 m.
Fine, reddish yellow clay (5YR 6/8) with some sparkling inclusions; red slip (10R 4/8).

Broken body preserves handle attachment.
Italian, late 1st century after Christ

b. Pres. H. 0.045, pres. L. 0.023, pres. W. 0.032 m.
Fine, very pale brown clay (10YR 7/4).

Preserves handle and fragment of body.
Cf. O. Broneer, *Isthmia*, III, *Terracotta Lamps*, Princeton 1977, p. 161, pl. 10: Type XXVII, 2nd century after Christ

c. Pres. H. 0.025, pres. L. 0.021, pres. W. 0.016 m.
Coarse, reddish yellow clay (5YR 7/8).

Only handle is preserved.
Athenian Pre-glaze, 3rd century after Christ

3 (86-FS-6) Beehive rim — Pl. 77

Pres. H. 0.050, pres. L. 0.105, est. diam. rim 0.28 m.
Coarse red clay (2.5YR 5/8) with some white inclusions and sparkling inclusions.

Beehive with straight vertical sides to plain horizontal, vertically thickened rim. Interior is marked with horizontal and vertical, roughly perpendicular combing.
Cf. E. Crane, *The Archaeology of Beekeeping*, London 1983, pp. 45–51; O. Broneer, "Excavations at Isthmia, Fourth Campaign, 1957–1958," *Hesperia* 28, 1959 (pp. 298–343), p. 337, no. 17, from Tower 7 in the Fortress, and IPR 68-40, from Tower 2.

4 (86-FS-3 a–e) Fragments of Slavic ware

a. Body sherd. Pres. L. 0.028, pres. W. 0.022 m.

b. Body sherd with incised parallel lines on exterior. Pres. L. 0.022, pres. W. 0.018 m.

c. Base fragment. Pres. L. 0.034, pres. W. 0.024, pres. H. 0.016 m.

d. Base fragment. Pres. L. 0.015, pres. W. 0.013, pres. H. 0.015 m.

[57] Aupert (footnote 25 above); J. Russell, "Transformations in Early Byzantine Urban Life: The Contribution and Limitations of Archaeological Evidence," *17th International Byzantine Congress, Major Papers*, New Rochelle, N.Y. 1986, pp. 117–154.

e. Rim fragment with incised parallel horizontal lines on exterior. Pres. L. 0.029, pres. W. 0.025 m.

Coarse, reddish yellow clay (5YR 6/6) with many medium to large, white and black inclusions and some sparkling inclusions.

Fragments are blackened on interior and exterior.

Cf. P. Aupert, "Céramique slave à Argos (585 ap. J.-C.)," *Études argiennes* (*BCH-Suppl.* 6), Paris 1980, pp. 373–394, dating the ware to A.D. 585. Excavation at Isthmia suggests that the pottery may span a greater time, extending well into the 7th century.

5 (86-FS-4 a and b) Mosaic tesserae Pl. 78

a. Pres. H. 0.020, pres. L. 0.050, pres. W. 0.031 m.

Largest individual tessera: 0.017 × 0.011 m.

Six white tesserae in two rows of three each are held in place by cement that contains tiny pieces of clay, pebbles, and grit.

b. Pres. H. 0.020, pres. L. 0.060, pres. W. 0.033 m.

Largest individual tessera: 0.015 × 0.012 m.

Nine reddish brown tesserae, five in one row, four in the other, are set in cement with tiny pieces clay, pebbles, and grit.

6 (86-FS-8) Diamond-shaped floor tile Pl. 78

Pres. L. 0.125, pres. W. 0.072, Th. 0.043 m. The sides are roughly 0.075 m. long.

Coarse, reddish yellow clay (7.5YR 7/6) with many large inclusions and voids.

Cf. O. Broneer, *Isthmia*, II, *Topography and Architecture*, Princeton 1973, p. 96: a tile from the Late Roman Cistern. **6** has the same dimensions as IA 78-51, from RB 78-25, along the west edge of Room XIX of the Roman Bath, otherwise unexcavated.

7 (86-FS-1) Marble revetment fragment, probably from anta Pl. 78

Pres. H. 0.178, pres. W. 0.150, Th. 0.036–0.045 m.

Rectangular piece of large-grained white marble, broken along upper or lower surface and on one vertical side. Smooth groove *ca.* 0.032 m. wide along one side of otherwise roughly finished back. Traces of mortar on back. On front, three shallow vertical grooves or "flutes" *ca.* 0.37 m. wide, rounded on at least one end. Many similar pieces have been found in the Roman Bath (e.g., IA 76-16, 76-165, 78-49, 78-98, 78-105), but these have shallower or deeper flutes and are not from the same series.

8 (86-FS-5) Inscription fragment Pl. 78

Pres. H. 0.033, pres. L. 0.072, pres. W. 0.055 m.

Gray, grainy marble, all sides broken. Letters have simple serifs.

]PE[

GLOSSARY

Magnetometry measures the localized disruption of the earth's magnetic field caused by the presence of natural (rocks, soils, and iron-bearing minerals) and cultural (artifacts, especially metals and ceramics, structures, and pits) subsurface features. Each class of material has a characteristic magnetic signature that can be identified once the readings have been filtered to remove the diurnal effect, i.e., the natural daily fluctuations in the intensity of the earth's field. The unit of measurement is the nanotesla (nT).

Anomaly: a disturbance in a magnetic, electrical, or electro-magnetic field that indicates the presence of subsurface features or artifacts.

Thermoremanent anomaly: a particular type of magnetic anomaly created when magnetization is imparted to an object by heating. Iron particles in the material (e.g., metal ores, clay, soils) are freed during the heating process and align themselves with any available field and preserve the new orientation upon cooling. Hearths, kilns, burned house remains, and bricks provide significant magnetic contrasts with surrounding soils.

Electrical Resistivity records how easily electrical current flows through the ground. Alternating electrical current is forced through the ground between two metal probes (electrodes), and the resultant flow of current provokes a potential difference, recorded in volts, between two other probes also inserted in the ground in the survey area; the probes can be placed in different arrays, with various spacings between probes. Subsurface stone structures and compacted soil layers (e.g., clay bedding or a use level) impede the current flow and appear as areas of high readings.

Soil Resistance is based on the same principles as electrical resistivity. The measurement of soil resistance is necessary to the computation of soil resistivity. Readings for the former are in ohms and for the latter in ohm-meters, and this difference makes resistivity more of a standardized measurement. Soil-resistance surveying also requires the use of four metal electrodes and a source of alternating current, and it can detect similar features (e.g. walls).

Self-Potential: This survey technique is based on the detection of natural electrical current flows (self-potential) in the earth. The key to the method is the spontaneous polarization that certain subsurface features, such as ore bodies, undergo. Archaeological features such as buried stone walls affect this natural flow of electricity, which can be measured in millivolts (mv) at the surface.

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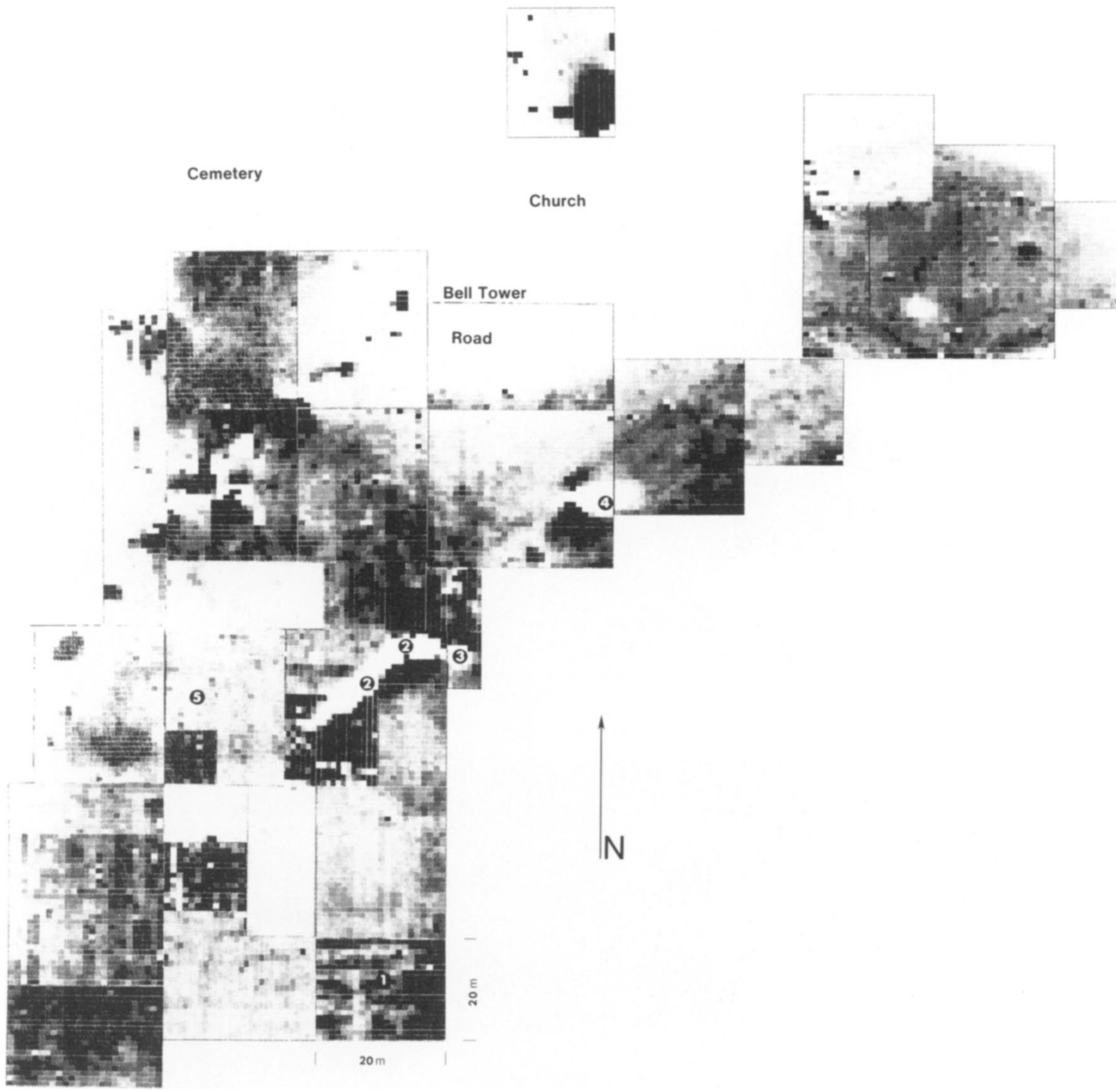
a. Interior of Fortress from tower in church yard: central and southern zones

b. Walls in Anomaly 1 (Structure 1) from east

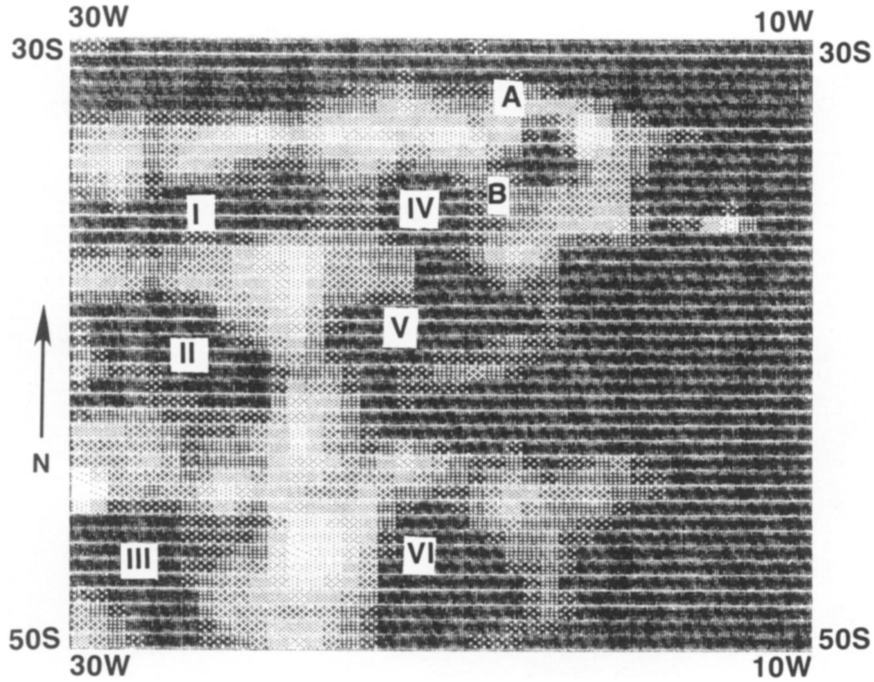
c. Interior of Fortress: southern zone

d. Interior of Fortress: walls

e. Walls in Anomaly 1 (Structure 1) from north

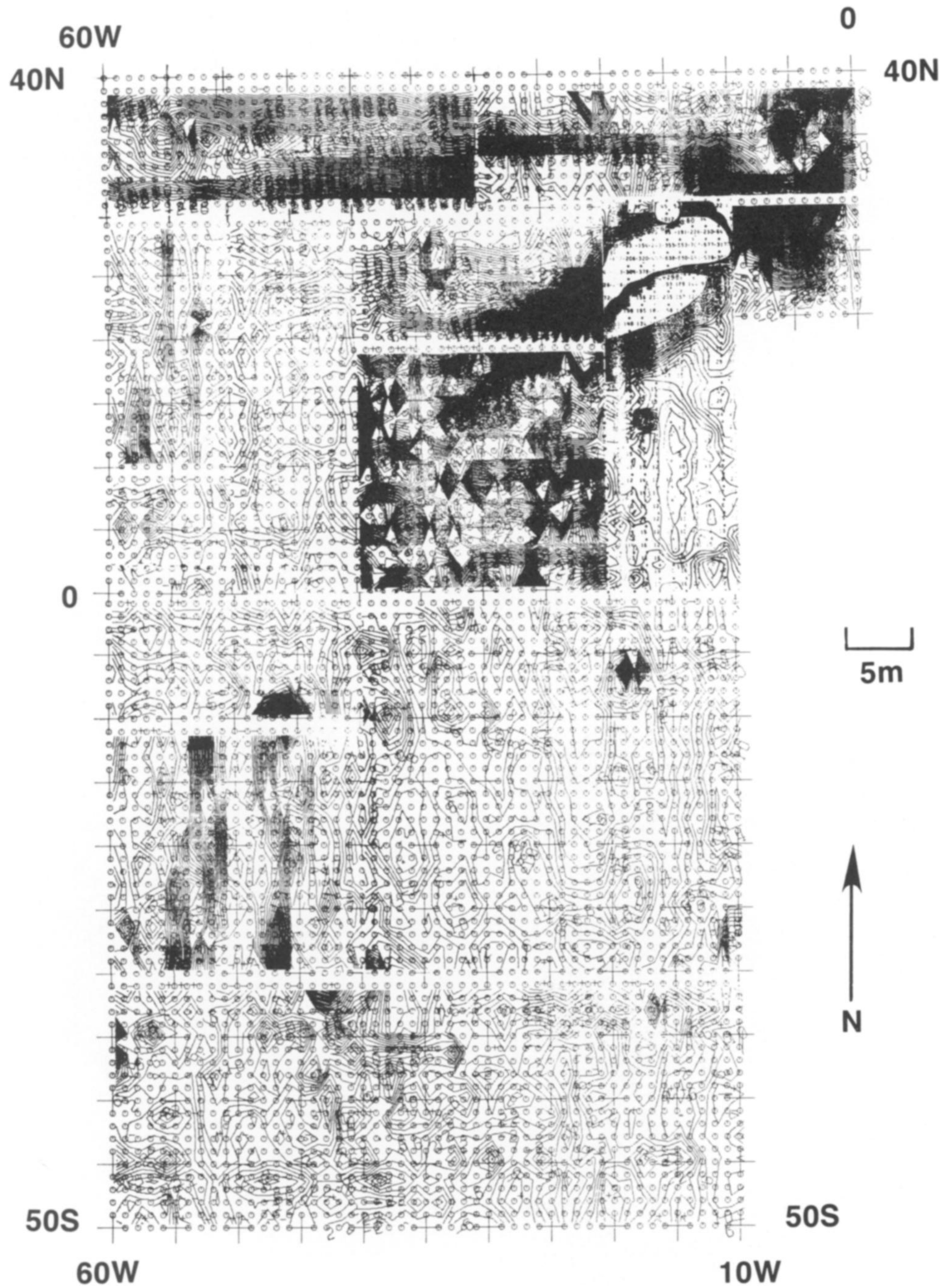


Dot-density image of magnetic readings in Fortress (major anomalies indicated by arabic numerals)



a. Dot-density image of magnetic readings in southeast corner of Fortress (contour interval = 2 nT. Area shown: 20 × 20 m.)

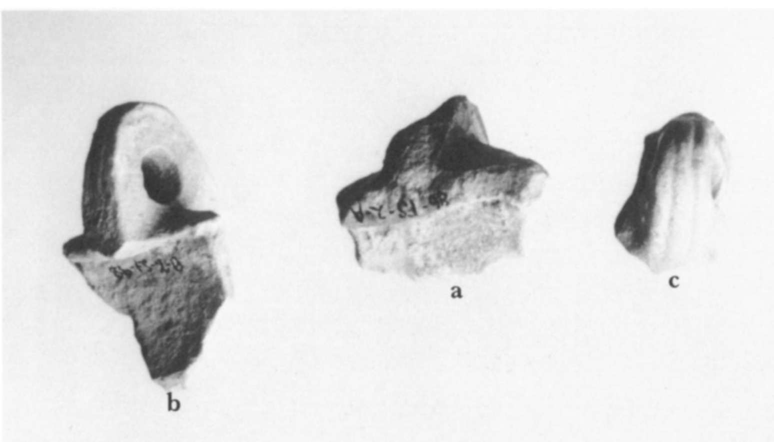
b. Work with the magnetometer



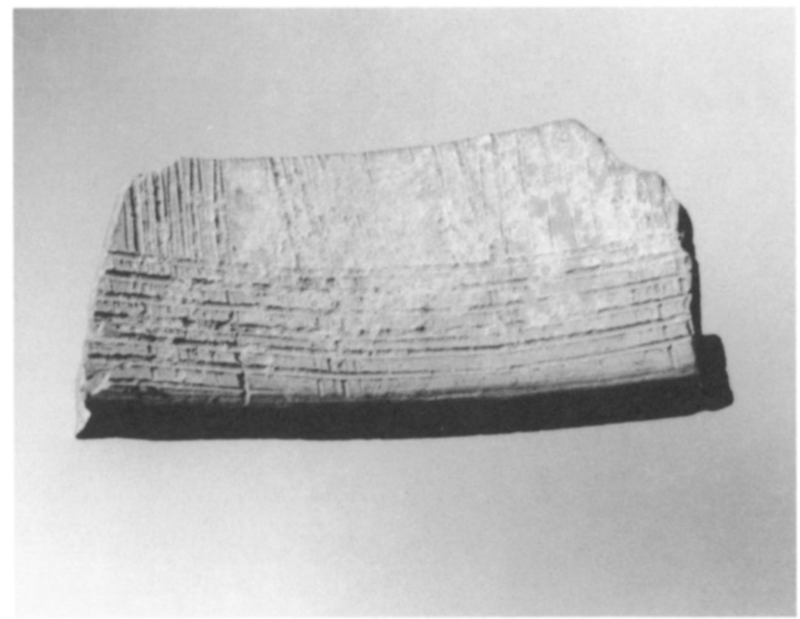
Magnetic readings in Fortress, 1985 (contour interval = 3 nT)

a. Wall with apse (Structure 3) from southeast

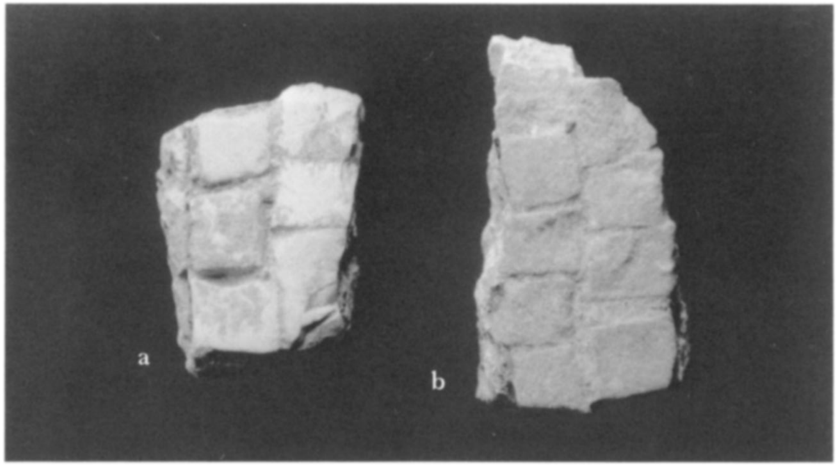
1. Stamped Roman plate fragment (1:1)



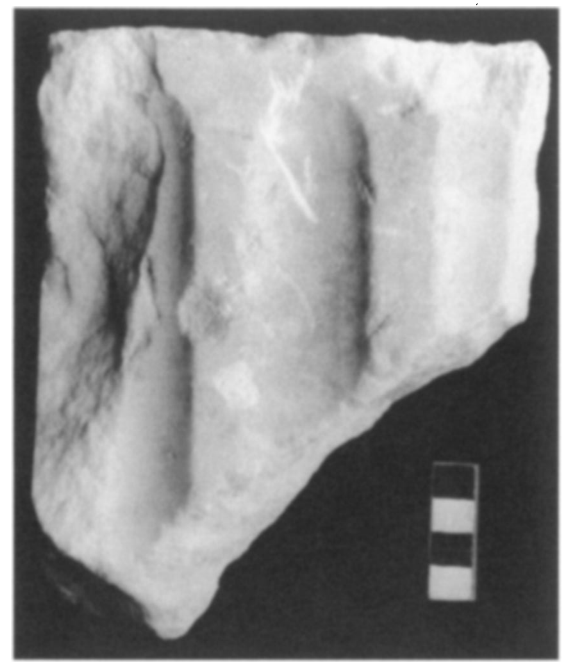
2. Lamp fragments (1:1)



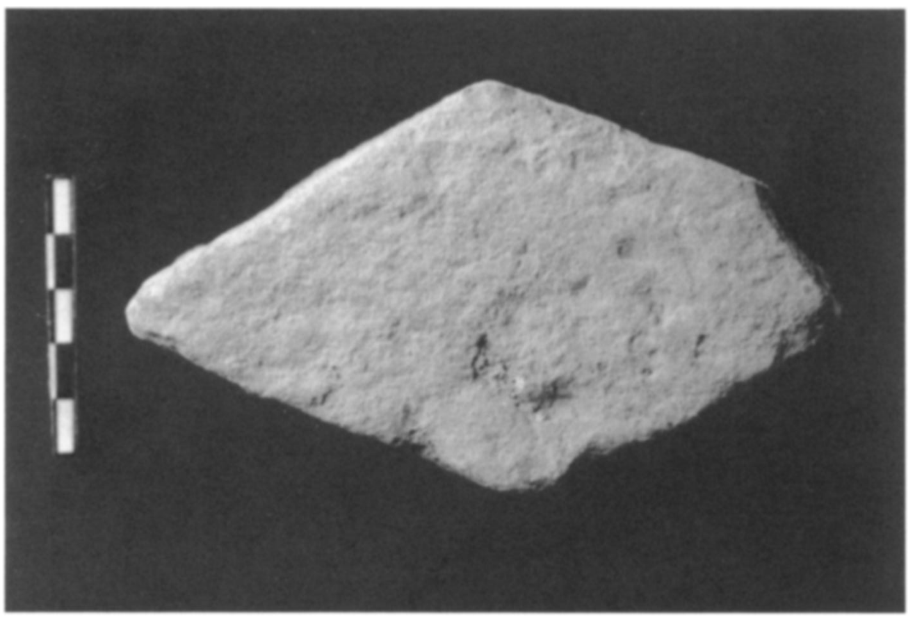
3. Beehive fragment (1:1)



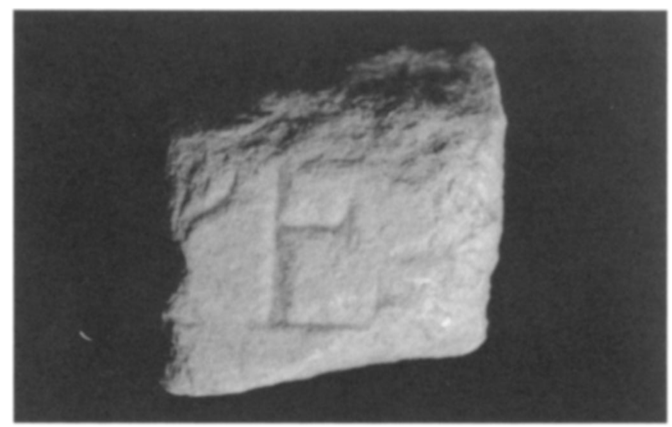
5. Mosaic tesserae (5:6)



7. Marble revetment fragment



6. Diamond-shaped floor tile



8. Inscription fragment