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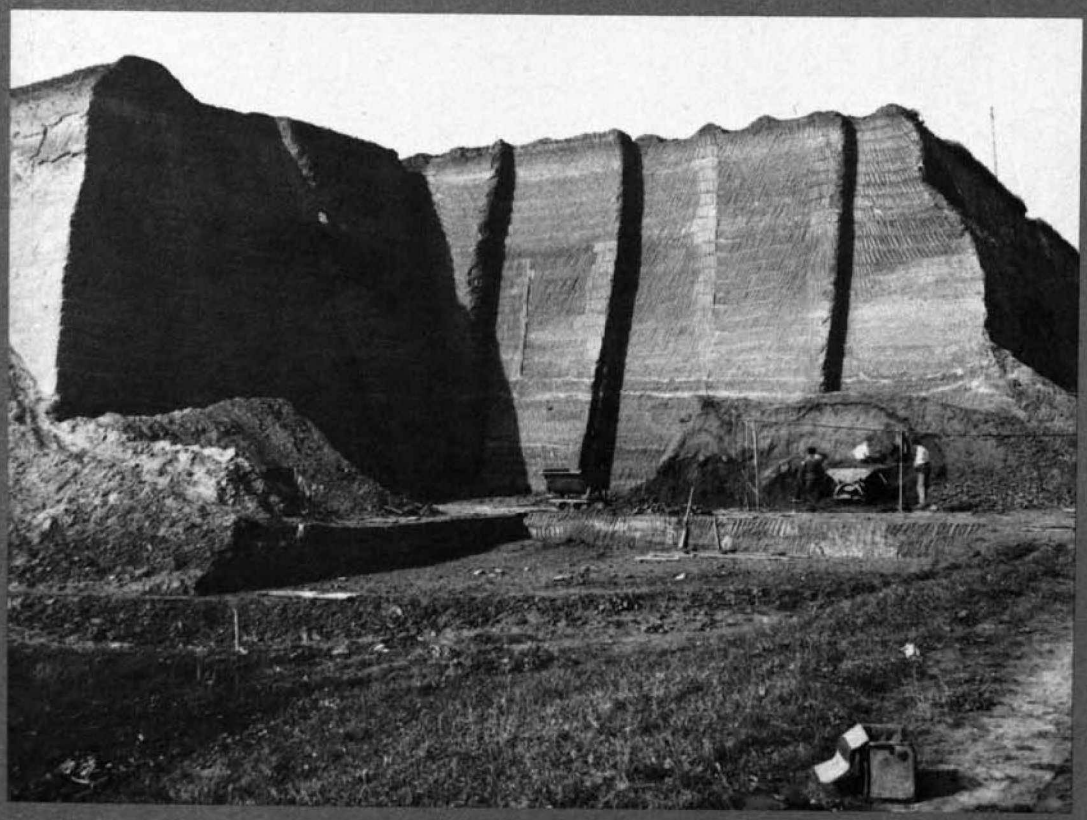

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Field Reports: Excavation and Survey

Publications

Book Reviews CURTIS RUNNELS

Soil Erosion and the Archaeological Landscape of Methana, Greece

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An attempt is made to assess the effect of soil erosion on the archaeological record of Methana, Greece, by detailed analysis of the distribution and quality of sherds in relation to soil conditions and land morphology. Sherds have been concentrated through soil removal caused by surface wash, the dominant erosion process, at least on terraced slopes. The chief agent of sherd displacement is probably livestock. Sherd distribution is therefore thought in general to be a reliable archaeological indicator. Certain of the agricultural terraces are likely to be of Classical age, and judging from their condition and from recent erosion processes affecting them, they appear to have been largely stable throughout the period of their existence.

Introduction

Intensive archaeological survey in Greece has revealed an "artifact-rich landscape" (Cherry et al. 1988: 159–163) but the processes which created this carpet of pottery sherds, tile fragments, and stone implements are not fully understood. It is likely that agricultural practices, in particular field manuring (Wilkinson 1982; Bintliff and Snodgrass 1988), were involved but erosion must also be considered as a possible contributory factor, particularly in a Mediterranean landscape of high relief. The archaeological survey of the Methana peninsula in Greece[1] encountered just such a landscape. The peninsula is in a central location in the Saronic Gulf (FIG. 1) but has been neglected by archaeologists and historians, no doubt because of the rugged topography. Yet in three seasons of survey over 100 sites were recorded. The sites are scattered throughout the peninsula, on the coast and in the interior, the periods of most intensive activity being the Early Helladic, Classical-Hellenistic, Late Roman, and Medieval (Catling 1987–1988: 22–23). Site definition did not prove particularly difficult since there was a marked contrast between the on-site and off-site artifact densities. There were, however, low density scatters which could plausibly be interpreted as eroded sites. Conversely, certain high-density scatters of worn artifacts seemed more likely to be the result of geomorphological processes, erosion having deposited the artifacts behind a spur or outcrop. Since most of the sites on Methana were located on slopes, the possible influence of soil erosion on site size also had to be considered. Nor could we make the assumption that off-site artifacts necessarily reflected human activity rather than geomorphological processes. It was evident that we needed to investigate the possible effects of soil erosion on artifact distribution.

Unfortunately, the peninsula of Methana offers little in the way of a sedimentary record, its stream courses being short and steep. For any analysis of the extent of erosion and any attempt at dating it, one is therefore dependent upon the data of landform and soil morphology, and the distribution of artifacts in relation to these. Thus it may be possible to be precise only about recent erosion events, although tentative conclusions about erosion in the longer term can be drawn.

The research reported here examines in detail the distribution, age, and other properties of artifacts (chiefly sherds) in relation to landform morphology and soil conditions in three selected areas. Evidence of soil erosion is deduced from these data and from observations made generally in the peninsula, and an attempt is made to assess the stability of artifact patterns since their original formation in the various types of landscape examined. The analysis concentrates upon the post-depositional environmental influences on artifact distribution, not the social, economic, and technological factors.

1. The Liverpool University Methana Survey, directed by Christopher Mee, Hamish Forbes, and Lin Foxhall, was undertaken under the auspices of the British School at Athens in 1984–1987.

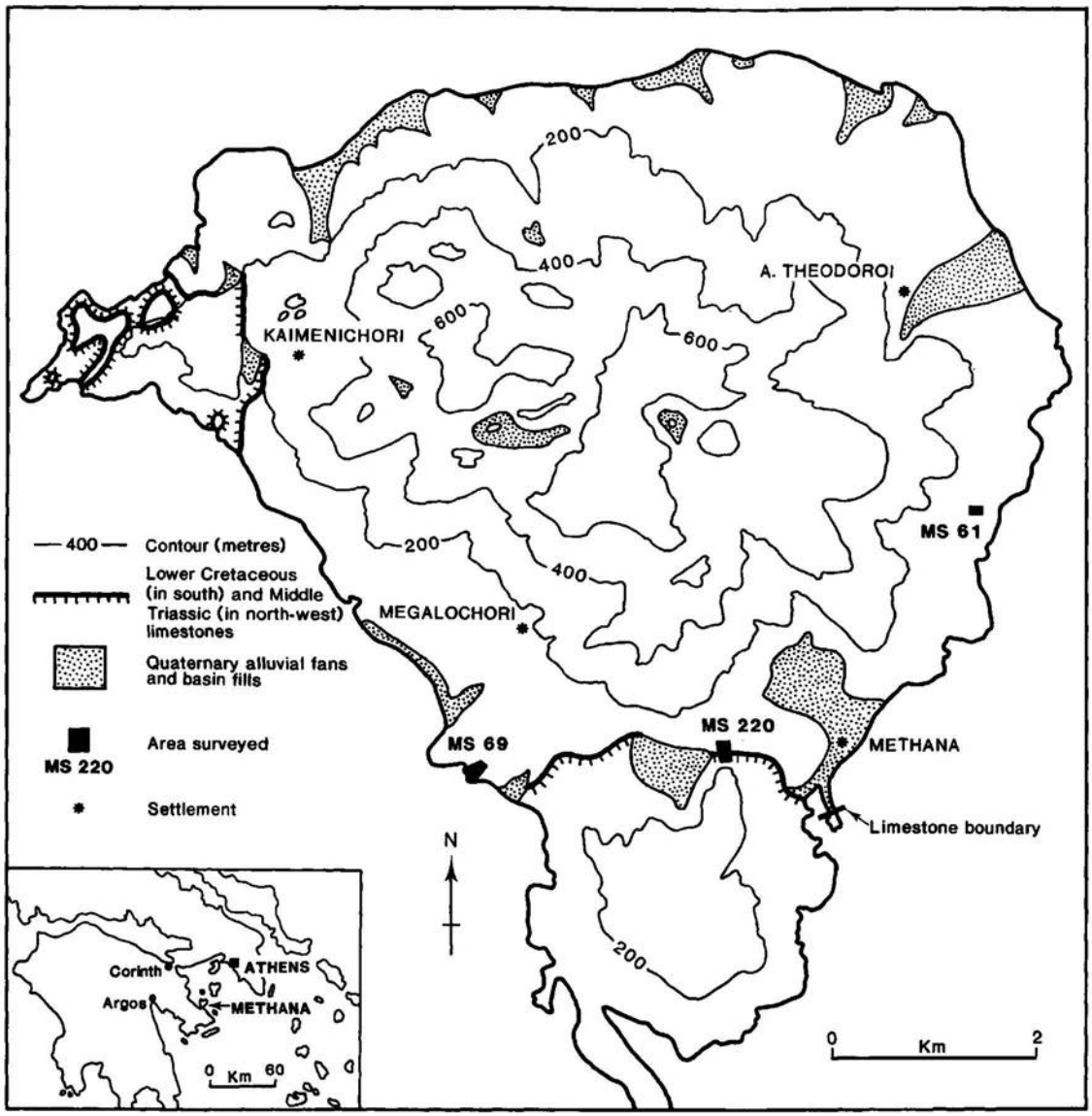

Figure 1. Methana: geology and relief, and location of MS61, MS69, and MS220.

The Physical Geography of Methana

The mountainous relief of the peninsula, 740 masl at its highest point, falls to the sea with no lowland plain. Flatlands occur in small upland basins between lava domes and in the plain of Throni, Methana's most fertile land, lying at 140 m. Apart from Jurassic and Cretaceous limestones outcropping as bold hills in the NW and south, the peninsula consists of andesitic and dacitic domes and lava flows which dominate the relief. Volcanic agglomerates commonly fill depressions between domes. Pyroclastic deposits are few. Four potassium-argon dates determined for lava rock by The Institute of Geology and Mineral Exploration (1984) range from 0.32 ± 0.07 myr to 0.9 ± 0.25 myr. It is therefore possible, though not proven, that present-day volcanic Methana is entirely a Quaternary edifice. The youngest lavas are those of the Kaimeno Vouno dome, located north of the village of Kaimenochori (FIG. 1), the eruption of which early in the 3rd century B.C. was recorded by Strabo (i.3.18), Ovid (*Metamorphoses* xv.296–306), and Pausanias (ii.34). The surface morphology of the andesite flows of the Kaimeno Vouno dome remains pristine; there is little vegetation cover apart from lichens. The limited extent of weathering and soil development is expressed in soil profile Meth 1 (FIG. 2) described from a depression in the jagged surface of the lava. This incipient soil is not typical of a lava that has been exposed for over

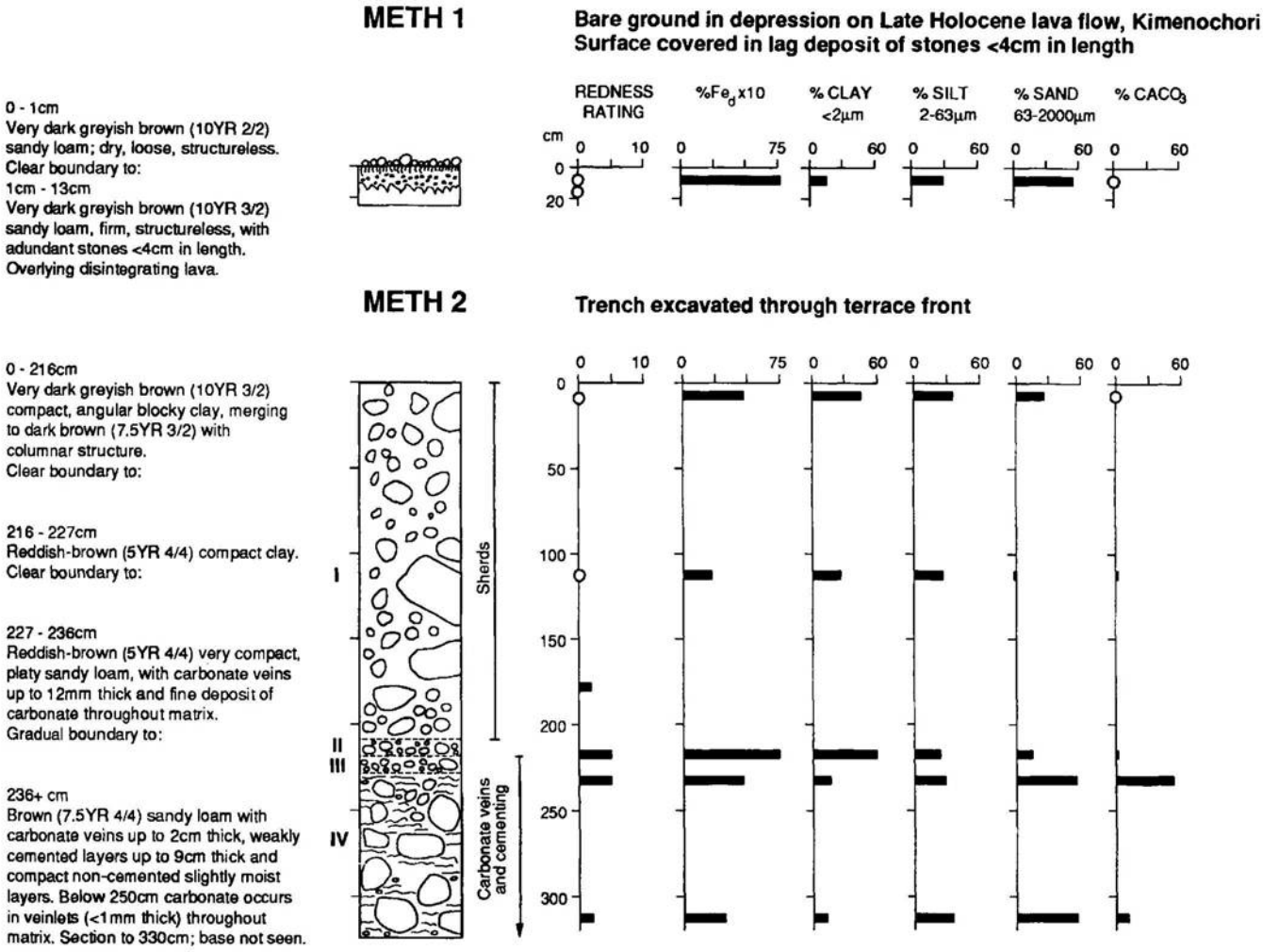

Figure 2. Soil profiles, Meth 1 and Meth 2. Redness rating is the Hurst index modified by Torrent, Schmertmann, and Schulze 1980. Fe_d = dithionite-extractable crystalline secondary iron.

two millennia. Washington (1894–1895: 805), however, could find no record of a major eruption since the 3rd century B.C., though he reports an apparently reliable reference to smoke issuing from "the recent volcano" in the north of Methana in August, 1922 (Washington 1923: 461). Nevertheless, there is no evidence that this was a major event. The age of most of the domes and flows on Methana remains unknown, but it is clear that most slopes and soils are very much older than those of Kaimeno Vouno.

The chief modifications to the compositional, volcanic landscape of Methana generally comprise stable depositional mantles on the slopes of lava domes; valley and basin fills; alluvial fans; and gorges and major gullies. In addition there is marine erosion of the cliffed coasts. The alluvial fans and basin fills are major landforms (FIG. 1). They compare with fans in other Mediterranean environments which were formed as a result of intense erosion associated with climatic conditions of the Pleistocene (Dumas 1969; Harvey 1988, 1992: 529). Fan surfaces have remained largely stable, though dissection of gorges or shallower forms and subsequent deposition within these have occurred during the Holocene and possibly the Pleistocene.

The construction of agricultural terraces significantly modified the morphology and soil of most gentle and moderate slopes on Methana. The terraces are bound by volcanic or limestone walls and have remained largely intact where abandoned. Terraces contain the effects of runoff and erosion, and their construction displaces or buries artifacts that would previously have been in the soil or on the slope. The age of the terrace systems is therefore

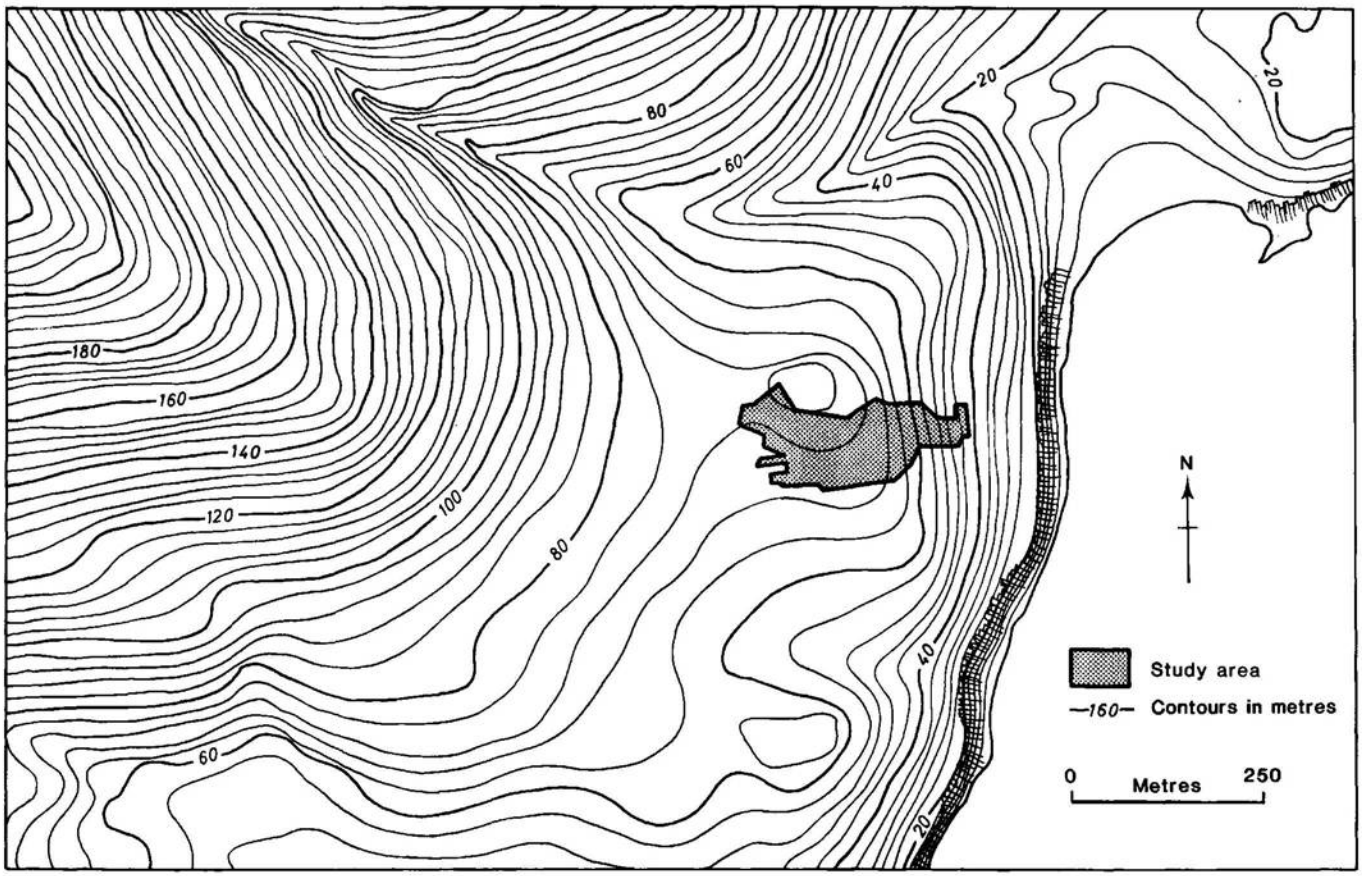

Figure 3. MS61: relief context.

a problem in the interpretation of artifact distribution and is addressed in the research.

The lava soils of Methana vary according to gradient, stability, and age of the land surface. They tend to comprise compact clay with a distinct, coarser, and often sandy surface horizon of about 10 cm in thickness. The soils are commonly of brown hue (Munsell 10YR), though in many profiles redness increases with depth. Many of the agricultural terrace soils comprise a brown soil overlying an older, undisturbed, and reddish brown soil as in profile Meth 2 (FIG. 2). In these older soils, apart from redness, the presence of illuviated clay in a Bt horizon, weak to strong carbonate cementation, and deposition of secondary carbonate as veins indicate an age which, in comparison with soils elsewhere in Mediterranean and semi-arid regions, is likely to be early Holocene or older (McFadden and Hendricks 1985: 193; Harden 1982: 21–22; Machette 1985; James and Chester in press).

On the limestone outcrops of Methana occur typical red Mediterranean soils of clay texture. In every case examined, the former A horizon had been removed. In places, there is evidence of recent downslope redistribution of the red soil by overland flow, probably triggered by burning of the *garrigue* (the low scrub vegetation, commonly of spiny and aromatic species, which is widespread on degraded or abandoned land in the Mediterranean region). Soils in pyroclastic (chiefly pumiceous) materials are lighter in texture and color than those on lava.

Experimental Design

The sites selected for study needed to fulfill a number of criteria: location on a slope; relative isolation so that there should be no contamination from an adjacent site; the existence of an artifact halo; limited size (in practice <3000 sq m); and a single period of occupation. Of the sites which met these criteria, five were eventually chosen for investigation, of which three are reported in detail below (FIG. 1): MS61 (Early Helladic, 3000–2000 B.C.), MS220 (Classical, 480–323 B.C.), and MS69 (Late Roman, A.C. 400–700).

The extent of each sample area was defined arbitrarily. First, a plane survey using a 30 m tape, prismatic compass,

and Abney level was completed. Terrace walls and other significant topographic features were mapped. Slope morphology was recorded by surveying one or more representative slope profiles transecting the area and, in the more complex relief, by recording angle and direction of slope at selected points. Second, sherd sampling was carried out using a 0.5 × 0.5 m square quadrat placed at fixed intervals along transects, with subjectively chosen positions on irregular slopes. With the exception of the moderately steep garrigue-covered limestone and lava slopes of MS220 and MS61, the terrain surveyed mainly comprised agricultural terraces. Most of the samples were therefore from terrace surfaces, but care was taken also to include sample points in other areas. At each quadrat, the characteristics of the ground surface were described in terms of slope angle, texture, and consistency of the surface soil, occurrence of soil crusting, and percentage cover of stones and vegetation. At selected locations the uppermost 20 cm of the soil was sampled and its texture, structure, consistency, and the quantity and lithology of its stone content were recorded. The soil sampling permitted the counting and description of sherds within a standardized volume of soil, measuring 25 cm × 25 cm × 20 cm deep (or of lesser depth where bedrock lay very close to the surface). These sherd samples are referred to as "topsoil" sherds.

In addition to the distribution of sherds, their characteristics offer potential insight into soil disturbance and erosion. The size, surface condition, and edge-rounding of sherds reflect to some degree the breakage and abrasion associated with tilling, transport, or surface wash. Although it is appreciated that pottery is not uniform in its response to mechanical wear, it was thought worthwhile to examine patterns of sherd size and wear and to suggest possible causes for the distributions observed. Therefore, for each sherd, the age, longest axis, and degree of wear (on a scale of 1 to 5) were recorded.

Much of the information recorded in the quadrat and topsoil sampling is amenable to statistical analysis. The statistical tests applied are all non-parametric and include Spearman rank correlation, the Chi-square test of association, and the Mann-Whitney and Kolmogorov-Smirnoff tests of difference (Siegel 1956).

Results

MS61: Early Helladic

The precise archaeological site center of MS61 has not been confirmed but is believed to lie on the knoll to the NW of the area sampled. The area mapped occupies a hill of dacite lava at 70 m above sea level and would be isolated from material eroded off the major slope above by a col to the west (FIG. 3). The profiles in Figure 4 illustrate the important difference between the steep eastern and more moderate southern slopes of the area. The former is rocky and garrigue-covered. The terraces of this slope are mostly isolated and degraded, the chief processes having been rainsplash and surface wash which have formed a crust of compact sand up to 2 cm in thickness. On such degraded terraces and on some surfaces which have not been terraced, overland flow is clearly concentrated but has not caused incision. The uppermost 10 cm of soil is sandy and very stony and overlies a compact to extremely compact clay or clay-loam. A "lag" deposit of stones is common on these surfaces and incorporates the locally high densities of artifacts. The larger terraces of the southern slope remain in cultivation. Their soils lack the stone-covered and crusted surfaces of the steep slope but do contain a 10–15 cm thick sandy horizon over a very compact, clayey subsoil.

Of a total of 396 sherds collected in this area, 384 were Early Helladic, 7 were Classical-Hellenistic, and 2 modern; there were also 3 obsidian fragments. The difference between the high density of surface sherds associated with the degraded terraces and the low sherd densities on the larger cultivated terraces of the gentler slope is striking (FIG. 5). On the steeper slope, sherd ***density*** decreased with distance downslope but there is no statistically significant variation in sherd ***size*** either with distance downslope or with slope angle. A higher proportion of the larger fragments, however, were on the gentle slope. The few Classical-Hellenistic sherds did not tend to be larger than those of Early Helladic date.

MS69: Late Roman

The site center of MS69 is defined by Late Roman walls (within which no examination of the soil was made). It occupies a terrace upon a bench and is some 10 m from a steep slope to the sea (FIG. 6). Geology is varied, including limestone outcrops, lava, and pyroclastic deposits (FIG. 7). Typical volcanic clay soils lie on the bench; the pyroclastic sediment on the steep slope carries a deep but poor sandy soil in which the plowsoil was 12 cm deep and tended to contain less silt and clay than the subsoil. Terraces throughout the area remain in use.

Of 216 sherds counted in the quadrats, 210 were identified as Late Roman, 3 Early Helladic, 1 Classical-Hellenistic, 1 Medieval, and 1 modern. A clear maximum in the surface sherd map occurs on the Late Roman site, with relatively low values across both the bench at the same elevation to the south and upon the steep slope (FIG.

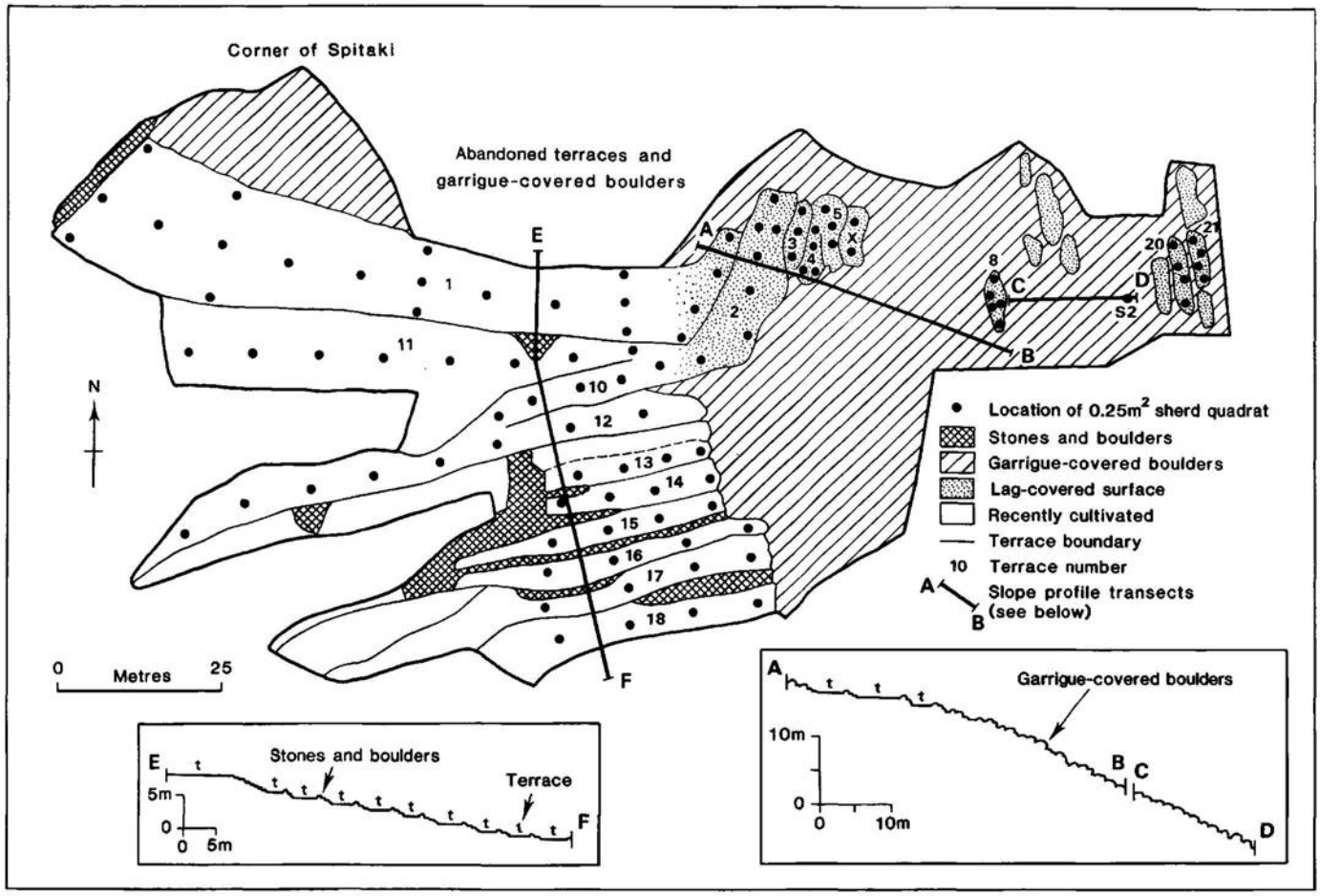

Figure 4. MS61: topography, terrace numbers, and location of sample points.

8). The exception on the slope occurs at the south end of terrace T10 where Early Helladic and Classical-Hellenistic sherds were mixed with Late Roman. This position lies downslope of a small limestone cave which is likely to have been a focus of activity but was not explored. Sherds within the topsoil were counted in nine quadrats outside the Roman walled area and near the transect of the slope profile. Values for quadrat 1 (T4) and quadrat 3 (T5) on the bench were 75 and 25 respectively. On the slope below the bench counts within the soil ranged between 1 and 11. The size distribution of Late Roman topsoil sherds varied significantly between bench and steep slope, there being a much larger proportion of <1 cm sherds (41% compared with 16%) on the slope. There was no significant difference in wear between bench and slope, however.

Slumping has occurred on the fronts of several terraces built in the weak pyroclastic sediment of the steep slope. This was the only evidence of recent mass-wasting in any of the areas sampled, and it is likely to have occurred throughout the life of the terraces and possibly before. Slumping would certainly cause downslope movement of any artifacts within as well as upon the soil and is the only situation encountered where sherd movement is likely to have been by a process other than those acting upon the ground surface.

The slumping in the front of terrace T10 had exposed a meter-deep section. Within this section the soil was uniform (apart from the slight textural difference of the topsoil and an increase in moisture content and firmness of soil with depth) and revealed no buried "sub-terrace" surface. Fourteen sherds were found between 5 cm and 95 cm below the surface. These were Late Roman, except for one Classical-Hellenistic sherd at 40 cm. That only a few sherds counted in the whole of area MS69 were other than Late Roman points to that period as the likely time of terrace building, possibly on the volcanic bench as well as on the steep slope. Any form of arable agriculture on the latter would have required some form of terracing, so

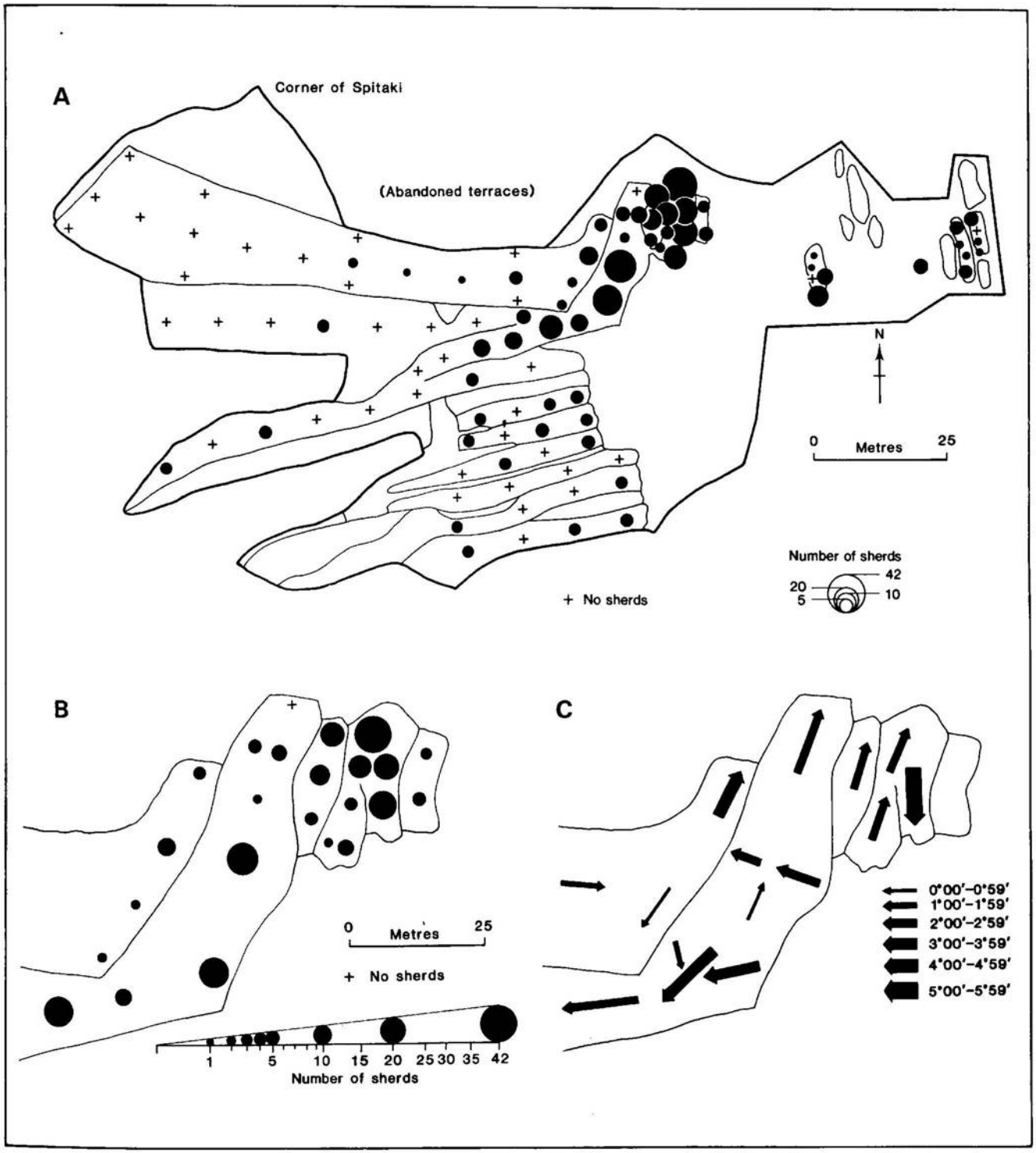

Figure 5. MS61: surface sherds per 0.5 sq m quadrat.

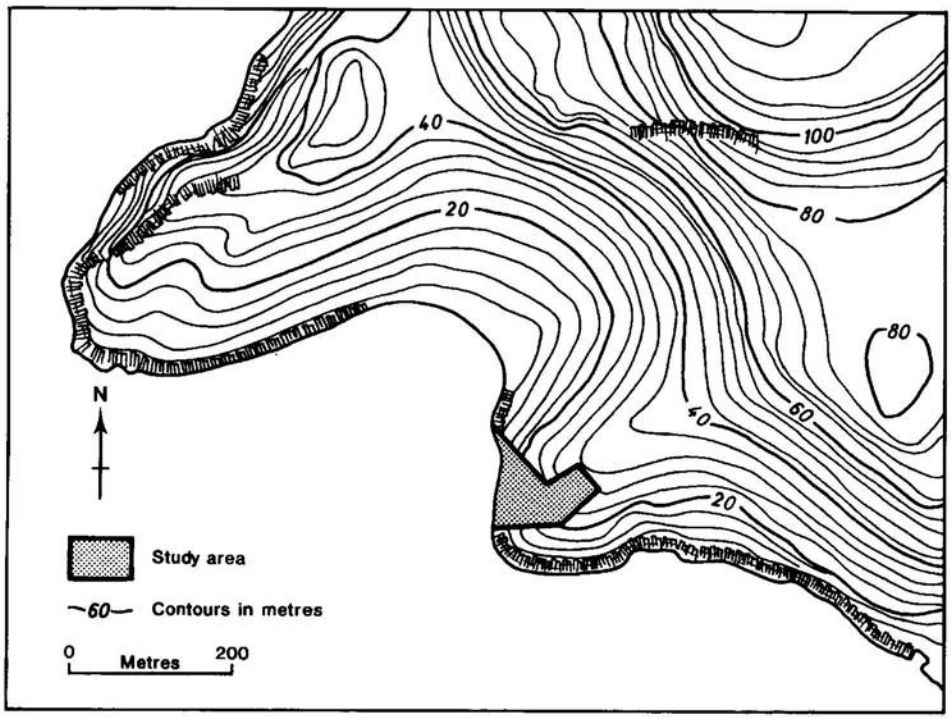

Figure 6. MS69: relief context.

it is possible that the pyroclastic slope may not have been used before Late Roman times.

MS220: Classical

In terms of detailed topography and especially of artifact distribution, the area of MS220 was the most complex of those studied. The area sampled extends from the lower, moderately steep slope of Cretaceous limestone to gently sloping ground on volcanic agglomerates (FIGS. 9, 10).

The limestone has a complex morphology with local slopes in excess of 40°. Scattered in the predominantly rocky and boulder-strewn surface are terraces comprising walled pockets of soil, now much degraded, as well as natural pockets of soil. The slope has a moderately dense cover of garrigue (*Pistacea, Quercus coccifera, Juniperus, Cistus, Erica, Lavandula,* and *Phillyrea*). Where the gradient is less, near the downslope limit of outcropping limestone, a number of larger terraces occur, though these are also eroded and were abandoned for agricultural purposes at some unknown date.

The soil of the limestone slope is *terra rossa*. From the red or reddish-brown clay a former topsoil has been stripped by surface wash, though where soil pockets are shielded from runoff by boulders or by rock outcrops, an A horizon of slightly darker, reddish-brown color lies to a depth of 10 cm or so.[2] This protection against runoff channelling into natural soil pockets and old agricultural terraces was observed to be important: where runoff was unimpeded it had resulted everywhere in the formation of a surface crust and stone lag cover, the former typically 2–3 mm thick but in places 1 cm, and commonly of platy microstructure with crude laminations. Stones within the residual soil were angular and derived from the subjacent bedrock: they had not been displaced downslope, nor presumably had the sherds found with them. No evidence of rilling or gullying was recorded. The importance of grazing in the area is evident in the presence of a goat path that runs across the limestone slope (FIG. 10).

The landscape of the volcanic area stands in marked contrast to that of the limestone; the surface of the volcanic agglomerate slopes gently toward a deep but stable gully. The terraces are mostly large and in use at present. The dark reddish-brown volcanic soil is compact to ex-

2. Loss on ignition was determined for all samples as an estimate of organic matter content. Values, which lay between 5.3 and 11.2%, may be higher than expected for degraded soils, but clearly reflect significant levels of organic input from the garrigue vegetation. As ignition was only at 450°C, there should not have been a significant loss of any fraction other than organic matter. The beneficial effects of the humus content on physical and nutrient conditions would reduce the erodibility of the soil.

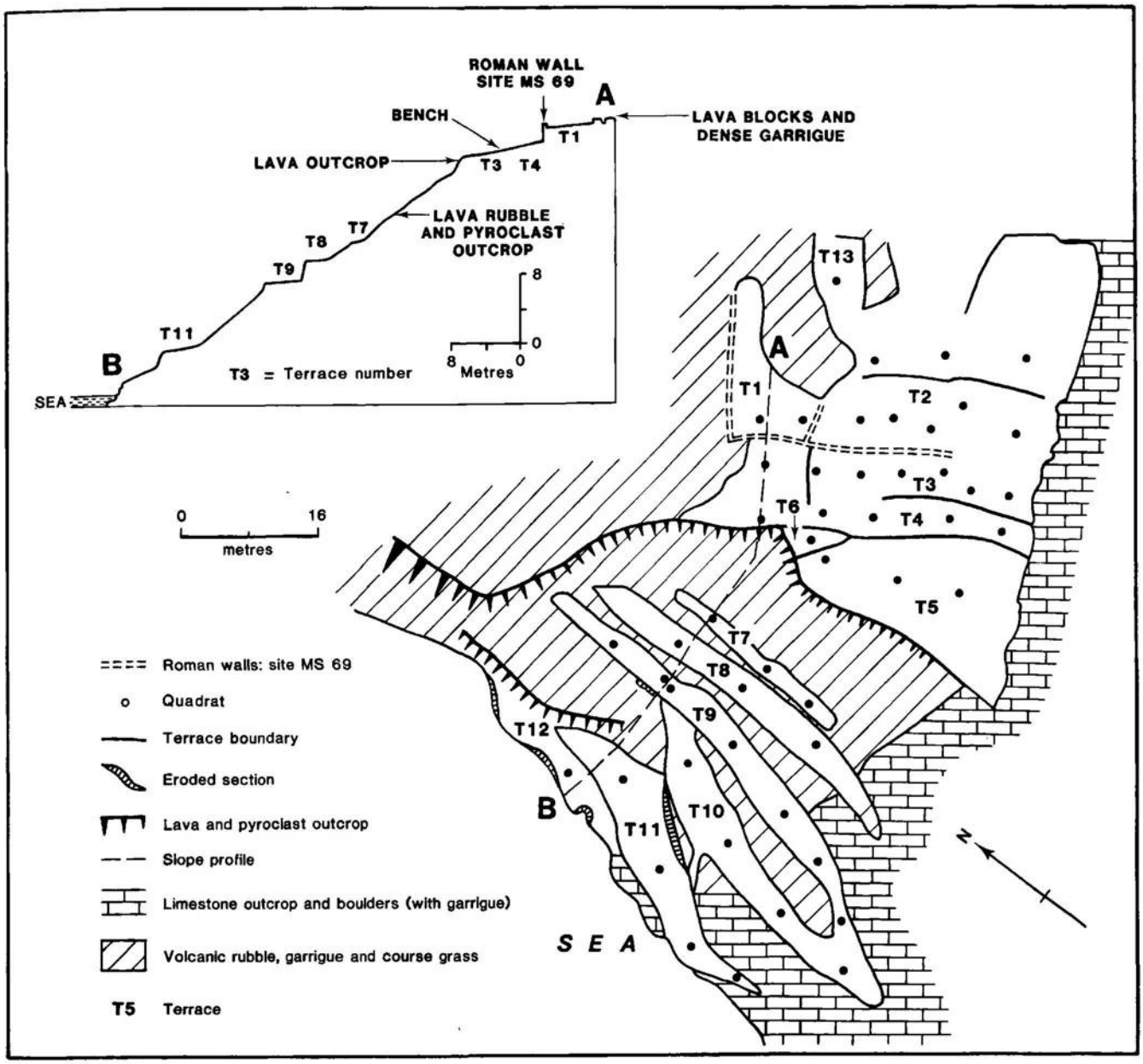

Figure 7. MS69: relief, geology, terrace numbers, and location of sample points.

tremely compact clay, with the uppermost 10 to 12 cm commonly of coarser silt or sandy loam texture. At the time of sampling, a surface crust occurred on most terraces except where soil had been tilled within recent months. Gradients recorded within quadrats on terraces varied from 0° to 4° 20′, and crusting occurred on gradients as low as 1°.

The geological boundary between limestone and volcanic agglomerate appears to coincide with the garrigue boundary plotted in Figure 10 or, in places, lies some meters downslope of this. The related soil boundary is a gradual one, with limestone stones and boulders intermixed with volcanic soil at least 24 m downslope from outcropping limestone bedrock. Fragments of lava have also been displaced upslope and incorporated into the *terra rossa:* the means of their transport was clearly human, volcanic soil probably having been carried to augment the soil volume and nutrient status of the limestone terraces.

Numbers and ages of surface sherds in each of 87 quadrats are shown in Figure 11. Classical and Early Helladic

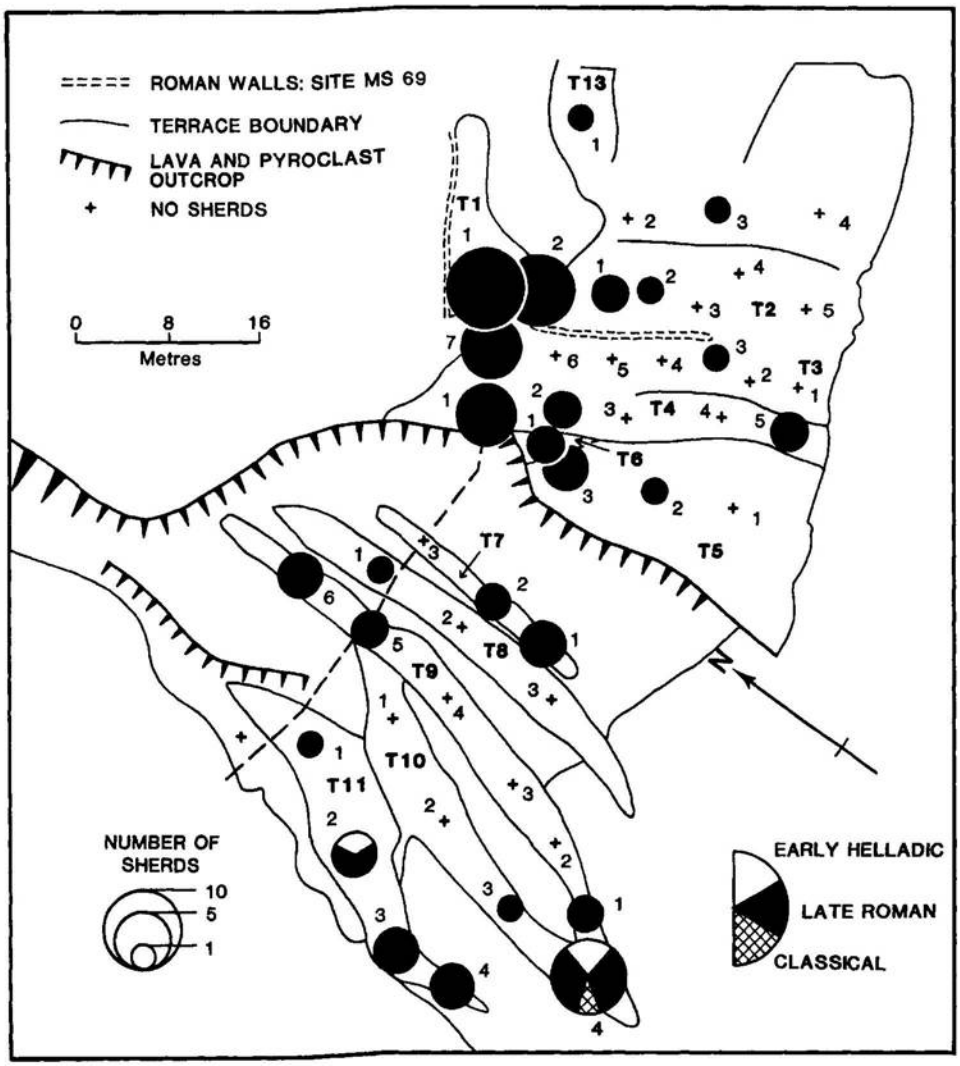

Figure 8. MS69: surface sherds per 0.5 sq m quadrat.

sherds occur to the south of the gully, with Classical and Late Roman to the NW, the latter presumably related to a Late Roman site north of MS220. Early Helladic sherds are more numerous on the volcanic than on the limestone slope, though they appear on the latter between quadrats 14 and 25. In this locality occur the highest sherd numbers. There is a clear and apparently significant concentration in quadrats 14 and 15 (32 and 26 surface sherds respectively) upon an old terrace, sloping at 4° with pronounced stone cover and a 2 mm-thick soil crust, and also in quadrat 25 (19 surface sherds) on a smaller abandoned terrace of 1° 50′, the slope also being lag-covered with a 3 mm soil crust. The two terraces which carry this peak in the sherd distribution occur on an irregular bench on the otherwise steeper limestone slope. Upslope of this bench sherd numbers are low.

The pattern of sherds recorded within the topsoil where soil was sampled is shown in Figure 12. The contrast between the spatial patterns of surface and subsurface sherds is striking: in place of the peak in the surface distribution there is a spread of high values extending from the limestone bench to the base of the limestone slope, a distance of nearly 40 m. The terrace containing quadrats 14 and 15 is represented in terms of subsurface sherds by quadrat 12, where 105 Classical sherds were counted within the soil. The largest count of topsoil sherds, 109 (87 Classical, 22 Early Helladic), lay beneath quadrat 49, however.

The stratigraphy of sherds—ground surface over topsoil—is of interest. Where Early Helladic material overlies Classical, as in quadrats 12, 25, 49, and 67, the former has clearly been transported by a human or natural agency.

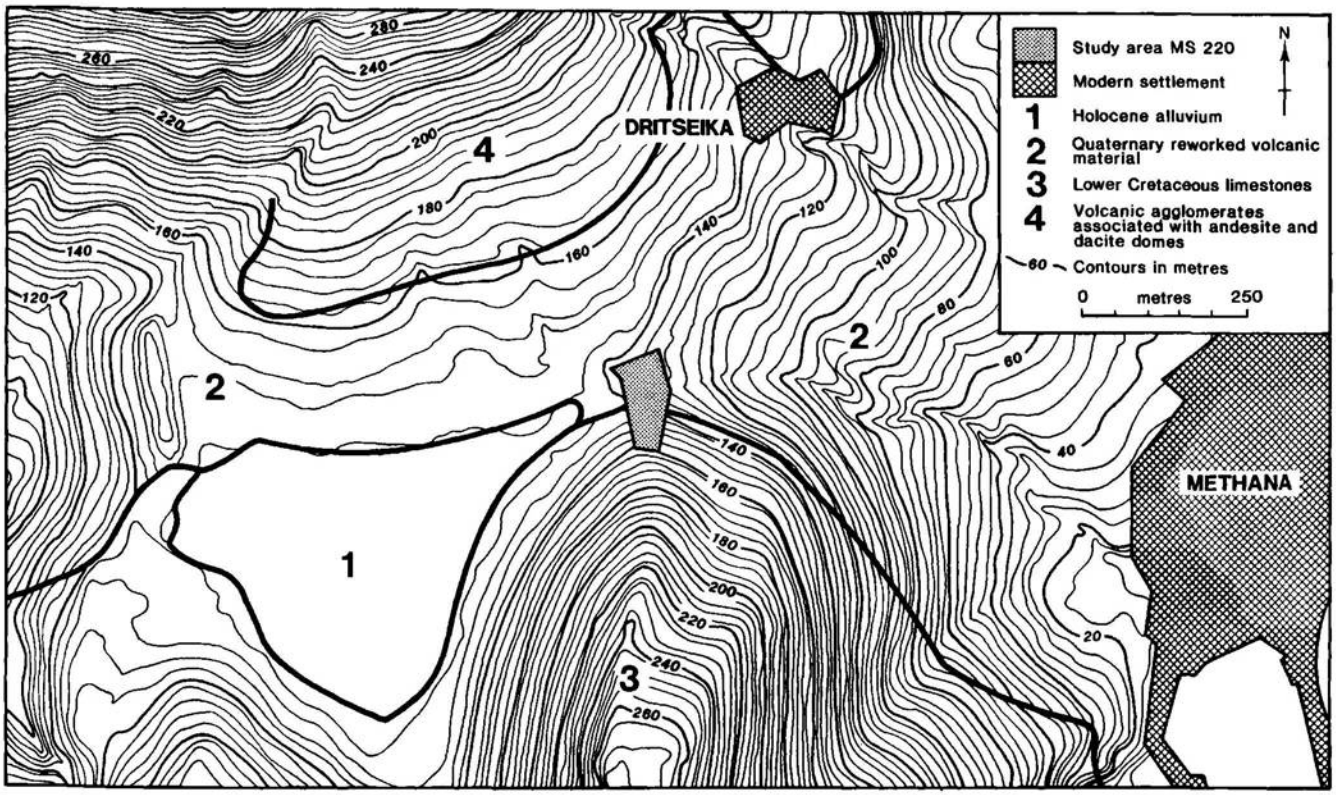

Figure 9. MS220: geology and relief context.

Judging by the attitude of the Classical sherds within what is a very compact former subsoil, the Early Helladic sherds on the surface do not owe their presence to mixing by cultivation: they have been introduced by a lateral movement such as kicking or manure-spreading.

In addition to the distribution of sherds, their quality offers potential insights into soil disturbance and erosion. Therefore, patterns of sherd size and wear were examined and an attempt was made to suggest possible causes for the distribution observed. The statistical analysis was restricted to Classical sherds, as these alone occurred in large number. Surface sherds were treated as a separate sample from topsoil sherds. As a first step in the analysis, the proportions of *topsoil* sherds which were large (long axis >4 cm) or small (long axis <3 cm), and relatively well preserved (wear class 3 or less) or highly worn (wear class 5) were determined for each quadrat in order to map these characteristics using proportional circles. Only sherd samples greater than five in number were processed (FIG. 13). A striking feature of the maps is the difference between the lower volcanic area and the higher, steeper limestone slope. Sherds within the volcanic soil are significantly more worn and significantly smaller than those within the limestone soil. This may reflect a distinct difference between the volcanic and limestone soil or terrain, or a more gradual shift in conditions downslope. The tendency for values to change across the landscape divide is, however, remarkable.

Wear and length of the less abundant *surface* sherds were introduced into the analysis by treating the frequency distributions of surface and topsoil sherds for limestone and volcanic areas (TABLE 1). Sherds found within the volcanic soil are significantly smaller and very significantly more worn than those found lying upon the volcanic soil surface. There is no similar difference between surface and topsoil sherds on the limestone slope. The wear of surface sherds is greater on the volcanic than on the limestone soil, but there is no significant difference in length. The sherds within the volcanic soil are also significantly more worn than those within the limestone soil.

There are three possible reasons for the greater fragmentation and wear of sherds found in areas which are cultivated at present, compared with those situated higher on slopes where terraces are abandoned and degraded: 1) the sherds of the lower cultivated slope have been transported greater distances by erosion; 2) these sherds have been battered by more intensive or more long-term cultivation; or 3) they were more worn and smaller than the

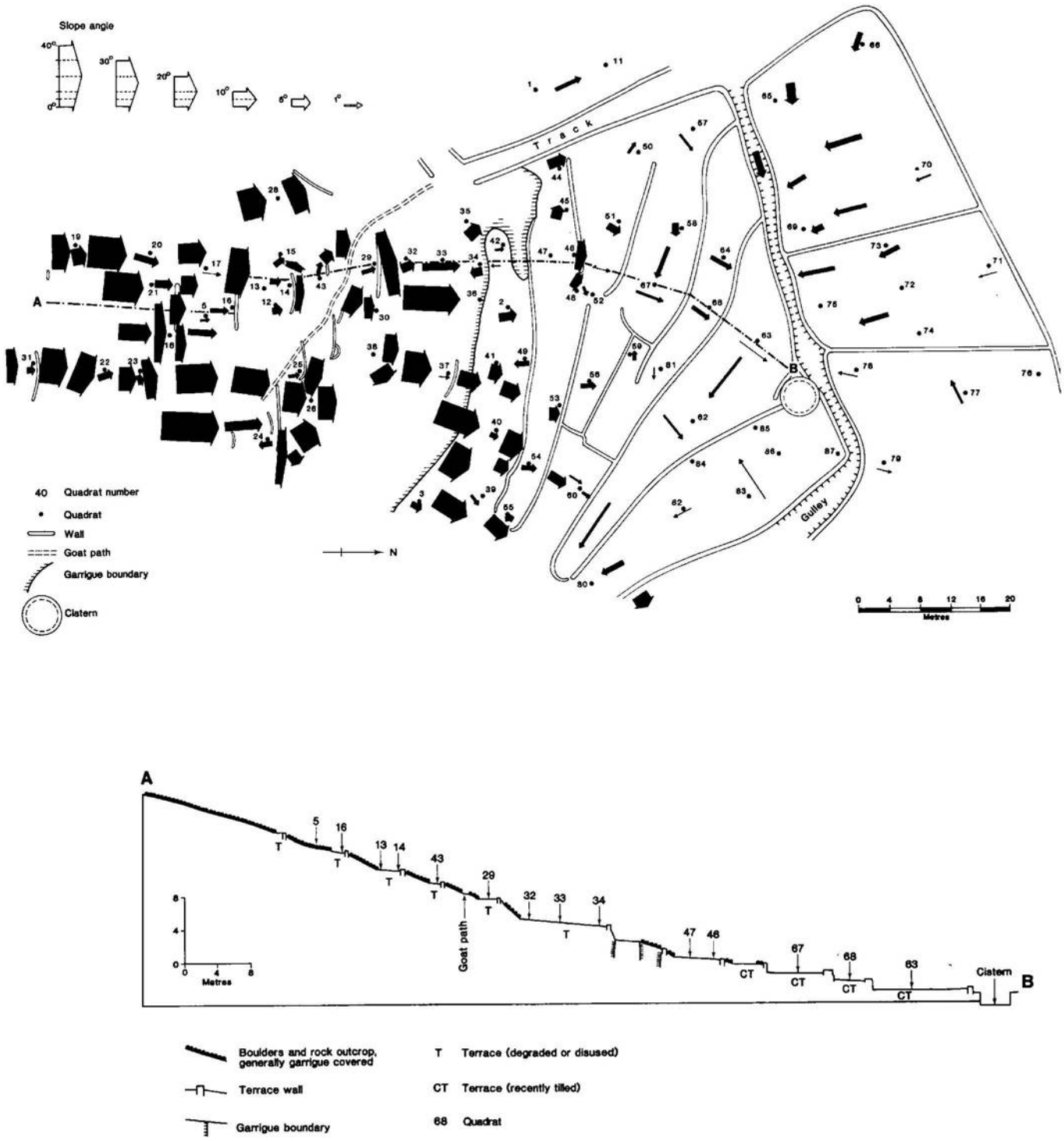

Figure 10. MS220: topography.

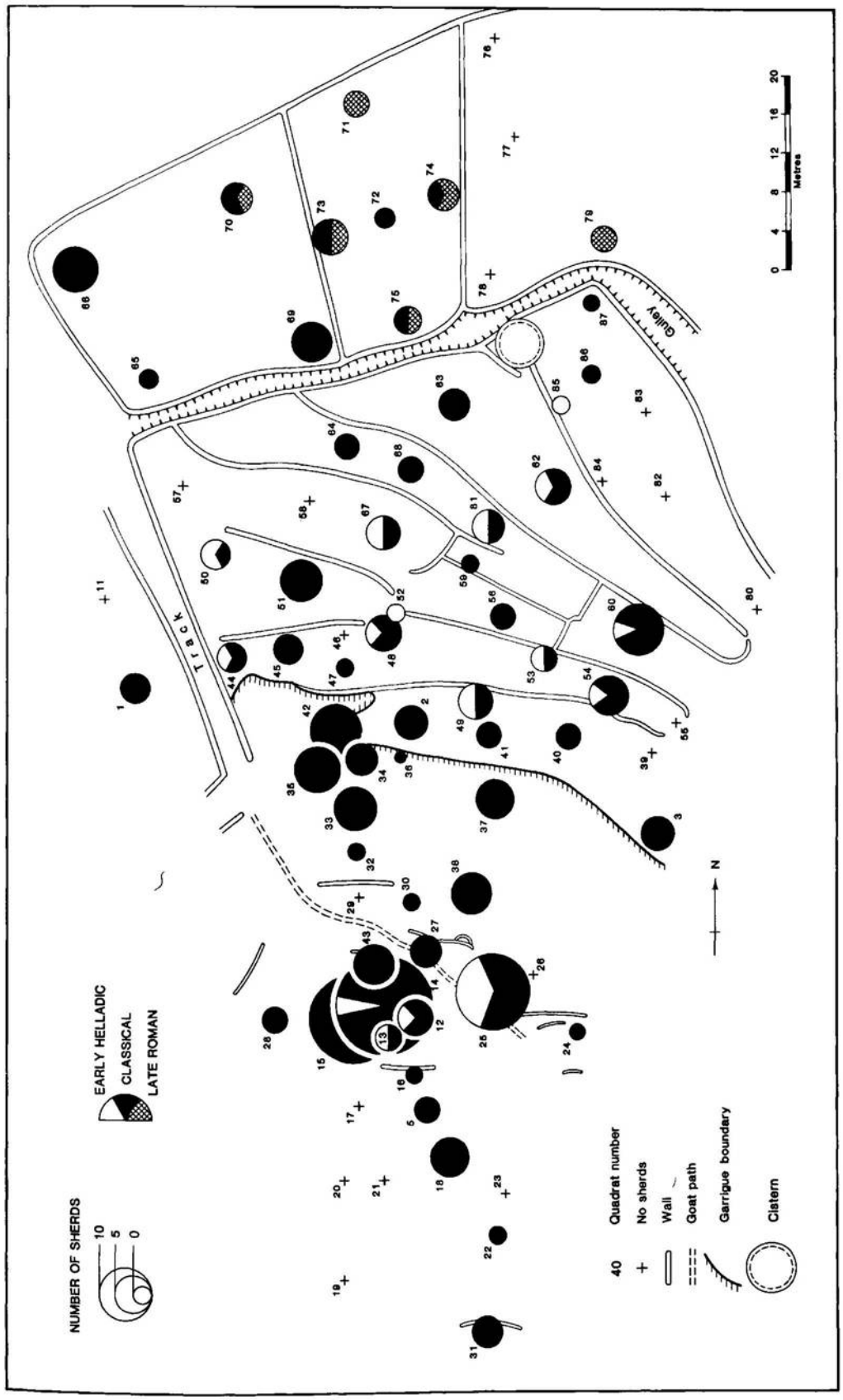

Figure 11. MS220: surface sherds per 0.5 sq m quadrat.

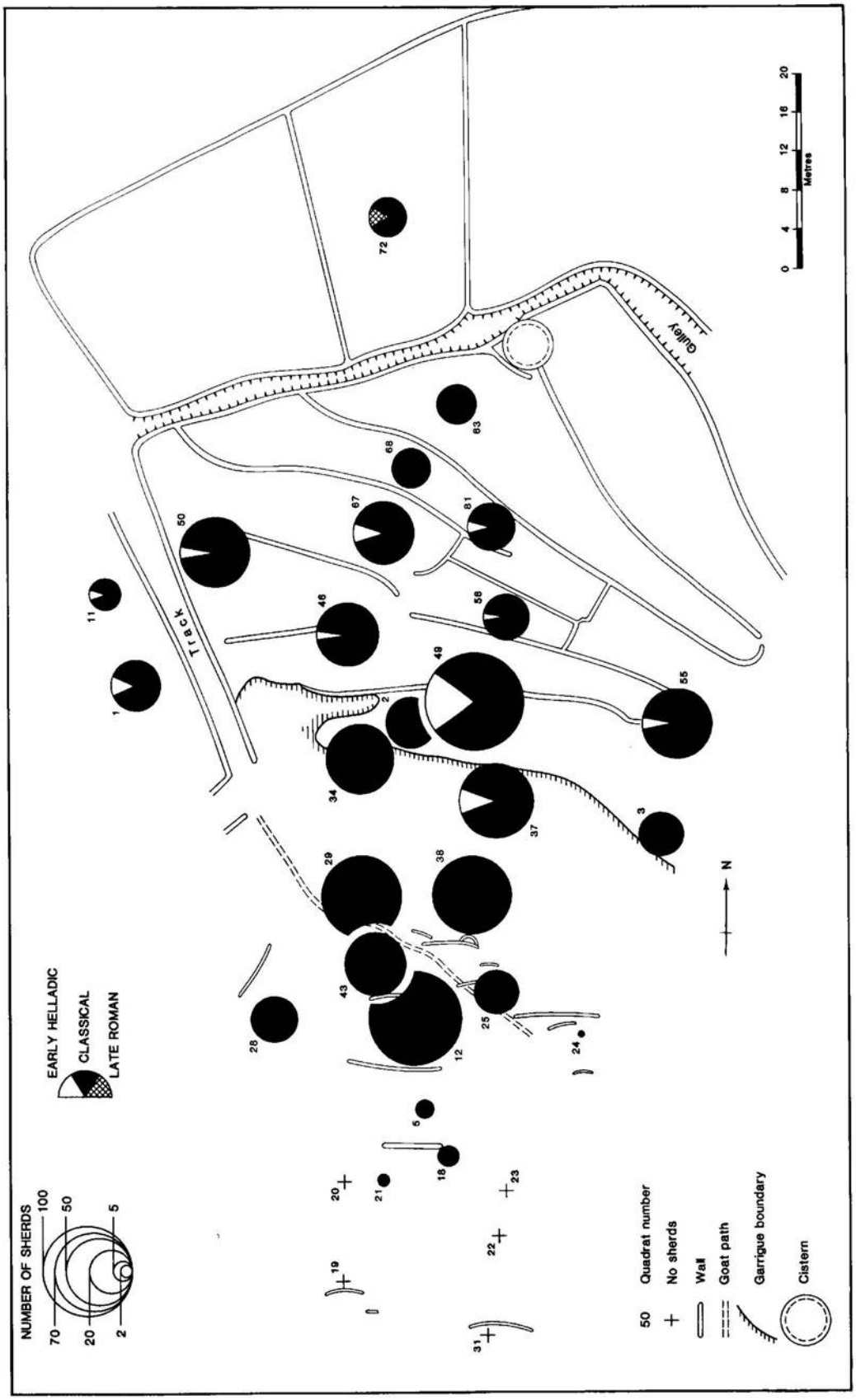

Figure 12. MS220: topsoil sherds per 0.25 sq m.

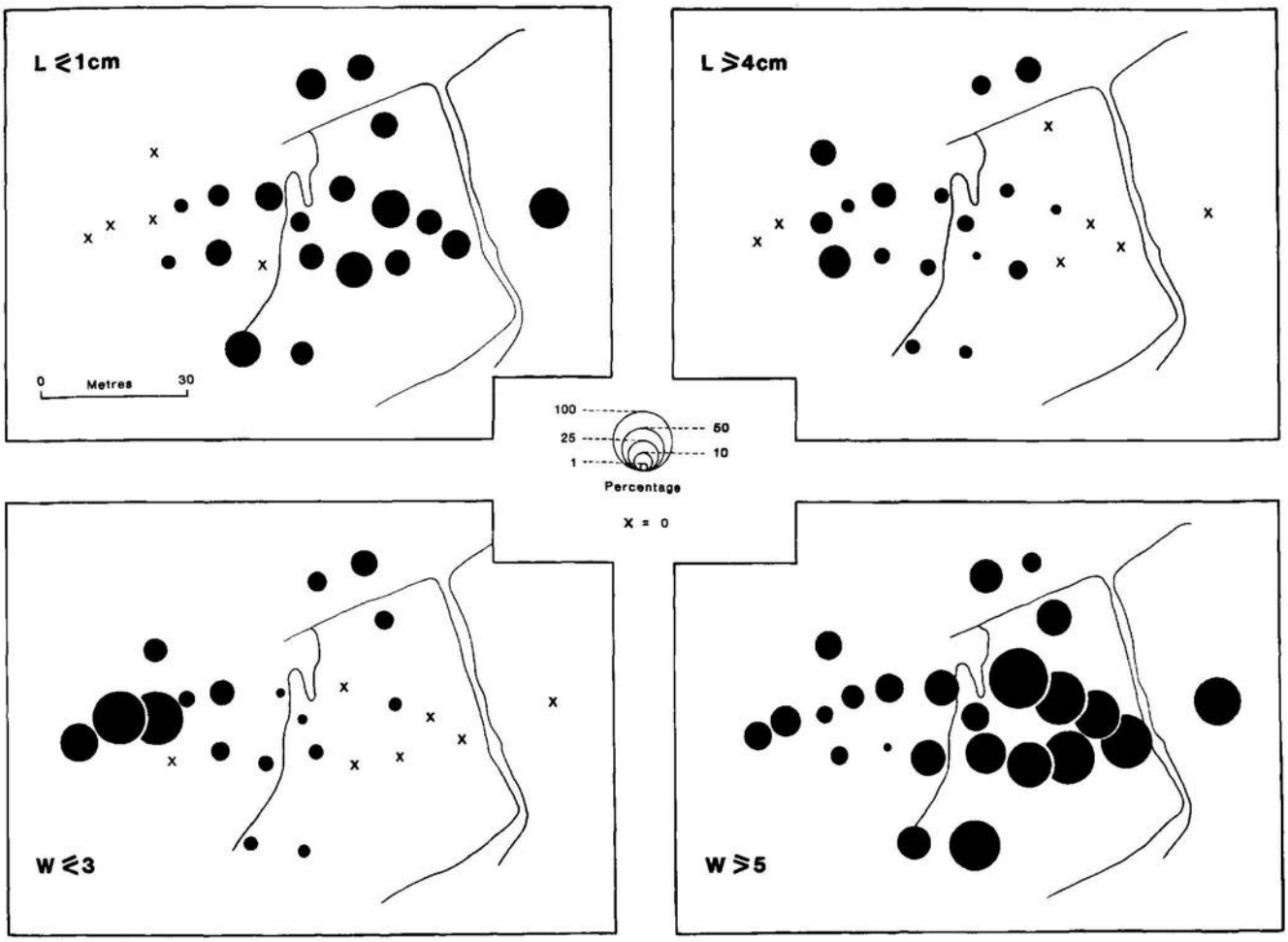

Figure 13. MS220: percent of topsoil sherds in size classes (length), <1 cm and >4 cm, and wear classes, <3 and >5.

sherds of the higher area when they were discarded or spread across the land. For MS220, in the case of (1), movement of artifacts off the limestone slope or from the direction of the plain of Throni would be possible, but

Table 1. MS220: Chi squared values and significance levels derived from Kolmogorov-Smirnov one-tailed test of difference in sherd length and sherd wear between different groups of samples. The direction of the significant differences is shown using abbreviations relating to row and column categories.

	Sherd length			*Sherd wear*		
Context	*Limestone surface*	*Limestone topsoil*	*Volcanic surface*	*Limestone surface*	*Limestone topsoil*	*Volcanic surface*
Limestone topsoil	2.25 ($p > .30$)	–	–	0.42 ($p > .80$)	–	–
Volcanic surface	4.26 ($p > .10$)	4.38 ($p > .10$)	–	7.21 ($p < .05$) VS > LS	4.147 ($p > .1$) VS > LB	–
Volcanic topsoil	3.98 ($p > .10$)	2.205 ($p > .30$)	12.8 ($p < .01$) VS > VB	47.02 ($p < .001$) VB > LS	38.54 ($p < .001$) VB > LB	17.4 ($p < .001$) VB > VS

despite the limestone clasts which are mixed with the soil of the volcanic slope in MS220, there is no evidence of the scale of erosion during the last 2500 years which would have been necessary to move fragments of the size of the sherds measured. In MS220 the most likely explanation is the second: the volcanic soil of the larger, better terraces does not show signs of the truncation suffered by the limestone *terra rossa* and has remained in cultivation, causing greater wear and tear on sherds, particularly those near the soil surface. This hypothesis does not explain why the larger and less worn sherds are found on the *surface*. The most likely reason is that when larger sherds are worked to the surface they remain there, whereas smaller fragments tend to be reworked into the plow layer. Lewarch and O'Brien (1981: 308) cite theoretical and empirical evidence for the sorting of large fragments such as artifacts to the surface of soil disturbed by cultivation.[3]

Discussion

Three matters to be discussed are the nature of soil erosion evident in the present landscape and its implications for the spatial distribution of artifacts, the age of the terrace systems, and the likely extent of erosion which occurred before slopes were terraced.

The Evidence of Soil Erosion

In any evaluation of the extent and archaeological significance of soil erosion, it is essential to take into account the spatial variability in factors which have determined erosion risk. Of these, slope morphology is one of the most significant. It is also one of the more constant through time, at least within the lifetime of agricultural terraces. On the volcanic and limestone bedrock of Methana several slope systems may be distinguished on the basis of slope gradient and the distribution and condition of terraces.

First, there are slopes on which terracing is more or less continuous and which range in gradient from very gentle to moderately steep. Such land occurs both at low elevations and in the mountains. The gentler slopes carry the better soils and are cultivated today, whereas continued use of the steeper slopes depends upon their location. Second, there are slopes of steeper gradient and of more rugged morphology on which terracing is discontinuous and usually abandoned and garrigue-infested. Third, there are the steepest and most rugged slopes where terrace-building would not have been feasible. Indeed, one would not expect there to have been sedentary human activity at any time.

These three slope systems relate both to land use types discussed provisionally by Mee et al. (1991) and to the degree of soil erosion evident in the present landscape. On the first type, the better land, tree crops would have been cultivated alongside cereals, possibly since Classical times (though whether upon terraces is not certain), with olives at lower elevations and vines in the cooler mountains. The better, chiefly more gently-sloping land in this category has remained in cultivation to the present day and shows little sign of erosion. The steeper slopes with less continuous or isolated terracing, particularly those slopes which rise from the near-coastal lowland to the mountainous interior, probably would have supported olives throughout their cultivated history. On these slopes neglect and abandonment have been followed by erosion on part of the soil. On the very steep, non-terraced slopes, gully and rill erosion has occurred, though this may have little significance for archaeology except where sediments have built up significant landforms and may have buried former surfaces.

On terraced slopes even of moderate gradient, rills and gullies are rare, despite the reduction in infiltration capacity by surface crusting. With the exception of the now stable gully incised by the ephemeral stream which flows through the area of MS220, there were no gullies in the areas sampled. There were a few cases of short linear depressions which connected abandoned terraces on steep slopes: these are likely to be eroded both by water and by animal trampling. On Methana generally, the few instances of gully erosion on terraced slopes tended to be in the bottoms of moderately steep valleys. The only mass movement observed to have occurred on terraced slopes was the localized slumping in the weak pyroclastic sediment of area MS69. Furthermore, no depositional forms were recorded in the sample areas apart from the soil crust present on many terraces. In their discussion of terraces in Greece, Rackham and Moody (1992: 129) state that, in their experience, "terraces are highly resistant to water erosion." They report that the most severe flood in eastern

3. An analysis of several phosphate fractions and a number of forward and reverse field mineral magnetic properties was undertaken on the soil samples from MS220. Enhanced levels of soil phosphate and of certain mineral magnetic properties are known to have resulted from human activity at archaeological sites and to have persisted in the soil to the present day. In MS220 there is a relatively strong statistical relationship between topsoil sherd content and both fixed and total inorganic phosphorus. A case could be argued that this correlation reflects the in situ survival of both soil and sherd content since the period of use of the site. There remains a possibility, however, that the correlation reflects the independent factor of soil type, rather than an anthropogenic influence upon the soil. In the case of the pattern of mineral magnetic properties, soil type rather than any anthropogenic factor emerges clearly as the over-riding influence. There is no conclusive evidence in the soil analytical results that high sherd concentrations have remained in place with their associated soil matrix since their discard in Classical times, but no evidence, either, to suggest that this may not be the case.

Crete in more than 74 years had relatively little effect on walled terraces, and almost none on abandoned terrraces.

The short-term effect of overland flow is the production of the soil surface crust. This is as much as 2 cm thick on volcanic soil, of coarser texture than underlying soil, frequently stratified, and generally compact and brittle. Mucher and De Ploey (1977) showed that crust deposits without stratification were caused by raindrop splash and that lamination was the result of overland flow or rainwash (combined splash and flow); crusts formed by overland flow without splash (so-called afterflow) were distinctly stratified. According to these findings, the soil crusts of Methana are mostly formed by combined splash and flow and afterflow. Their formation on gently sloping terraces in particular may reflect the inverse relationship between slope gradient and degree of surface sealing recorded by Poesen (1986). That such a crust was not found on pyroclastic soils may reflect their greater infiltration capacity compared with the volcanic clays: the evidence therefore is that surface wash is less potent on pyroclastic than on volcanic soils despite the greater erodibility of the former which arises from low organic matter content and very low structural stability. The formation of a crust within a season, or at most one or two years, is evidenced by its presence on recently-furrowed terrace soils. Frequent cycles of crust formation and cultivation may be the cause of the coarse surface soil horizon on the volcanic soils.

The selective removal of clay by rainsplash and surface flow is well documented. Rainsplash has been found effective in suspending clay particles (Mucher and De Ploey 1977; Mucher, De Ploey, and Savat 1981). Savat (1982) found that at low Froude numbers (or flow power), flow across loess removed mainly clay-sized material. On slopes of between 0° and 4.5° in a semi-arid environment, removal of soil from interrill areas is limited more by the transporting capacity of overland flow than by the amount of sediment made available for transport by raindrop detachment: the flow is not capable of transporting the coarser material detached by raindrop impact.

The mode of erosion on the terraced slopes has been restricted largely to wash by non-rill overland flow. Whether ground-surface sherds could have been moved from their original positions by erosion depends upon the power of the process. Depth and rate of overland flow are limited by surface roughness, which is characteristic of the Methana slopes and, on terraces, by gentle gradient. Size and shape of sediment eroded have received much less attention than total quantities moved. Morgan (1980: 309) found that overland flow failed to transport the coarse sand and gravel of a sandy loam soil on an 11° slope in Bedfordshire, England. On Belgian loam soils, Poesen (1987) reports rill erosion as being capable of transporting 9 cm rock fragments, whereas the size limit of transport by interrill flow, the process equivalent to that on the Methana terraces, was an order of magnitude less (<1 cm). On the interrill areas, he considers splash-creep (Moyersens and De Ploey 1976) and runoff-creep (De Ploey and Moyersens 1975) to be responsible for the slight downslope displacement of fine pebbles. Poesen (personal communication, 1990) emphasizes the importance of size rather than shape of transported fragments, though the resistance of platy sherds to movement would be greater than that of non-platy stones. In the Colorado Front foothills, Morris (1986) considers sediment detached and transported by rainsplash to be less than 8 mm in diameter. In moister environments, soil creep has been judged capable of transporting large fragments (greater than 30 cm on forested hillslopes of Virginia: Mills 1986), but there is no evidence of powerful soil creep on Methana. It is of interest to note, however, that Schumm (1964) found that creep was surprisingly effective in semi-arid to arid western Colorado. Soil creep on terraced slopes is nevertheless likely to be negligible.

Of the 1306 sherds examined in area MS220, 15% measured 1 cm or less in length. These are capable of being transported by non-rill surface wash according to Poesen's findings. In MS61, a significant positive correlation between sherd density and microrelief gradient could reflect sherd transport by water flow, though in any case there would be a tendency for surface sherds to be displaced by creep and by kicking into permanent or semi-permanent depressions caused by concentrated overland flow (the pre-rills of Roels 1984). On the lower gradients of most of the terraces examined, runoff velocity would be low and its effect limited to the winnowing of fine particles, resulting in the relative concentration of surface rock fragments and sherds. In many instances, the sand particles (maximum diameter 2 mm) forming a surface soil crust may be almost the largest particles moved by overland flow, and it is difficult to envisage the transport by water of even the smallest sherds measured, except in channels between terraces and possibly only then where the normally dense garrigue cover is reduced by heavy trampling and grazing. Kicking by grazing stock and by humans is, however, an inevitable process of sherd displacement: the passage of flocks across most of the terraced areas sampled is frequent. On steeper slopes traffic would be concentrated and likely to take advantage of the gentler gradient of disused terraces. The action of kicking by stock is likely to be the major cause of displacement of coarse fragments, including sherds, exposed on the ground surface of Methana.

Thus, the longer term effects of soil erosion on the terraced slopes of Methana appear to be the slow selective removal of fine earth and the relative concentration of coarse fragments upon the surface. On terraces where cultivation has ceased, sherds would have to be exposed at the surface by this loss of soil before they suffered movement which, at least for the larger sherds, is likely to be by faunal disturbance. On much of Methana's previously cultivated land, soil erosion may have brought sites into sharper focus by stripping them of the soil which concealed them. But it is likely that other agents have then scattered the artifacts.

The Age of Terraces

Wise management of cultivation on Methana would always have included effective soil conservation by terracing or by other means that limited soil erosion. The clearing of land (particularly if it entailed removal of forest) and terrace construction on any scale must have resulted in a certain amount of hillslope instability. Once established, the terraces one sees today were stable when in use. The abandonment of terraced land for cultivation in periods of contraction (such as the late Hellenistic period [2nd century B.C.] and from the 6th century A.C.; Mee et al. 1991) is likely to have been followed by the fairly rapid, stabilizing growth of garrigue, unless this was retarded by either grazing or fire. The present situation on abandoned land is instructive. Fire on Methana, in both limestone and volcanic areas, is associated with appreciable erosion of the soil of terraces which are no longer cultivated, although, except on steep slopes, recent fire-induced erosion was found to have been limited to surface wash. Grazing and the passage of flocks are also seen to be important, particularly on abandoned terraces, where local livestock limit the extent of vegetation cover, thus exposing soil to surface wash. Mee et al. (1991) argue that pastoralism has been important on Methana since at least the Classical-Hellenistic period, in which case the grazing of caprovines would have been a potential factor in erosion since that time.

The geomorphological and soil features, and related artifact patterns in the present landscape are indicative of likely past change, but only upon the extant terrace system. Unfortunately, as is the case in many regions of terraced agriculture, the age of the terrace systems of Methana is not known. Rackham and Moody (1992: 129) argue that terraces on Pseira in Crete might be Middle Minoan, and in the Berbati-Limnes area Wells, Runnels, and Zangger (1990: 227–228) suggest that terraces may have been constructed by the Mycenaeans. An Archaic date has been proposed for terraces on Chalki on the basis of their masonry style (Rackham and Moody 1992: 128), but it is not until the Classical period that there is clear evidence for the use of agricultural terraces, particularly in southern Attica (Lohmann 1992: 51), although Classical authors seldom mention their existence (Amouretti 1990).

Close examination of sections exposed through terraces on Methana yielded no sherds buried in the ground underlying the terrace soil, whereas within that soil sherds were often found to be abundant (FIG. 2). In one trackside exposure, a brown terrace soil of 50 cm depth overlay a reddish-brown volcanic clay. Sherds occurred within the brown soil, at the base of which was one dated Classical-Hellenistic, 5th to 3rd centuries B.C. (David Gill, personal communication, 1987) which would appear to date the terrace to this period at the earliest. The abundance of sherds of Classical, and in some cases Early Helladic, date encountered upon and within the soil of the more substantial terraces on the volcanic slope in area MS220 again suggests the Classical period as a latest date for terrace construction.

Slope Stability before Terrace Construction

In many of the sections exposed artificially through terraces, a brown terrace soil has survived. At its deepest this was 65 cm. It occurs over a substrate of much older sediment, the redness, translocated clay, and calcium carbonate content of which were discussed earlier. In some situations this base sediment was a stratified slope deposit and possibly represents the latest phase of major slope instability prior to terrace construction. This entailed the local displacement of a great quantity of soil and rock but resulted in a restraint on erosion, at least on the gentle and moderate slopes if not on the steeper ones, which may have been effective across much of the agricultural land of the peninsula for two and a half millennia.

With the present data one can do no more than hazard a guess at the age of slope sediments underlying the terraces. Neither the reddening nor the carbonate deposition encountered over the volcanic rocks of Methana are pronounced, but reddening in particular suggests an age spanning much of the Holocene, if not more. In Mediterranean environments between southern Portugal and Greece, and in a variety of lithologies, soils of red hue are associated with Pleistocene, or at latest early Holocene, as opposed to mid or late Holocene deposits. In southern Greece, van Andel and Zangger (1990: 145) describe "mature, deep, red calcareous soils" on Pleistocene alluvial fans of the Argive Plain fringe. Similarly, red soils occur upon Pleistocene fans in the Berbati-Limnes area (Wells, Runnels, and Zangger 1990). The rate of calcrete formation varies geographically according to a number of factors (Goudie 1983). Thus the degree of carbonate cementation of soil may not be a reliable indication of its age. Whereas thick

calcretes are likely to be of Pleistocene or earlier age (Dumas 1969: 560; Goudie 1973: 90), there are records of calcrete crusts which have formed in living memory and others in the Mediterranean region which are post-Roman (Goudie 1973: 84; Delano-Smith 1979: 280).

Research in other areas of the NE Peloponnese has produced some of the better resolved chronologies of erosion, alluviation, and settlement change to have emerged from the Mediterranean region and these are of particular interest because of their geographical proximity to Methana. It would be unwise, however, to base any prediction of Holocene environmental events in Methana upon those described for other areas of southern Greece. First, the physical environment of volcanic Methana contrasts so markedly with these other areas, and second, it is clear that the detailed temporal patterns of settlement growth and decline and of erosion vary among these areas.

In the southern Argolid van Andel, Runnels, and Pope (1986: 108–123) have identified three Pleistocene alluvial units (272,000–33,000 years B.P.) and four which date within the last 5000 years, most of the latter being associated with well developed soils that indicate prolonged periods of stability between erosion events. The first of the Holocene erosion events, the "catastrophic sheet erosion of slopes," is dated to the later 3rd millennium (EH II–III) and is attributed to intensified land use rather than the initial clearance of woodland in the later 4th and early 3rd millennia (van Andel, Runnels, and Pope 1986: 113–116; van Andel, Zangger, and Demitrack 1990: 382). The decline in settlement and consequent collapse of terrace walls, possibly as a result of livestock damage, may have been responsible for the second phase of erosion in the last few centuries B.C. (van Andel, Runnels, and Pope 1986: 118–120; van Andel, Zangger, and Demitrack 1990: 383). The third event is thought to have been caused by renewed upland settlement from the 9th century A.C., whereas the fourth phase in the Early Modern period is due to the decay of terraces and the clearance of land by bulldozers (van Andel, Runnels, and Pope 1986: 122–123; van Andel, Zangger, and Demitrack 1990: 383).

There were three periods of settlement extension which did not cause extensive soil erosion, possibly as a result of effective conservation by terracing or other means: the Mycenaean (later 2nd millennium B.C.), the Geometric-Early Hellenistic (8th to 3rd centuries B.C.), and Late Roman (3rd to 6th centuries A.C.). Periods of settlement decline during the 11th to 10th centuries B.C. and the 7th century A.C. were also associated with soil stability, which is thought to have been ensured by the rapid growth of *maquis* (van Andel, Runnels, and Pope 1986: 114–122; van Andel, Zangger, and Demitrack 1990: 382–383).

In the much more extensive catchment of the Argive plain, three major phases of Holocene erosion have been identified: a coarse alluvium of the 5th–4th millennia (Late-Final Neolithic), followed in the 3rd millennium (EH II) by "the most pervasive environmental change in the Argive plain" when the brown woodland soils were stripped from the hills and deposited in the plain; finally in the 13th-century B.C. (LH IIIB) torrential flooding buried parts of Tiryns under several meters of alluvium. The landscape has subsequently remained fairly stable (van Andel, Zangger, and Demitrack 1990: 384–385).

An Early Bronze Age episode of soil erosion is also evident in the Berbati and Limnes basins on the eastern edge of the Argive plain. This is dated to the early 3rd millennium and is attributed to the movement of farmers into the hills in the Final Neolithic and Early Helladic periods (Wells, Runnels, and Zangger 1990: 222).

On Methana there is also an increase in the level of settlement at this time. Whereas only one Neolithic site has been identified, 26 date from the Early Helladic period. This colonization of more marginal environments is attested throughout southern Greece and may have been facilitated by the technological innovations characterized as the "secondary products revolution" (van Andel and Runnels 1988: 242–243; Pullen 1992: 45–49). Most of the Early Helladic sites on Methana were scattered around the coast; the mountainous interior does not appear to have been intensively exploited. Settlement numbers remained fairly constant throughout EH I–II but there is a sharp decline in EH III which is represented by a single site. The three MH and five LH sites constitute only a modest recovery, and it is not until the Classical period that settlement on Methana was once again extensive.

The conditions that apparently prompted the major Early Bronze Age erosion episodes in the Southern Argolid and the Argive plain—settlement expansion followed by rapid decline—were clearly replicated on Methana, and the archaeological evidence does suggest that there might have been a phase of erosion in the later 3rd millennium. The ubiquitous Early Helladic artifacts encountered off-site on Methana could not be satisfactorily explained in terms either of past agricultural activities or kicking by stock; in addition there were also the problem sites described in the introduction: discrete but relatively high-density scatters of rather worn Early Helladic sherds. It seems possible that the decrease in the number of settlements and the consequent failure to maintain adequate soil conservation measures might have precipitated large scale erosion. Geomorphological studies on the peninsula have not revealed evidence of widespread soil erosion at this time, however. Moreover, the Early Helladic site which was investigated to test this hypothesis, MS61, did not produce an extensive artifact scatter. Indeed it would

seem that erosion, *unless catastrophic,* lacks the dynamic capacity to transport artifacts appreciable distances. The fact that most of the "problem" sites lay just below a major EH settlement suggests that, while geomorphological processes should not be disregarded, their effects will have been localized. The off-site artifacts are more likely to reflect past human activities.

Conclusion

Examination of the morphological effects of hillslope erosion in Methana highlights the importance of defining the mode of erosion as well as assessing its quantity. This is of particular importance to the archaeologist as the mode of erosion controls the exact source and size of sediment that is entrained. The threshold of size of eroded particles is critical in relation to the size of artifacts present: appreciable erosion of soil by surface wash may not result directly in significant redistribution of artifacts. This would require a deeper-seated process of erosion. The spatial variability of mode and magnitude of erosion within the catchment or other geomorphological unit must also be considered since erosion risk may well vary within a local geographical area. The spatial complexity of erosion may render estimates rather meaningless for many purposes.

There is a case for considering at least some of the terraces of Methana to be of appreciable age, possibly Classical, and to have been geomorphologically stable throughout the period of their existence. Apart from those studies in Greece which have been cited, few discussions of Mediterranean environments have emphasized relative stability rather than instability for significant lengths of time. One notable exception is the geoarchaeological study by Gilman and Thornes (1985) of SE Spain. Here the archaeological evidence points in general to the survival of the morphology of the land and its regolith over the last few millennia. Even certain gully systems appear to have been fairly stable for some 3500 years. The evidence of generally low rates of soil erosion was contrary to Gilman and Thornes' expectations and contrary to the first impression created by the visual impact of the scenery of the region (Gilman and Thornes 1985: 61).

The evidence of erosion in the hills and the occurrence of sediment fills, often of more than one age, in the valleys are striking features of the physical geography of the Mediterranean region. Erosion risk arising from climate, relief, and long human settlement is a major theme of Mediterranean geography and history. The present soils and vegetation of the region are often classified according to their degree of degradation resulting from human use and soil erosion (Polunin and Smythies 1973: 25; Duchaufour 1977: 407; Harant and Jarry 1960–1963, discussed by Delano-Smith 1979: 292). The model of land instability is implicit in the geographical literature on the Mediterranean, and one may have to guard against an assumption that instability has been the rule for all hillslopes. One might expect that survival of the large quantities of artifacts encountered on hillslopes such as those of Methana is unlikely, but survive they do. And if the effects of erosion have indeed been minimal, it also follows that the archaeological record is reasonably reliable.

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