Cuaternario y Geomorfología, 6 (1992), pp 5-20

INTERACTION BETWEEN ARCHAEOLOGICAL SITES AND GEOMORPHOLOGY

J. BINTLIFF

Dept. of Archaeology, 45, Saddler St. Durham DH1, 3NU

1.Catchments in a Dynamic Landscape

As an archaelogist I am usually primarily inrterested in placing an ancient settlement into its gographical context. A lasting contribution to this exercise has been the formulation in 1970 of the concept of Site Catchment Analysis (Vita-Finzi & Higgs, 1970). Taking as fundamental the hypothesis that human communities exhibit territorial behaviour much like other animals, these authors advocated the interpretation of ancient sites in terms of their location with respect to surrounding environmental resources, defining the likely explotative territory as up to 1 hour's walking distance out from a site for farming settlements, and up to two hours for a pastoral or hunter-gatherer settlement. A very considerable number of field studies have been published from all over the world employing Site Territorial Analysis, with notalble success. Empirical experience shows that these time/distance constraints are rare maxima, with most pre-Industrial settlement requiring far smalller radii for their explotative needs. In Southern England, eg, historical geographers had already shown that medieval villages were frequently spaced at some 4 Kms form each other (ie less than 1/2 hour radius territory), and in a classic early application of STA to settlement patterns in this region from Neolithic to early Medieval times, Ellison & Harriss (1972) found a 2 km radius territory ftted the data best.

Despite the fact that one of the two inventors of Carçhment Analysis, Claudio Vita-Finzi, is a geomorphologist, it is curious that site territories were often analysed with little attention to landscape changes between the presentday and the period of site occupance. One notable example where I personally participated as a student carrying out carchment walking is the study of the site territories of a sample of the famous earlier Neolithic ditched villages in the Tavoliere Plain of South-East Italy (Jarman & Webley, 1975). In the modern landscape these Neolithic sites lie on and surrounded by a soft limeston "costra" sediment ideal for primitive farming, beyuond which lie much larger expanses of heavier alluvial soil (Figure 1). Jarman and Webley suggested that the slightly higher zones of "costra" were deliberately chosen for Neolithic settlement because of the economic concentration on cereal growing. Unfortunately a geomorphologist studying the same settlements in the context of mapping and dating Holocen sediment sequences in the Tavoliere published evidence very soon afterwards to show that significant areas of the heavier alluvial soils were post-Neolithic erosion deposits from the higher costra surfaces, often burying lower-lying Neolithic sites and leaving only a sample exposed to view (Delano-Smith, 1981).

2.Regional Landscape Change

It may be possible for a geomorphologist or geoarchaeologist to identify widespread landscape change phenomena affecting whole settlement systems of archaeological sites. One example I studied also in the early 1970's was the later Holocene evolution of the Plain of Western Macedon, where the scale of landscape transformation was vast as a result of the mighty river systems involved in the growth of sediments in this coastal plain (Figure 2). The modern landscape bore no resemblance to that of Neolithic times, and even a more recent era, that of the Classical and Hellenistic Kingdom of Macedon under Philip, Alexander and their predecessors, saw a quite different plain from that of present times. Here we can introduce an additional and important complication, that landscape change in the Holocene is clearly not a 'uniformitarian' geomorphic process, where observation of presentday geomorphic behaviour and measurements of rates of accumulation or denudation can be extrapolated backwards into prehistory. Although the great rivers such as the Axios, debouching into the Macedonian coastal plain, will always have deposited a heavy bedload, the parameters of alluvial floodplain development changed completely during the mid-Holocene, with the shift in worldwide eustatic sealevel rise from a rapid rise regime to one characterising the later Holocene till today, where sealevels have perhaps risen only slightly (maybe 1 metre per millennium on average). From a situation where much of the potential river silt was deposited into the waters of a rising Thermaic Gulf, this caused a dramatic modification, where alluvial deposition easily outstripped sealevel rise, giving rise to the well-documented massive expansion of a subaerial delta over the last 2500 years, landlocking a former harbour town of Pella some 30 kms from the present coastline (Bintliff, 1976).

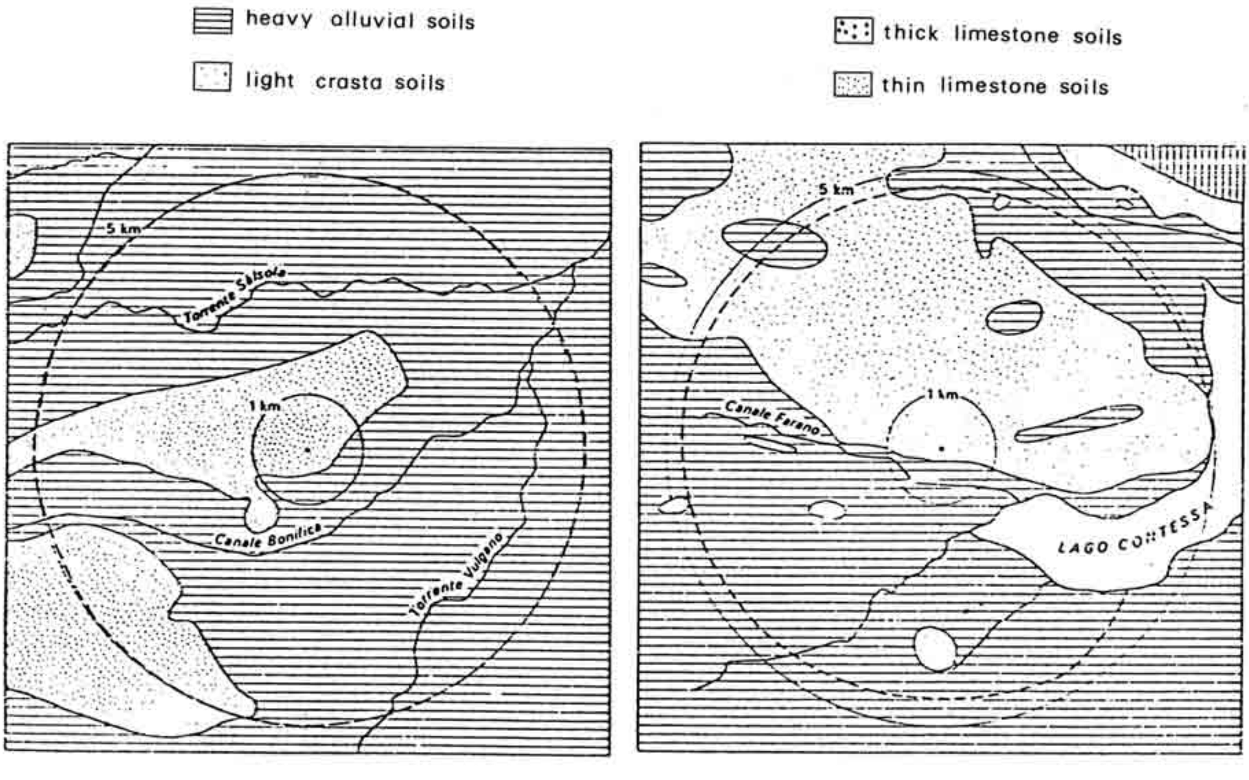

Fig 1. Catchment analyses of two Neolithic sites on the Tavoliere Plain, Italy, using the modern geomorphological context (from Jarman and Webley 1975)

Similar changes in environmental parameters help to account for rates of growth in the great coastal river systems of Western Turkey (Figure 3) which clearly cannot be extrapolated back through the Holocene, and which were responsible for recurrent shifts in associated human settlement systems, most notably with the great Greco-Roman cities which floutished in these valley systems eg Ephesos (Bintliff 1981). Although here as with the Plain of Macedon we can isolate natural environmental changes and their impact, it has also long been clear that horizons of human impact can alñso create lasting transformations in geomorphic regimes for whole regions. We do not know enough about thje potential relationship between the intensity of human settlement and land use in the hinterland catchments of rivers like the Axios in Macedonia, although we may suspect that the rapid delta advnce since Calssical times should partly be a reflection of vastly increased human clearance upstream. But we do know more about Aegean Turkey and the clear archaelogical and historical evidence for major population growth and more intense land use upstream of these coastal plains, which will certainly have been a major contributory factor in the recorded historical modifications to the coastaline.

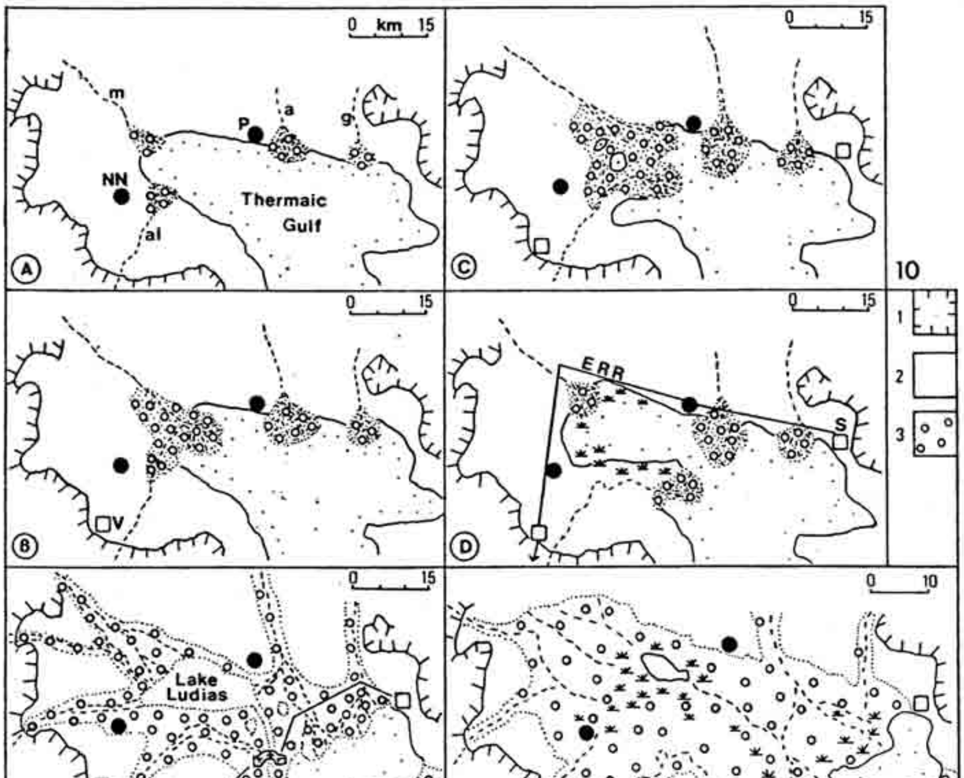

Fig 2. Reconstruction of the mid to late Holocene evolution of the Plain of Western Macedon (from Bintliff 1976). The author's revised reconstructions of the growth of the Plain. Key: A = early prehistoric period; B = fifth century B.C.; C = fourth century B.C.; D = around o B.C./A.D.; E = Late Roman period, around 500 A.D.; F = 1908 A.D.; 1 = Cristalline limestone upland; 2 = Tertiary and Quaternary lacustrine marls, sands, silts and travertines; 3 = Younger 'Historic" Alluvial Fill and Holocene deltaic fill. NN = Nea Nikomedeia; P = Pella; S = Salonika; V = Verroia; m = Moglenitsa river; al = Aliakmon river; a = Axios river; g = Gallikos river; ERR = Early Roman Road; LRR = Late Roman Road.

One final example from the same area, this time the Plain of Troy in the far North-West of Aegean Turkey, will remind us how intimately geomorphic study of Holocene sequences can affect the interpretation of archaeological settlement sites. Field research by myself and an American-Turkish geological expedition (cf Bintliff in press, and Kraft *et al*, 1980) has made it quite clear that any understanding of tha function of the site of Troy, and at any period from the Copper Age to Byzantine times, depends on a specific reconstruction of the contemporary appearance of the Trojan Plain around it,

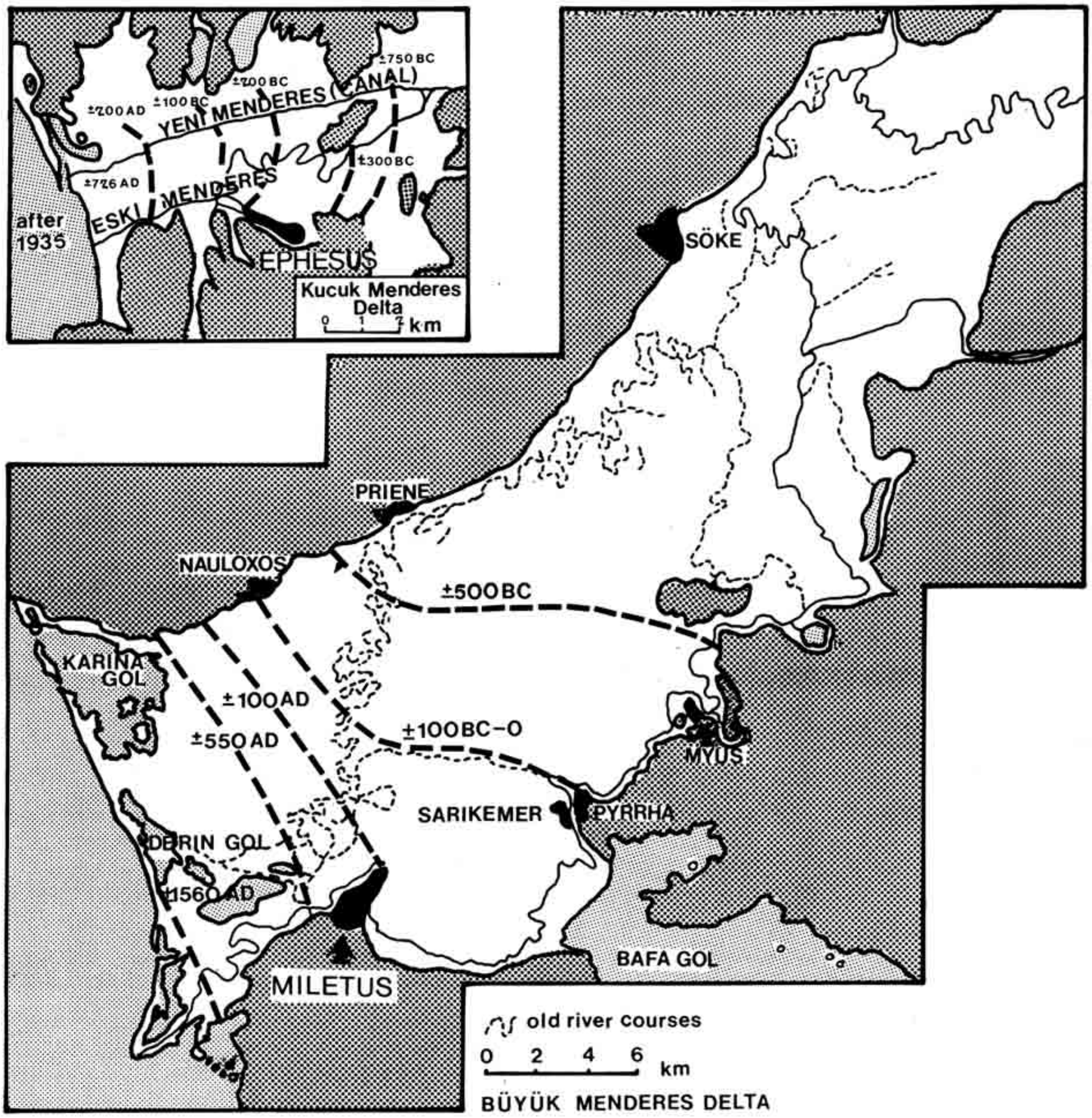

Fig. 3. Growth of later Holocene estuarine sediments in the great river valleys of the ancient cities of Miletus and Ephesus, on the Aegean coast of Turkey (from Bintliff 1981, after Eisma).

a landscape which was significantly different for every archaeological phase recognised in Trojan stratigraphy. But lest we place too much reliance on purely geomorphic sequences into which we slot purely archaelogical sequences, I should add that trying to focus on a short period of time, however important historically, may prove too difficult for the level of resolution permissible within the geomorphic database. Thus in the case of Troy , the first question one might want to ask is: what was the landscape like at the time of the supposed Trojan War? Hasving tried I think with some successs to reconstruct a likely Trojan Plain landscape for a period between the later Bronze Age and early historic times or the Iron Age, and been excited to confirm that it matched very colsely the kind of landscape one could reconstruct purely from the geographic descriptions in Homer's Iliad, it is chastening to have to admit (Figure 4) that the limited chronological fixes for the geomorphic database get us to no narrower a time range than 1300-700 BC, leaving us unable to decide whether the Homeric description was a genuine transmitted poetic memory of the Late Bronze Age scenary, or merely Homer or a contemporary in the 8th century BC fitting the traditional story to the visible Trojan scenary of their own times!.

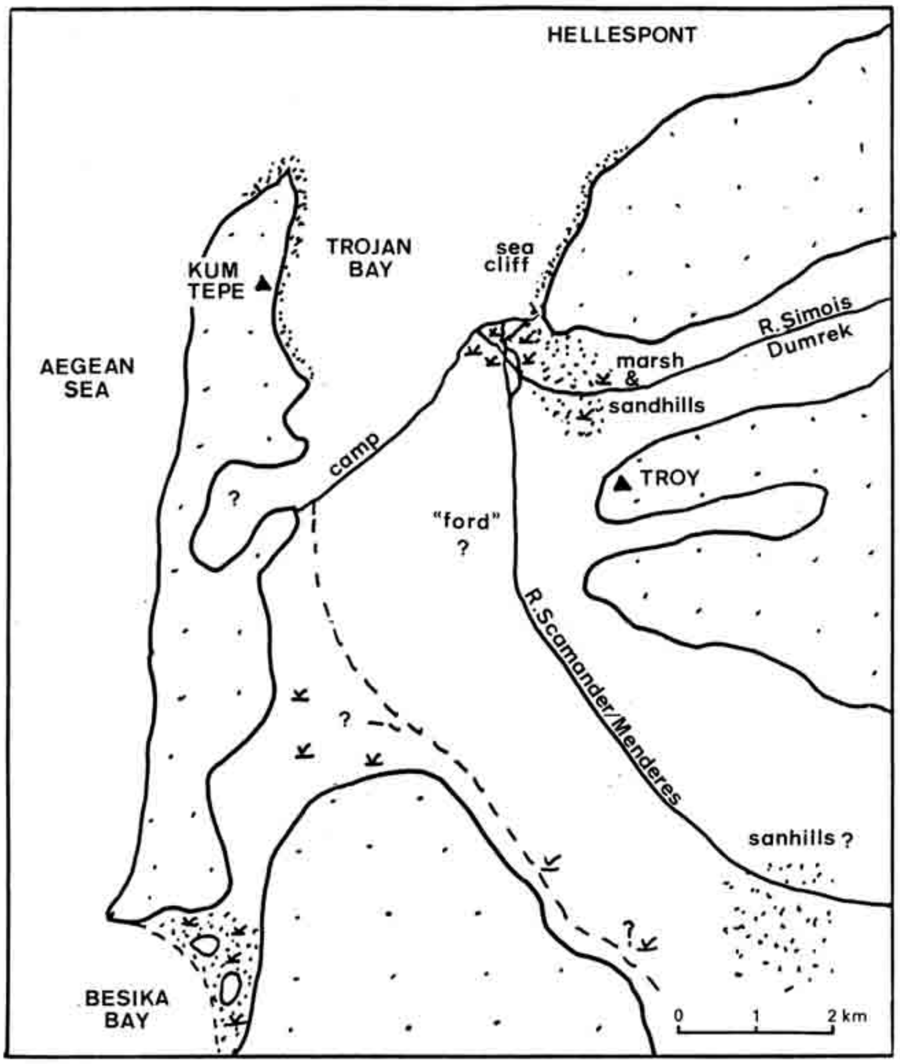

Fig 4. Reconstruction of the Plain of Troy, North-West Turkey, from geomorphic data and the description of Homer's Iliad. the chronology of this phase in the progressive development of the Plain would fit a date of either 1300 BC or 800 BC (from Bintliff, in press)

3. Punctuated Equilibrium in the Landscape: The case of the Younger Fill

In the examples I have chosen so far to illustrate geomorphological contextualising of archaelogical settlements at the individual site and settlement system levels, I have pointed out that a uniformitarian approach, the 'present is the key to the past', has only a limited validity for understnading the Holocene evolution or specific archaeological landscapes. To be sure, the kinds of processes we can observe in the Mediterranean today or in Temperate Europe are essential to help us make sense of palaeosedimentary series, yet it has become clear that the observable landscape today around an archaeological site and current geomorphic behaviour within its catchment could be a very unreliable guide to earlier geomorphic regimes for taht area. The environmental parameters may have changed in the past, for longer or shorter periods, and we may need to look to contemporary processes elsewhere where conditions more closekly approximate those that seem to have created the palaeolandscapes empirically obsevable. On the other hand, although the most interesting deposits in a regional geomorphic series may be hard to parallel in that area today, it may also be true that they sit anomalously amongst sediments that are characteristics for regional, zonal goegraphy and climate. Such long-term records, where goemorphic episodes quite out of character form those normally found in the region today and in the long-term, appear at irregular intervals, can be dubbed sequences of 'Punctuated Equilibrium', and by way of example I would like briefly to discuss one of most intriguing phenomena in Mediterranean Holocene Geoarchaelogy -the case of the younger Fill (Bintliff, 1987; Bintliff & Zangger, in prep.).

Although ancient writers such as Plato portrayed erosion processes as perennial in the ancient world, Vita-Finzi was able to show quite convincingly in his PhD dissertation (1969) that the Mediterranean geomorphic record, instead of being characterised throughout the Holocene by seamless accumulations of eroded hill soils in valleys and plains, showed for the greater part of the Holocene relative landscape stability. However at rare intervals short-lived episodes of dramatic erosion had given rise to well-defined phases of slopewash and valley fill deposits, including a Mediterranean-wide formation dated by him from Late Roman to Medieval times and which he called the 'Younger fill'. Since apparently many periods of high population and extensive clearance of woodland, associated with intensive grazing and farming, had nor given rise to similar erosion episodes, Vita-Finzi took the controversial step of attributing the Younger Fill to a non-anthropogenic alteration to environmental parameters, namely to a climatic fluctuation which brought wetter and cooler climate to the circum-Mediterranean region.

Working in many separate districts of Greece in the early 1970´s, I also found evidence for restricted goempoprhic change and a formation of Younger Fill character, associated frequently with similar dating evidence to that adduced by Vita-Finzi (Bintliff 1975, 1977), and drew similar conclusions to those if that scholar about the respective roles of human impact and natural factors in landscape change.

In hindsight, I can see that the bourgeoning of interdisciplinary fieldwork in the 1970´s encouraged researchers such as myself and Vita-Finzi to try to exploit all the possible approaches to landscape archaelogy before an adequate methodology had been agrred on by the profession. Projects were typically designed with a vast range of specialist subdisciplines taken into consideration, yet often each specialist had only limited time in the field to obtain data expected to reveal major generalisations.

The existence of anomalous results to the Vita-Finzi scheme, such as those of Judson (1963) in Sicily or Van Zuidam (1975) in Spain, where major alluviation seemed to fit closely with attested periods of major human impact, were see as exceptional to the more general trends supporting climatic determinism.

Just as the first heady applications of Catchment Analysis suffered from a lack of qualified geoarchaeological support, so the succeeding early use of geomorphic mapping suffered from the desire of quick, conssistent results valid over large areas. Although in my own research province of Greece several minor studies began to expose the inadequacies of Vita-Finzi´s Younger Fill scenario, the definitive test came when independently two separate teams of geologists spent several years analysing the geomorphic sequences of quite small districts in Southern Greece, Roland Paepe (1980) with a Belgian team in Attica, and Tjeerd van Andel with an American team in the Argolid Peninsula (Pope & Van Andel, 1984; Van Andel *et al*, 1986).

Just as important as the new depth of empirical investigation was the fact that both came up with virtually identical geomorphic sequences. Firstly it is important to note that the Punctuated Equilibrium scheme remains fully vindicated by these excellent scintific studies: for nearly all the Holocene the two landscapes concerned show limited geomorphic activity consistent with a semiarid climate and adequate woodland/scrub cover to prevent significant erosion episodes. But this equilibrium picture is broken at irregular intervals from the middle Holocene onwards by short-lived, and widely-spaced, phases of severe erosion. Whereas in Attica the settlement patterns in the geomorphic study region were poorly-known, allowing Paepe to interpret every erosion episode in terms of climatic fluctuations, the American Argolid study was carried out as part of a long-term archaelogical survey of the South-West Argolid Peninsula, and it was immediately clear that the date of the desequilibrium erosional episodes conincided exactly with periods of maximum population build-up and intensive land use in the region (Figure 5).

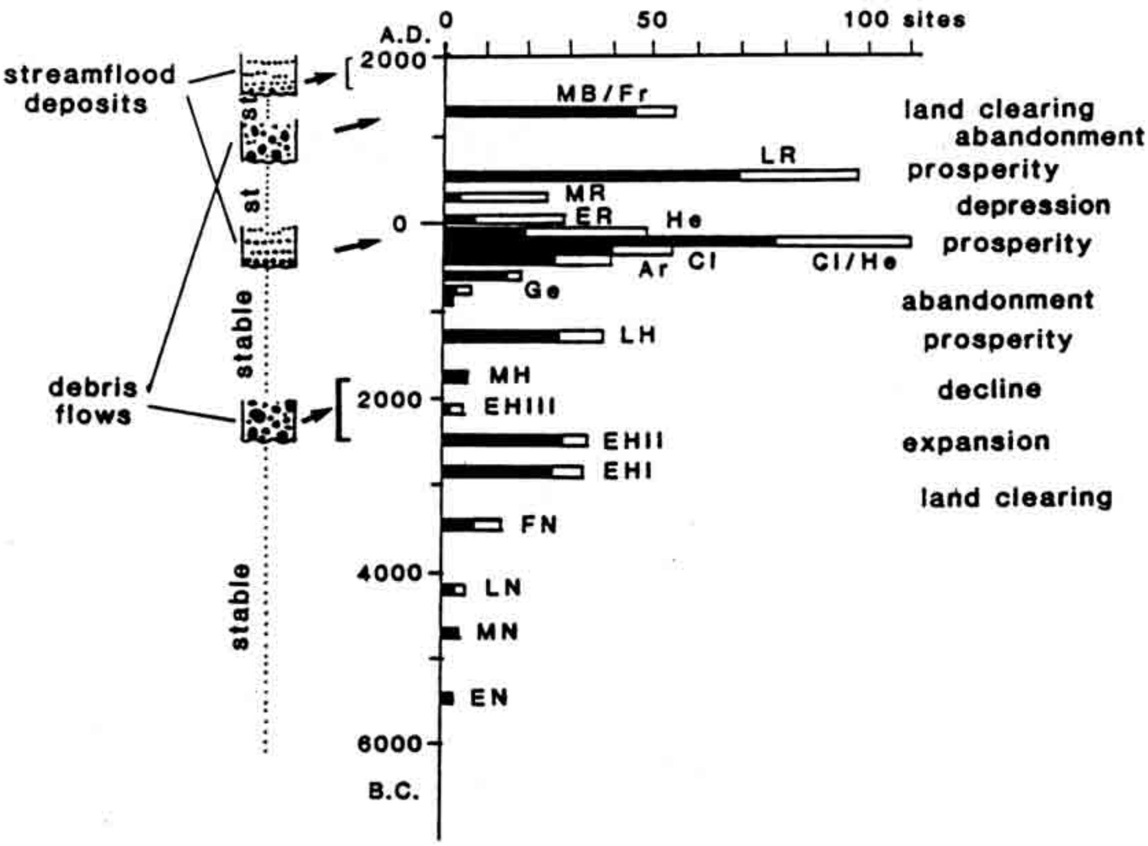

Fig. 5. Chart from Van Andel et al. (1986) correlating archaeological survey evidence for human demographic and land use fluctuations with geomorphic evidence for discret erosional episodes in the South-West Argolid, Greece.

Van Andel and co-workers made a detailed case, which seems to me beyond argument, that intensive human land use was the critical factor in these soil-stripping and alluviation episodes. The new era of in-depth geoarchaeology had brought us away from uniformitarian natural processes and into geomorphic processes whose understanding could only be historical and anthropogenic. An obvious parallel in temperate geoarchaeology is the pioneering PhD research of Martin Bell on the archaeological landscapes of the southern Chalklands of England (Bell, 1982), where trenches cut through dry-valley fills in the immediate catchments of archaeological settlements evidenced a clear correlation between episodes of valley sedimentation resulting from upland erosion, and the periods when neighbouring sites were occupied. Further Mediterranean case-studies of humanly-linked erosion episodes are discussed by Bruckner (1986).

4. The Interaction Between Archaeological sites and Geomorphology: Just one way traffic?

There clearly is a danger that current concerns over "Green Isssues" cloud our minds to natural variability in ecosystems. We pointed out earlier that the mid-Holocene change in the rate of eustatic rise, a purely natural phenomenon, created a fundamental parameter shift in the ability of sediment-laden rivers to create expanding coastal plains and deltas. In the same way, it seems to me, the interpretation of erosional sequences by Van Andel and his co-workers seems to present a passive landscape moulded by patterns of human interference. Yet how could we forget that it is not ploughing, or grazing, or woodland clearance, that strips soil, washes it downslope and deposits it in valley floors and coastal plains - it is rain, wind and river regimes, and as anyone who lives in a semiarid region will know, weather and stream systems are never fixed and predictable. To underline that point let me make reference to the very useful book recently published by the ancient historian Garnsey (1988), which examines the frequency and causation of food scarcity in the Greco-Roman Mediterranean. He shows that climatic variability is a normal feature of Mediterranean farming life, and that even regions renowned for their grain exports often had recourse in antiquity to food imports, when expected harvests failed due to unpredictable perturbations in rainfall or temperature.

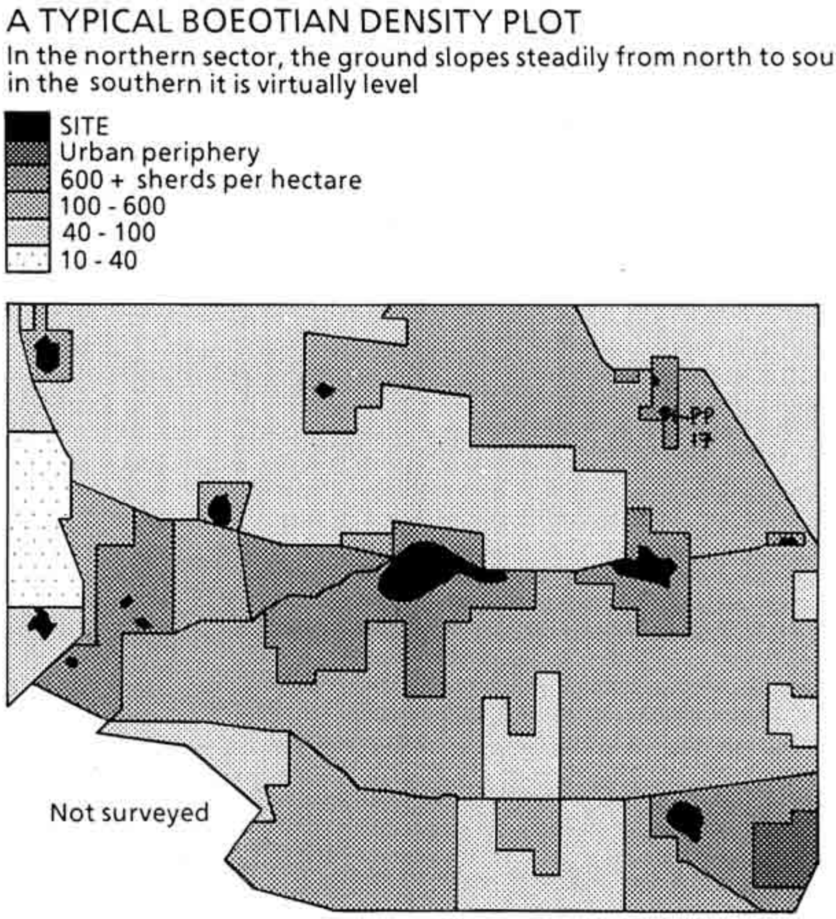

Fig. 6. A sector of landscape in the province of Boeotia, Greece, to illustrate the mapping of offsite surface pottery counts and their relationship to settlement sites (cf. Bintliff and Snodgrass 1988).

Having made this point, we have nonetheless just established from the geomorphic record, that however regular these perturbations in climate are, they cannot explain the very rare erosional events recorded in the Mediterranean sedimentary sequences for the Holocene.

I have recently argued (Bintliff 1987; Bintliff & Zagger in prep.) that a proper understanding of erosional sequences in the Mediterranean (and by implication elsewhere) must view them as specific 'historic' ie non-predictable, events resulting from rare and particular interactions between unusual (even 'catastrophic') events in the natural environment. It is apprpriate at this major conference inIberia that I derive this viewpoint from research into the cause of Mediterranean erosion carried out in Spain by Professor John Thornes and Spanish co-workers (cf. Gilman & Thornes, 1985; Thornes & Gilman,1983).

By studying the impact of normal 'equilibrium' rainfall on exposed and protected Mediterranean landsurfaces, in comparison with the effects of 'extreme event' catastrophic rainfall, which can occur at intervals as widely spaced as 50 years or longer, Thornes has been led to suggest that the really significant 'work' on the landscape which transforms it into disequilibrium erosional conditions, is usually atributable to rare natural events of the latter variety. But, and this is a very important but,... the effect of extreme climate events is most pronounced on the most susceptible erosional surfaces, with least vegetational protection and a geology/soil structure most amenable to erosional processes. Back to the archaeology!

The erosional sequences being revealed in many different provinces of the Mediterranean by the new teams of intensive geoarchaeologists do generally have several features in common. Usually there is little disequilibrium in the Early Holocene, except in North Africa where climatic irregularities have long been attested throughout this period. We can reasonably attribute this to a well-developed vegetative cover as yet broken up insufficiently by human populations to allow extreme climatic events to transform soil cover. But by the Middle Holocene times, Copper Age-Early Bronze Age in the archaeological sequences, in most areas of the circum-Mediterranean there are clear signs from geomorphic erosion episodes of major human impact on the landscape. Subsequent erosion episodes are widespread in the Late Bronze Age and in the Classical greek and Roman Imperial periods over most of the Mediterranean. Each one of these periods combine dense populations with intensive land use. At these times the landsurfaces on easily erodable soils are least protected and more susceptible to the ruinous potential of extreme rainfall events can be dated. The landscape is therefore 'pre-adapted' for the unpredictable extreme climatic event that actually causes the erosion episode.

A corollary of my revised interpretation of the origin of erosion sequences, is the suggestion that an era of unusually intensive land use and high population could pass by without coinciding with an extreme climatic event creating soil erosion. This could be the explanation for the absence in Greece of a major erosional episode coinciding with the highly populous Mycenaean civilisation of the Late Bronze Age. A further example may be given to reinforce my argument. Paul Goldberg in a series of detailed geoarchaeological studies throughout the southern deserts of Israel (Goldberg, 1986) has identified two major periods when very extensive areas of these landscapes were covered by waterborne loess deposits. The raw material is a light airborne dust brought from Africa, but under 'equilibrium' conditions for the Holocene of this region not deposited onto the Israeli deserts. However, in Chalcolithic and Early Byzantine times local climatic conditions were modified remarkably so that unaccustomed rainfall brought the dust down onto the deserts in considerable quantities, then carried it over the landscape through runoff and heightened stream activity. The effects in this harsh landscape were actually very positive for agricultural potential, bringing a new light and rich soil to the valleys, and presumably through the increased moisture-availability improving the efficiency of local runoff agriculture. The settlement patterns of both eras reveal a major expansion of population and land use in the southern deserts.

5. New Approaches to Landsurface investigation on and between archaeological sites

Not only have many archaeologists gone out of their archaeological sites to study the surrounding landscapes using Site Territorial Analysis, since the early 1970´s, but during the 1980´s an increasing number of field archaeologists specialising in surface survey have begun to record the archaeology that especially in the Mediterranean lies between archaeological sites. I was drawn to this kind of 'offsite-' or 'nonsite-archaeology' through studying the advanced theory of archaeological surface survey practised in

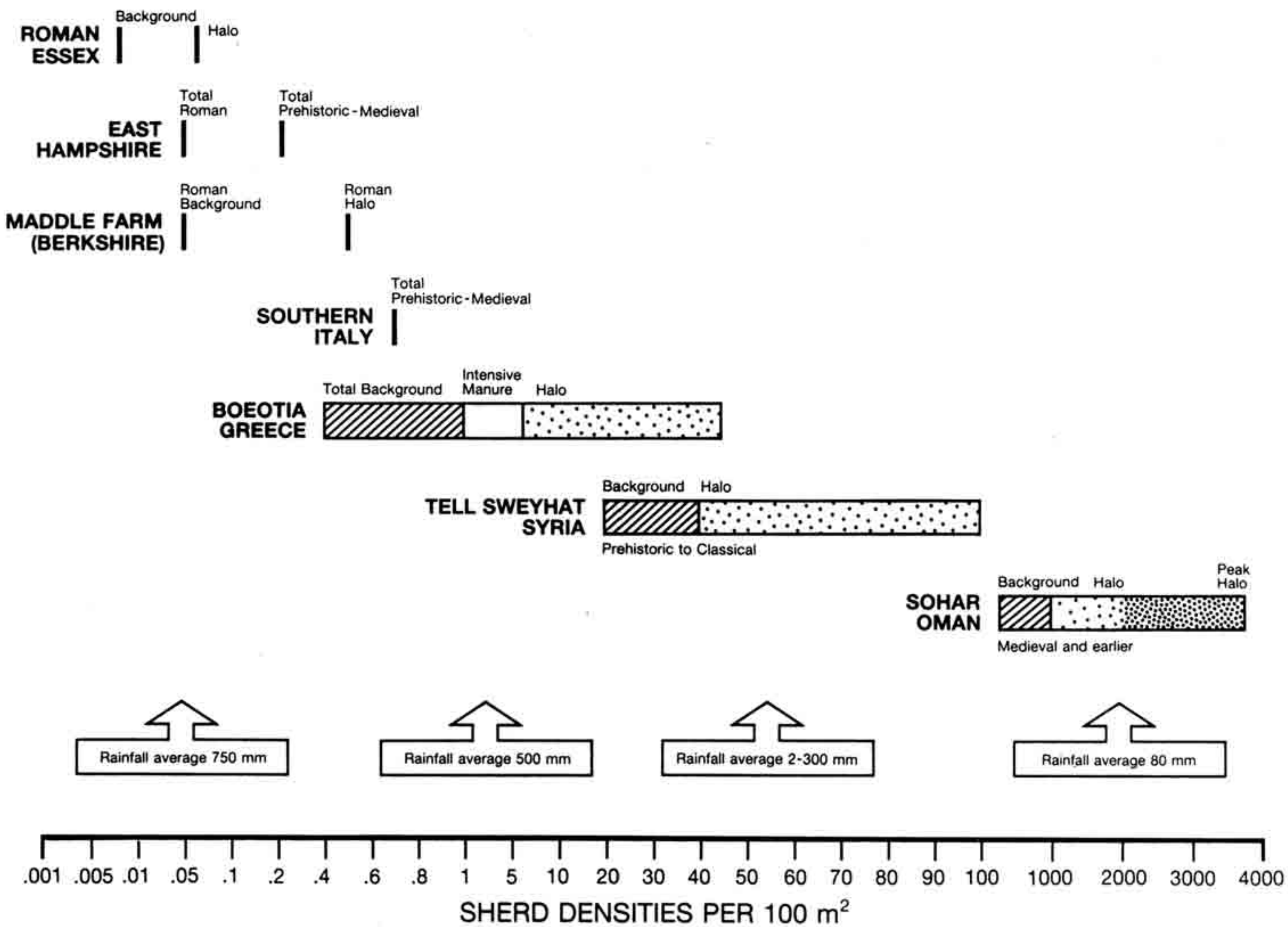

Fig. 7. Graph (from Bintliff & Snodgrass, 1988) comparing published offsite surface pottery densities for a transect from North-West Europe to Arabia

America within the New Archaeology tradition, and from 1979 till the present time have been conducting a regional survey in Central Greece (the Cambridge-Bradford Boeotia Project), where we have been recording the total density of all archaeological surface artefacts over the entire landscape (Figure 6). So far over 40 sq kms have been fieldwalked and mapped in this way, and it was as a result of comparing our offsite pottery densities with those recorded in England by Williamson, and in Arabia by Wilkinson (1982) that I was led to the hypothesis that the offsite archaeological landscape could shed invaluable insight into geomorphic processes (Bintliff & Snodgrass, 1988). Although the comparative database I was able to assemble was a small one, nevertheless it is a striking fact that the average density of offsite surface pottery rises consistently along a cline from North-West Europe through the Western Mediterranean, through the Eastern Mediterranean into the Arabian Peninsula (Figure 7). We argued that the dominant factor behind this empirical reality was the intensity of soil erosion.

The origin of the offsite "carpets" of pottery and other artefacts is however of great interest for a different reason, for we were led to support the earlier argument of Wilkinson in the Middle East they were put in place not by natural weathering processes but though deliberate deposition over the landscape by past communities in the processes of manuring.

MEAN METAL VALUES OF INDIVIDUAL SITES AND THE REGIONAL SURVEY

	METAL				
	Pb	Zn	Cu	Mn	Ni
	SITE MEAN SOIL METAL (mg/kg)				
REGION	6.6	6.6	5.7	761	192
THESPIAI	13*	18***	19***	239***	113
PP17	53***	7.5	13***	1019***	69***
PP27	11*	5.0	6.7	171***	89***
TPW2	23***	49***	23***	478***	446***
VM4	20***	17***	21***	70***	89***
VM64	16***	65***	26***	624*	232
VM89	19***	55***	28***	604***	473***
VM95	15***	55***	21***	532***	254

Values different from the regional mean are shown at the following significant levels: *** 0.1%, ** 1%, * 5%.

Fig. 8. Chart to summarize trace metal values obtained from Greco-Roman surface sites in Boeotia, compared with average soil values for the region.

If widely true, the mapping of offsite artefact zones, and the dating of these artefacts, offer the serious possibility of mapping on a period-by-period basis, the zones of intense farming activity. In Boeotia, for example, our field survey has identified a dominance of Classical Greek and Late Roman offsite pottery, coinciding nicely with an archaeological landscape almost entirely filled with rural sites of those two periods. However, in 1989 we carried out the first season of field survey in a new district of Boeotia, in the land of a small city called Hyettos. Here the offsite pottery is almost entirely Classical Greek and suggests that the area entered a permanent agricultural decline by Roman times.

Surface pottery spreads, as shown in studies such as that by Kirkby & Kirkby (1976), survive the washing away by erosion of the fine soil particles around them, and indeed we have argued that the greatly enhanced quantities Mediterranenan surface survey has found compared to survey in Britain is eloquent proof of the enhancement of pottery on the surface as surrounding soil has been washed away. Yet another technical advance pioneered on the Boeotia Project allows us to set limits on the scale of soil loss for particular periods of the past, as well as providing further information to supplement that form offsite archaeology about ancient farming activity on and between settlement sites.

For several years I have collaborated with Prof. Brian Davies of the Environmental Science department at Bradford University on experimental analyses of soil samples from within and around surface survey sites in Boeotia. Prof. Davies is an expert in modern soil pollution using the evidence of trace elements in the soil. What we discovered in Boeotia (Figure 8) was that ancient farms and cities revealed highly anomalous accumulations of similar trace metals to those detected in modern soils, such as Copper and Lead, and that these accumulations extended around these ancient sites in remarkably similar patterns to the offsite pottery spreads. The same soil samples, analysed for magnetic susceptibility and viscosity, likewise revealed highly anomalous values indicating human activity debris.

What this accumulating evidence from geochemical and geophysical analysis of site and offsite soils is showing us, is the inorganic fraction of human waste disposal behaviour. The household and farmyard rubbish and animal byproducts, deposited in middens on rural sites and smeared over the surounding cultivated lands, has survived to be measured through these novel techniques (Figures 9-12). Moreover, as well as showing us that activity zones are much larger than the areas of farm structures (what we have called site "haloes), we have begun to find evidence that trace metal levels in the open countryside show long-distance trends probably reflecting the intensity of manuring from major population centres (cf. for example the rising levels over 4 kms as we approach the major city of Thesplae, in the lead transect of Figure 13.

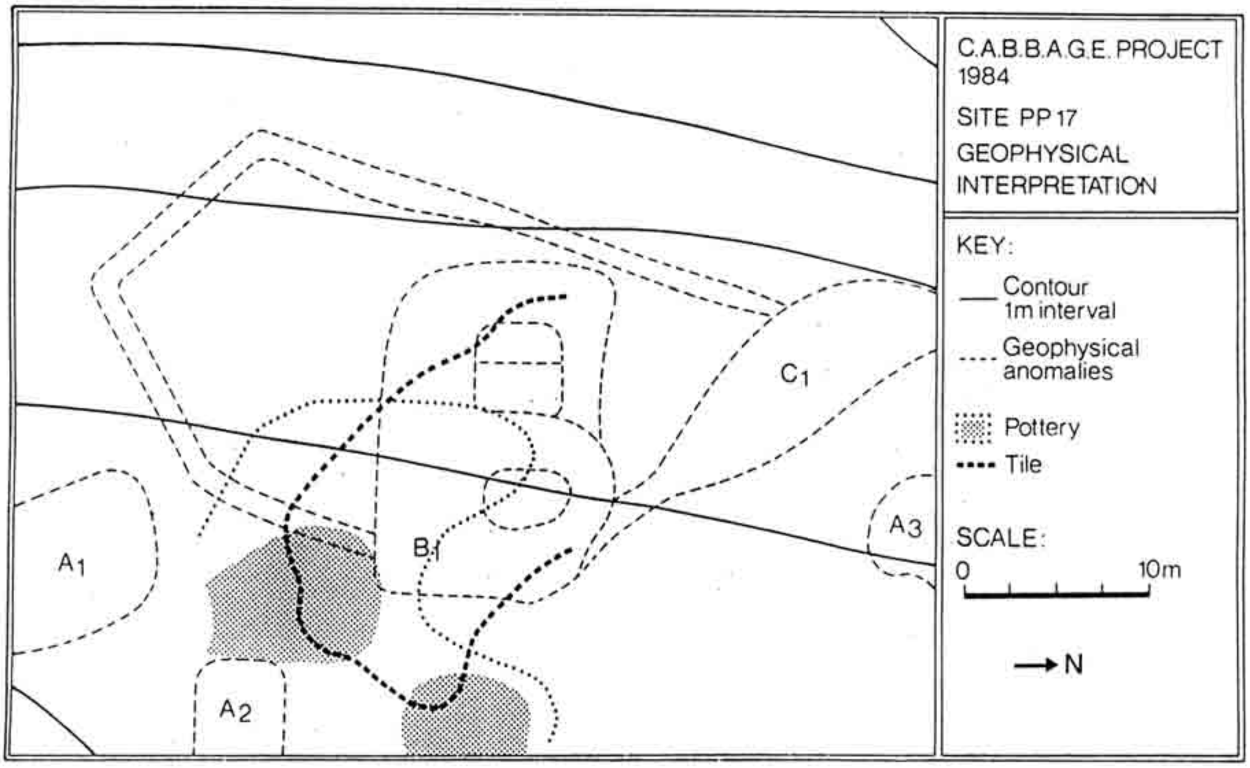

Fig. 9. A small Greco-Roman farmsite (PP17) discovered by surface survey in Boeotia, showing the interrelation of rooftile from the collapsed farm structure, domestic pottery from adjacent rubbish middens, and the traces of the farmhouse and farmyard wall picked up by geophysical resistivity analyses.

Returning to the question of intensity of erosion, however, it is of the utmost significance that the new chemico-physico evidence is directly complementary to the evidence of offsite pottery counts. Whereas the latter shows by regional contrasts tha variations in soil loss, as a result of the realtive absence of their original soil matrix, in contrast, the trace elements and magnetic charges are attached to the fine particles of the soil and can only survive in situ as palaeosol units. By comparing the two series

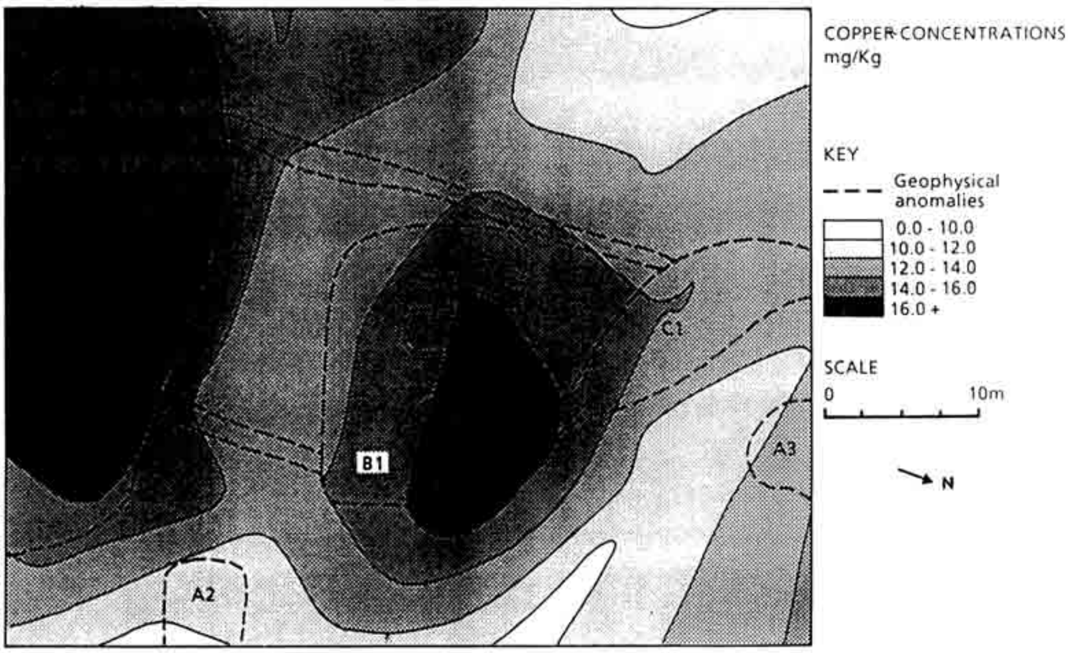

Fig. 10. Site PP17, as in Figure 9, but with soil copper values plotted over the farmhouse and farm enclosure of Greco-Roman date. All values shown are well above the regional norm for soil copper. Copper concentrations pick up the farmhouse and also surround the structures, identifying rubbish disposal areas and manuring in the fields immediately adjacent to the actual house. These 'haloes' of rubbish accumulation coincide exactly with similar high values in offsite pottery around identified farm sites (cf. Figure 6).

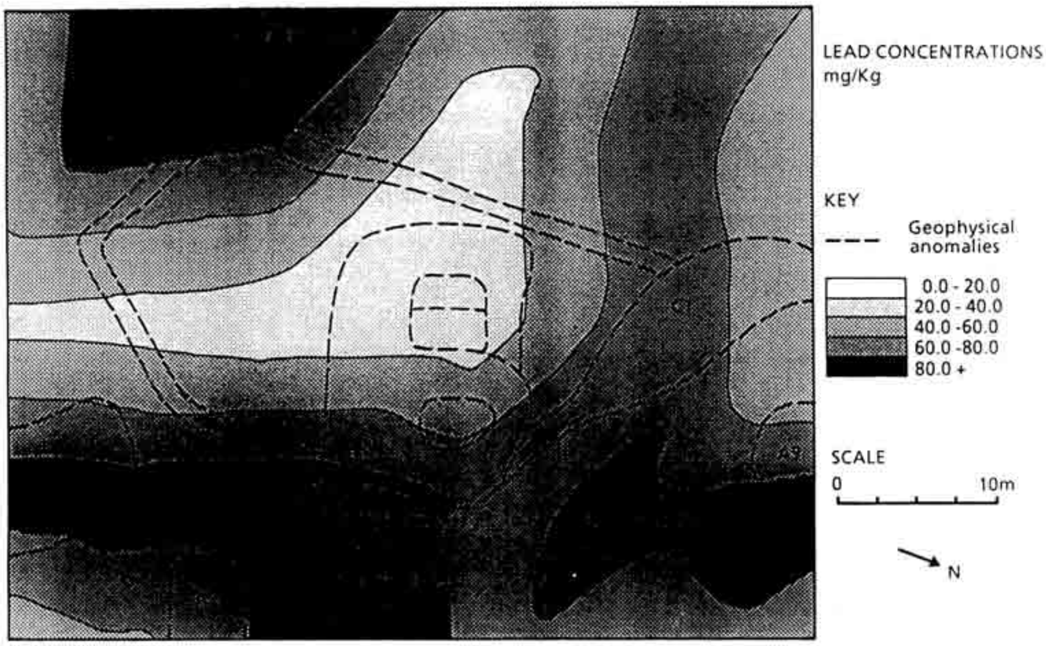

Fig. 11. Site PP17, with Lead values. All values are well above the normal regional lead levels. Here lead forms a solid accumulation of abnormal concentrations immediately surrounding the farmhouse and farmyard enclosure.

of results for the Mediterranenan landscape we can therefore suggest that in Boeotia, for example, although topsoil erosion has been severe, sufficient original palaeosol has survived for Greek and Roman times to produce an unmistakeable high signal for human activity debris on and around ancient sites, up to several kilometres distance in the case of major centres. In confirmation Prof. Van Andel has quite independently tried to estimate the total depth of soil lost in the South-West Argolid during the several major erosional events he has recorded for the past 5 milennia, and come up with a figure of less than one metre in total (Van Andel *et al*, 1986, p. 111).

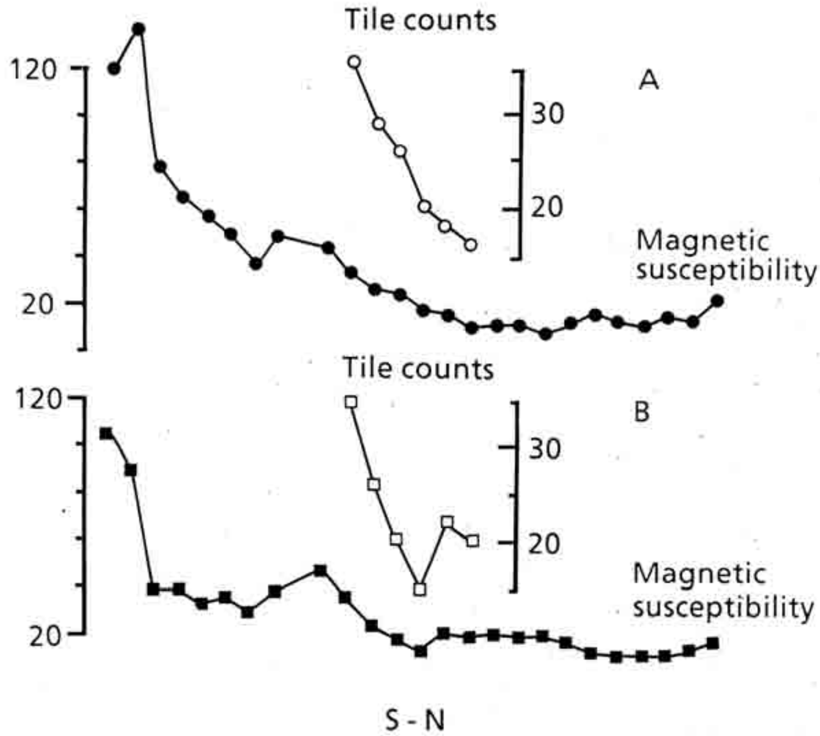

Fig. 12. Two parallel transects for soil sampling were taken on a South-North axis across a Greco-Roman farmsite in Boeotia, (site VM 64). Surface tile counts successfully picked up the location of the main farm bulding. The magnetic susceptibility readings on both transects closely echo the rooftile counts, emphasizing soil magnetic enhancement over the farmhouse, but even higher values are shown in the fields immediately to the south of the farmsite. These latter values should indicate rubbish disposal and manuring carried out from the settlement.

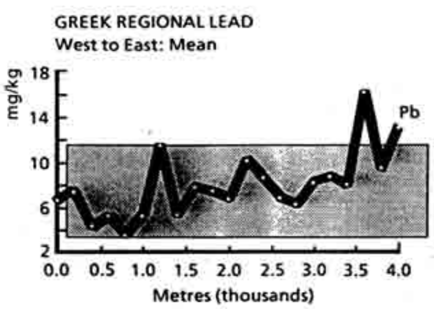

Fig. 13. Trace metal values for lead on soil samples over a 4km long transect, running from open country on the left to the edge of a major ancient city (Thespiae) on the right. The overall trend of rising values can be attributed to increased levels of ancient manuring as one gets closer to the city.

References

Bell, M., (1982): The effects of land use and climate on valley sedimentation. pp: 127-142. In: A. Harding (Ed) *Climate Change in Later Prehistory*. Edinburgh University Press.

Bintliff, J.L., (1975): Mediterranean alluviation: New evidence from archaeology. *Proceedings of the Prehistoric Society*, Vol 41, pp: 74-84.

Bintliff, J.L., (1976): The Plain of Macedon and the Neolithic site of Nea Nikomedia. *Proceedings of the Prehistoric Society*, Vol 42, pp: 241-262.

Bintliff, J.L., (1977): *Natural Environment and Human Settlement in Prehistoric Greece*. British Archaeological Reports, Oxford.

Bintliff, J.L., (1981): Archaeological and the Holocene evolution of coastal plains in the Aegean and Circum-Mediterranean. pp: 11-31. In: D. Brothwell & G.W. Dimbleby (Eds). *Environmental Aspects of Coasts and Islands. British Archaeological reports, Oxford.*

Bintliff, J.L., (1987): The Younger Fill: A timely review. Paper delivered at the *XII Congress of the International Quaternary Association*. Otawa.

Bintliff, J.L., (in press): Flussveranderungen und Palaolandschaften in der Troas: Ihre Bedeutung fur eine historiche Erdkunde dieser Gegend. In: E. Kirsten & E. Olshausen (Eds), *Griechische Siedlungskunde.*

Bintliff, J.L.& Snodgrass, A.M., (1988): Off site pottery distributions; A regional and interregional perspective. Curreent Archaeology, vol. 29, pp: 505-513.

Bintliff, J.L, & Zangger, E. (in preparation): *The significance and timing of holocene alluviations in Greece and the Mediterranean.*

Bruckner, H., (1986): Man's impact on the evolution of the physical environment in the mediterranean region in historical times. *GeoJournal*, vol. 13, pp: 7-17.

Delano-Smith, C., (1981): Valley changes; some observations from recent field and archives work in Italy. pp: 239-246. In: G. baker & R. Hodges (Eds). *Archaeology and Italian Society*. British Archaeologial Reports, Oxford.

Ellison, A., & Harriss, J., (1972): Setlement and land use in the prehistory and early history of southern England: a study based on locational models. pp: 911-962. In: D.L. Clarke (Ed). *Models in Archaeology. Methuen*, London.

Garnsey, P., (1988): *Famine and Food Supply in the Graeco-Roman World. Responses to Risk and Crisis*. Cambridge University Press.

Gilman, A. & Thornes, J.B., (1985): *Land Use and Prehistory in South-East Spain*. Allen & Unwin, London.

Goldberg, P., (1986): Late Quaternary environmental history of the Southern Levant. *Geoarchaeology*, vol. 1, pp: 225-244.

Jarman, M.R., & Webley, D., (1975): Settlement and land use in Capitanata, Italy. pp: 177-221. In: E.S. Higgs (Ed). *Palaoeconomy*. Cambridge University Press.

Judson, S., (1963): Stream changes during historic time in East-Central Sicily. *American Journal of Archaeology*. Vol. 67, pp: 2287-289.

Kirkby, A & Kirkby, M.J., (1976): Geomorphic processes and the surface survey of archaeological sites in semi-arid areas. pp: 229-253. In: D. Davison & m. shackley (Eds). *Geoarchaeology*. Duckworth, London.

Kraft, J.C., Kayan, I. & Erol, O., (1980): Geomorphic reconsructions in the environs of Ancient Troy. *Science*. Vol. 209, pp: 776-782.

Paepe, R., Hatziotis, M.E., & Thorez, J., (1980): *Geomorpholical Evolution in the Eastern Mediterranean Beltand Mesopotamian Plain*. Report for the International Geological Correlation Programme project 146: River Flood and Lake level changes.

Pope, K.O. & Van Andel, T.H.,(1984): Late Quaternary alluviation and soil formation in the southern Argolid: Its history, causes and archaeological implications. *Journal of Archaeological Science*. Vol. 11, pp: 281-306.

Thornes, J.B. & Gilman, A (1983): Potential and actual erosion around archaeological sites in South-East Spain. *Catena Suppl.*, pp: 91-113.

Van Andel, T.H., Runnels, C. N. & Pope, K.O., (1986): 5000 years of land use and abuse in the southern Argolid, Greece. *Hesperia*, Vol. 55. pp: 103-128.

Van Zuidam, R.A., (1975): Geomorphology and Archaeology. Evidences of interrelation at historical sites in the Zaragoza region, Spain. *Zeitschrift für Geomorphologie N.F.* 19, pp; 319-328.

Vita-Finzi, C., (1969): *The Mediterranean Valleys. geological Changes in Historical Times.* Cambridge University press.

Vita-Finzi, C. & Higgs, E.S., (1970): Prehistoric economy in the Mt. Carmel area of Palestine: site catchment analysis. *Proceedings of the Prehistoric Society.* Vol. 36, pp: 11-37.

Wilkinson, T.J., (1982): The definition of ancient manured zones by means of extensive sherd-sampling techniques. *Journal of Field Archaeology.* Vol. 9: 322-333.