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LANDSCAPES OF NOMADISM AND SEDENTISM

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Cover: The Bronze Age site of Goutsoura seen from the south. Photo: Björn Forsén

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Contents

A Geoarchaeological Study of the Goutsoura Sediments

Mika Lavento and Paula Kouki

The Bronze Age site of Goutsoura (PS 12) is one of the most many-sided of the sites that were found and excavated during the Thesprotia Expedition. It is located in a sheltered small nook on the lowermost eastern slope of the Liminari hill. Today, a small dirt road running at the foot of the hill divides the site into two parts, of which the larger part is located on the alluvial fan of the nook itself, whereas a smaller part is located to the east of the dirt road in the cultivated field. Just to the northwest of the nook, slightly higher up on the slope, there is a small terrace forming a third separate part of the site. Towards the east of the site a flat plain extending until the Kokytos opens up.

The archaeological excavation at the site was conducted mainly in the nook, in an area which has not been taken into modern cultivation and thus is better preserved as the part of the site which is located in the field to the east of the dirt road. Due to colluvial processes which have accumulated soil and gravel in the nook, several superimposed cultural layers and different structures could be detected. Some remains of the cultural layer were also observed on the uppermost terrace and at the westernmost edge of the field to the east of the dirt road.

The site was settled for the first time during the early and middle phases of the Early Bronze Age (ca. 2920-2400 cal. BC), after which it may have been abandoned for some 400 years before being used again as a cemetery during the late Middle Bronze Age and most of the Late Bronze Age (ca. 2000-1250 cal. BC). Finally, there is a late cultural layer that covers the graves and dates to between 1320 and 1100 cal. BC.[1]

After the site had been found during the field survey in 2004, it was investigated in 2005-2006 by coring and taking phosphorous samples in the field at the foot of the Liminari hill. Further samples were taken in the nook itself in 2007. The majority of these samples indicated highly anomalous phosphorous values. However, most of the geoarchaeological observations were made in 2008, when a magnetometer survey was also conducted at the site. This article will describe the results of the geoarchaeological research carried out at the site, with a special emphasis on the results of the soil cores and the phosphorous analysis.

Geological environment

Landscape archaeology is an essential part of reading the environment and its development during the Pleistocene and Holocene.[2] The northwestern part of Greece belongs to the

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[1] For the first preliminary descriptions of the site, see Forsén *et al.* 2011, 80-82; Forsén and Forsén 2012, 297-301. For a detailed description of the location and stratigraphy of the site, see Forsén, this volume. For pottery and its chronology from the site, see J. Forsén, this volume, for the preserved structures, see Lima, this volume. We owe thanks to Björn Forsén and Esko Tikkala for comments and help while preparing this chapter. All illustrations are by Paula Kouki, except for Fig. 3 which is by Esko Tikkala.

[2] Wiseman and Zachos 2003; Besonen *et al.* 2003.

area of the Alpine orogeny, which was active during the Triassic, Cretaceous and Eocene epochs as late as ca. 50-100 million years ago. The geological history itself is locally complex but the most essential local character is the ubiquitous presence of two main bedrock types: limestone has developed as an anticline and flysch as syncline in the bedrock formation.[3] The sedimentation of both limestone and flysch has taken place in deep marine environments during an early stage of the orogeny of the Pindos range, and the sedimentary rocks have later risen up through the processes of the tectonic history of the area.[4] Both of these bedrock types are primarily visible in the Kokytos valley.

Flysch is a relatively hard bedrock, consisting of coarse conglomerates or breccias. The parent rock is sandstone or mudstone, and the formations are directed upwards. They are dated from the Mesozoic era to the Eocene epoch. The flysch is a sediment rich in calcium carbonate, and both fossils and remains of chert are visible in the matrix. Typical for these formations are also greywacke-like sandstones, which are interbedded with flysch. Flysch gives the area its mountainous character, because the formations are still sharp in relief. It has been separated in the Alpine orogeny in particular, although sediments of the same kind are sometimes found also in other parts of the world.[5]

Limestone is the other main bedrock type in the region, and it is one of the most important bedrock types in the Pindos zone in general. The limestone of the area is dolomitic and its age is mainly Mesozoic, but there are also Eocene formations. Within the limestone it is possible to find fossils of, for example, calcareous algae, ammonite cephalopods and foraminifera. Despite being often heavily eroded, limestone is also present in parts of the research area and can be found in the mountain ranges.

Limestone or karst, which is the essential bedrock in the area, is particularly sensitive to weathering. The internal dynamics of the earth as well as other factors – climate, water, wind and vegetation – have influenced changes in the soil and bedrock.[6] Rain, runoff and groundwater have caused the development of dolines or sinkholes which transport water and produce subaqueous springs in the limestone bedrock.[7] It is an essential feature of these subterranean water channels that their locations have changed over time. This development results from the limestone being soft and easily soluble by groundwater. If a lot of groundwater is available, the subterranean streams and springs may change their places several times, even during a relatively short period. This characteristic of the local bedrock has influenced the location of prehistoric settlements and the possibilities for agriculture.

The large Kokytos valley, the bottom of which is more or less flat in relief, is a central element of the environment of Goutsoura. The Kokytos collects its waters from springs which are mainly located in its eastern part, on the lower slopes of the Paramythia mountain range, and in the plain itself. The water flow today is not very high during the summer in the upper course of the Kokytos.

However, the amount of water available in the area has varied during different climatic periods, which is indicated in the drillings and analyses done from the sediments

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3 Willis 1992, 139.
4 Runnels and van Andel 2003, 54-61.
5 Pettijohn 1975, 571-572.
6 Talbot and Allen 1996.
7 Runnels and van Andel 2003, 57-68.

Fig. 1. The nook at Goutsoura in front of the horseshoe-shaped slopes of the Liminari hill, view towards the west.

Fig. 2. Part of the Bronze Age site of Goutsoura with the flat plain extending on its east side until the Kokytos and with the Paramythia mountain range in the background. View towards the southeast. The large trial trench next to Area 1 is visible to the right (arrow).

from contemporary small lakes. For example, in Lake Limnoula to the north of Goutsoura, it has been possible to separate fluvial and dry periods in the Paleocene and Holocene deposits.[8] This indicates that there has been more water available also in the Kokytos valley, which is relatively dry in our days. The drying of the environment is not only dependent on natural conditions. After the mid-twentieth century, the lowermost parts of the valley were drained by means of constructing a network of ditches, and the intensive cultivation in the valley uses considerable amounts of water for irrigation.

The average elevation of the flat plain opening up to the east of Goutsoura is ca. 101-104 masl, falling slowly off towards the southeast and the Kokytos (Fig. 1). The remains of the site are located at between 104-116 masl, i.e., just above the level of the plain.[9] With the help of the slope profile of the Liminari hill, the site can be divided into three separate areas, which can still be observed today (Fig. 2). The highest part of the site complex lies on a small terrace at an elevation of ca. 114-116 masl. Here the site is heavily eroded and no structures were observed. The main part of the site is located in the sheltered nook at an elevation of ca. 106-110 masl. The site is best preserved here due to the sheltered location at the foot of the Liminari hill. This is also where all observed structures are located. The lowermost part of the site is located to the east of the nook along the westernmost edge of the fields, on the plain itself, and is largely destroyed by modern land use.

[8] Kluiving *et al.* 2011, 43-45.
[9] Forsén *et al.* 2011, 79.

It is important to keep in mind the central role that erosion and sedimentation have played at Goutsoura. Because the upper slope of the Liminari hill is relatively steep, erosion has led to considerable changes in environment, not only during its geological history, but also during the periods when the site was settled. Colluvial processes and cultivation have eroded a large part of soil and finds from the upper slopes and deposited them at the foot of the hill. There is even a small alluvial fan in the area of the settlement. This means that the original form of the slope has changed considerably, and the terraces which were originally used for habitation have at least partially been destroyed. It is also very probable that a large part of the archaeological material in the lowermost field does not represent the original deposition.

The site of Goutsoura has been the focus for human activity for most of the third and second millennia BC. The setting of the site must thus obviously have offered favourable living conditions for people with variable means of livelihood. Therefore it is reasonable to ask, where did the settlers get the water that is necessary for living? We know, for instance, that the Acheron plain has changed through the times because the river itself changed its course, and sedimentation took place in its alluvium.[10] Our own field observations indicate that similar phenomena have taken place also in the Kokytos valley. It is probable that in earlier times water was available in the immediate vicinity of Goutsoura, for example, due to sink holes and dwells in the limestone. At the moment, there are no functioning springs in the vicinity of the site, but a well in between the sheltered nook and the fields on its east side indicates the presence of rather rich and high groundwater within the limestone.

Soil sampling and analysis

The usability of soil phosphorus analysis for detecting archaeological sites was discovered by the Swedish scholar Olof Arrhenius as early as the 1930s.[11] Today, phosphorus analysis has developed into a standard tool in archaeology. In a large number of studies, phosphorus has been proven to be the most reliable and lasting chemical indicator of past human activity in soils.[12]

The samples at Goutsoura (Fig. 3) were mainly taken using a manually operated soil auger, although in some cases the soil was too stony for augering and a sampling pit had to be dug at first by spade. Phosphorus sampling was performed not at a fixed depth, but rather when evidence of human activity, such as tiny fragments of tile, pottery and charcoal, were noticed in the soil. Changes in grain size and soil composition were also noted from the cores.

The phosphorus samples were dried and analysed in the Archaeology Laboratory at the University of Helsinki. The analyses were carried out with a spectrophotometer using the method based on the colour intensity of the molybdenum blue complex. In this method, the soil samples are treated with 10% citric acid, which dissolves Fe and Al phosphates and easily soluble Ca phosphates, as well as some of hydroxylapatite

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[10] Runnels and van Andel 2003.
[11] Arrhenius 1935.
[12] See e.g. Holliday and Gartner 2007.

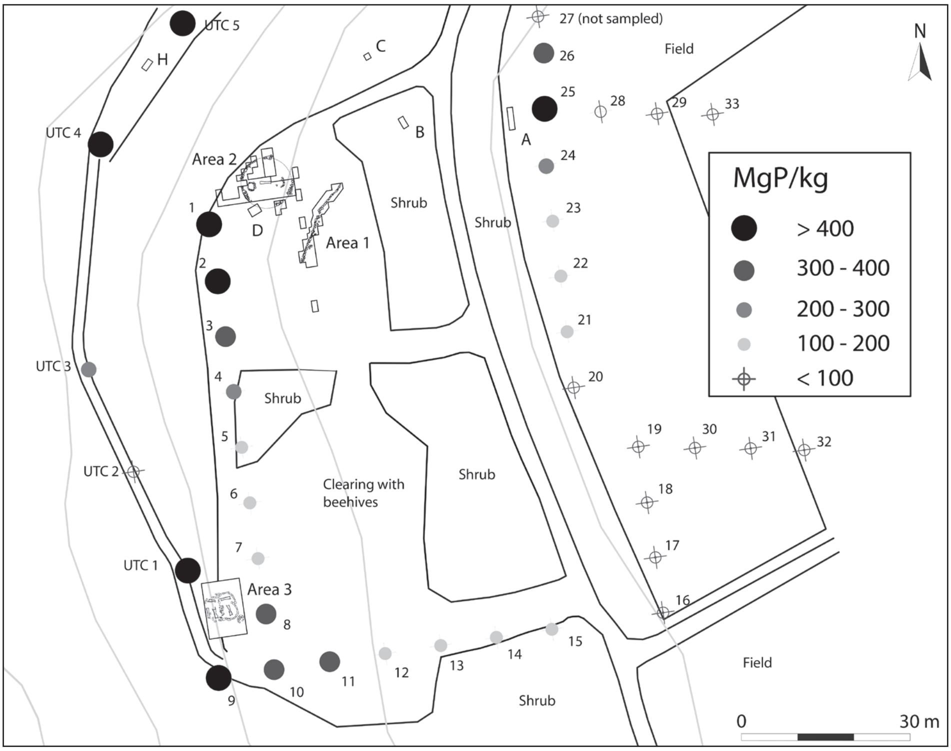

Fig. 3. Location of augering holes and distribution of phosphorous anomalies.

and soil organic phosphate compounds.[13] Although the treatment does not dissolve all the organic compounds of phosphorus, it has been shown to be adequate in recognising ancient human activity in a variety of environmental settings from the northern coniferous zone to the Mediterranean.[14] In areas, where the bedrock has a high calcium carbonate content, such as in the Kokytos valley, the soil pH tends to be alkaline or close to neutral, and organic phosphorus forms compounds mainly with the soil calcium carbonate. These compounds are dissolved by the treatment of the samples with citric acid, bringing the enriched phosphorus into solution. The samples are then sieved and reagents are added to the solution.[15]

The phosphorus content of the samples is determined by comparing the results with a calibration series prepared of samples with a known phosphorus content. The results are presented in the unit mgP/kg. Although the exact boundaries are not possible to give, in normal conditions the phosphorus values of natural soil remain below 50 mg/kg. Phosphorus contents of 50-100 mg/kg were treated as symptomatic, while phosphorus contents higher than 100 mg/kg were considered anomalous, indicating enrichment as a result of human activity.[16]

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[13] Jussila *et al.* 1989, 15.
[14] E.g. Arrhenius 1935; Lavento 2003.
[15] A full description of the method can be found in Jussila *et al.* 1989.
[16] Lavento 2003; Forsén *et. al.* 2011, 75.

Core no.	Cultural layer met at depth	Sampling depth upper/lower	P mg/kg cal.
1a	44	56-62	833
1b	44	80	783
2	30	37-46	480
3a	30	36-46	322
3b	30	49-61	284
3c	30	65-74	246
4	30	44-56	289
5	45	56-67	124
6	-	44-53	155
7	25	36-46	182
8	18	40-53	325
9	25	35	463
10	24	37-49	364
11	18	35-43	322
12	20	47-58	193
13	0	40-49	181
14	0	48-61	140
15	0	53-61	198
16	25	51-62	148
17	-	49-58	87
18	40	45-57	64
19	41	36-46	47
20	49	45-55	77
21	40	45-55	125
22	0	47-57	123
23	35	45-53	103
24	30	46-57	212
25	34	46-54	703
26	35	50-60	306
28	40	46-56	99
29	40	50-60	50
30	0	47-58	53
31	23	50-58	25
32	40	50-50	41
33	-	45-54	48
UTC1	-	54	482
UTC2	-	40-48	67
UTC3	-	45-50	260
UTC4	20	20-21	960
UTC5	-	53-60	490
PS12/01	-	50-60	25
PS12/02	-	54-64	28
PS12/03	-	50-60	35
2006/1			188
2006/2			171
2006/3			283
2007/1			408
2007/2			829
2007/3			825
2007/4			825

Fig. 4. Depth of cultural layers and phosphorous values observed in the augering holes. All depths in cm.

The first three phosphorus samples at Goutsoura were taken in 2005 in the cultivated field to the east of the dirt road (sample nos. PS 12/01-03), another three in 2006 along the westernmost edge of the same field (sample nos. 2006/1-3) and four in 2007 in the nook to the west of the dirt road (sample nos. 2007/1-4). The samples which were taken in the field showed natural levels of phosphorus (25-35 mgP/kg), whereas the samples taken along the upper edge of the field all had anomalous values (171-283 mgP/kg). However, the samples taken from the nook showed unusually high phosphorus values, ranging from 408 to 829 mgP/kg (Fig. 4).

On the basis of the results from the soil samples taken in 2005-2007, it was decided to focus further on Goutsoura, conducting trial excavations, a magnetometer survey and extensive soil sampling.[17] The purpose of the intensive soil sampling that was carried out in 2008 was to clarify the areal extent of human activity at the site by soil phosphorus analysis and to investigate erosional processes on the slopes of the Liminari hill.

Two roughly 80-100 m long, north to south running main phosphorus sampling lines were made, one in the nook, just at the foot of the slope of the Liminari hill (sample nos. 1-9), and the other one in the field below (sample nos. 16-27). A third, east to west running line connected these two main lines (sample nos. 9-16). In addition, two shorter lines oriented east to west were extended further towards the east into the field (sample nos. 19, 30-32, as well as 25, 28-29 and 33).[18] Samples were taken along these lines at intervals of 10 m. Furthermore, a series of five samples was

[17] For the progress of the work on the site, see Forsén, this volume.
[18] See Forsén *et al.* 2011, 80, fig. 3.

taken from the upper terrace on the lower slope of the Liminari hill (sample nos. UTC1-5) at intervals of 20 m (Fig. 3).

Discussion of results

The first main sampling line ran across the nook into which lead three dry ravines, bringing rainwater down from the Liminari hill. The stony topsoil, which was detected in cores 1-11, is ca. 28 cm thick in average (Figs. 5-6). The topsoil has probably been created as a result of hillslope erosion and later agricultural activities. The soil and pebbles transported

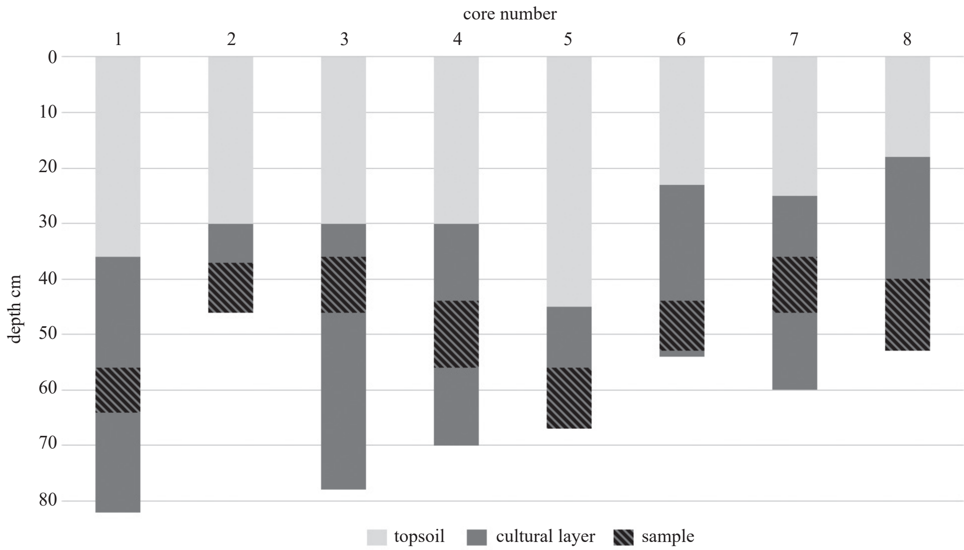

Fig. 5. The profiles of augering holes 1-8 in the nook.

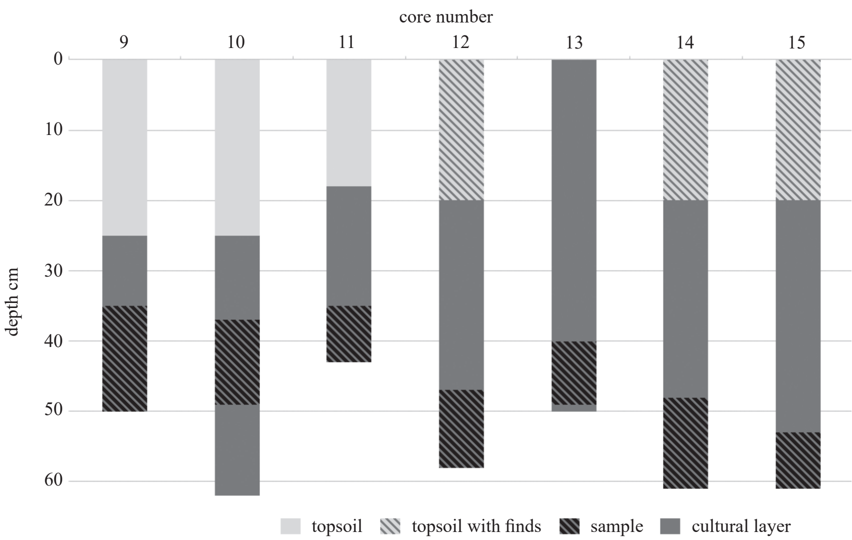

Fig. 6. The profiles of augering holes 9-15 in the nook.

by water and slope processes have buried the cultural layers of the Early to Late Bronze Age site. The upper limit of the cultural layer, indicated by the presence of pottery and tile fragments, was met at the depth of 20-45 cm. It tended to be less stony than the topsoil, consisting of fine sand mixed with gravel and pebbles. The cultural layer extended to the depth of at least 80 cm and in most cores its bottom was not met. The sampling depth for phosphorus was determined based on the presence of cultural debris in the soil, being 47-56 cm in average.

All the samples from the nook (sample nos. 1-15) have an anomalous phosphorus content, ranging from 124 to 833 mgP/kg (Fig. 4). However, in the lower part of the nook (sample nos. 12-15), there are finds mixed with the soil already beginning from the surface at the same time as the phosphate enrichment below the surface is only moderate (178 mgP/kg in average at the depth of ca. 47-57 cm). This suggests that the material on the surface may be dislocated as a result of erosional processes from higher up on the slope (Fig. 6).

The samples from the upper terrace (sample nos. UTC1-5, Fig. 7) support the idea that part of the human activity originally took place on the lower slope of the Liminari hill. There, significant concentrations of phosphorus were detected in the soil (the highest content of the site, 960 mgP/kg was measured in UTC4), even though evidence of a cultural layer was detected only in auger hole UTC4 (Figs. 4 and 7). A sterile layer of stones and pebbles, probably representing later erosional processes, extended in augering holes UTC1-4 down to a depth of 20-35 cm below the surface.

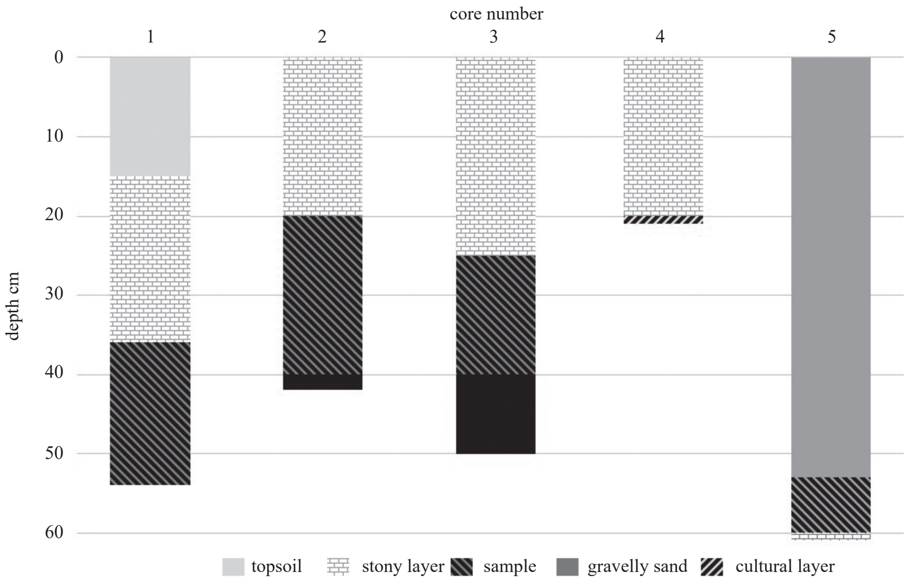

Fig. 7. The profiles of the augering holes on the upper terrace.

High phosphorus contents (212-703 mgP/kg) were only detected in the northwestern corner of the field (sample nos. 24-26), roughly at the same spot where prehistoric finds were previously collected on the surface and an EBA settlement layer was found in a trial trench at a depth of ca. 30-70 cm below the surface.[19] In the rest of the field to the east

[19] For Trench A and Area 2, see Forsén, this volume.

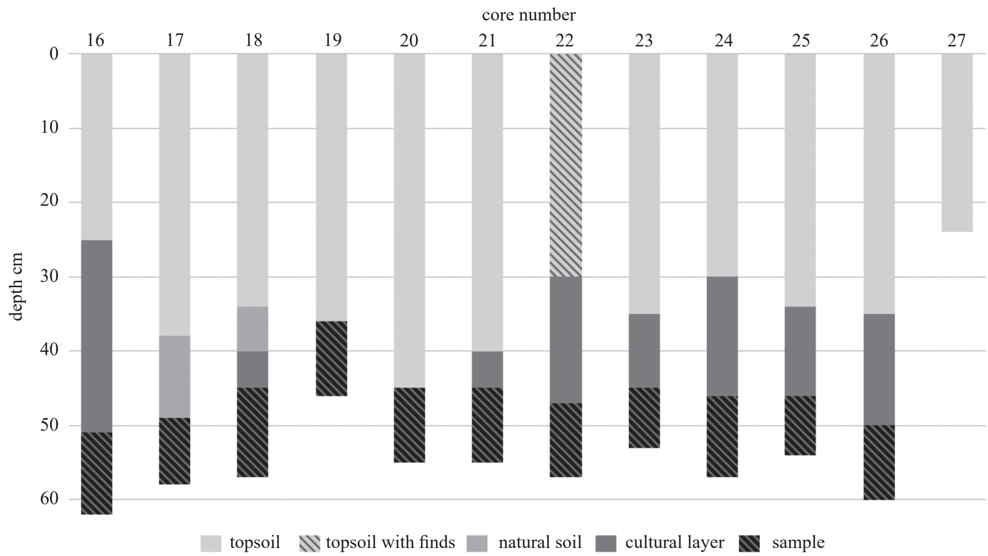

Fig. 8. The profiles of augering holes 16-27 in the field to the east of the dirt road.

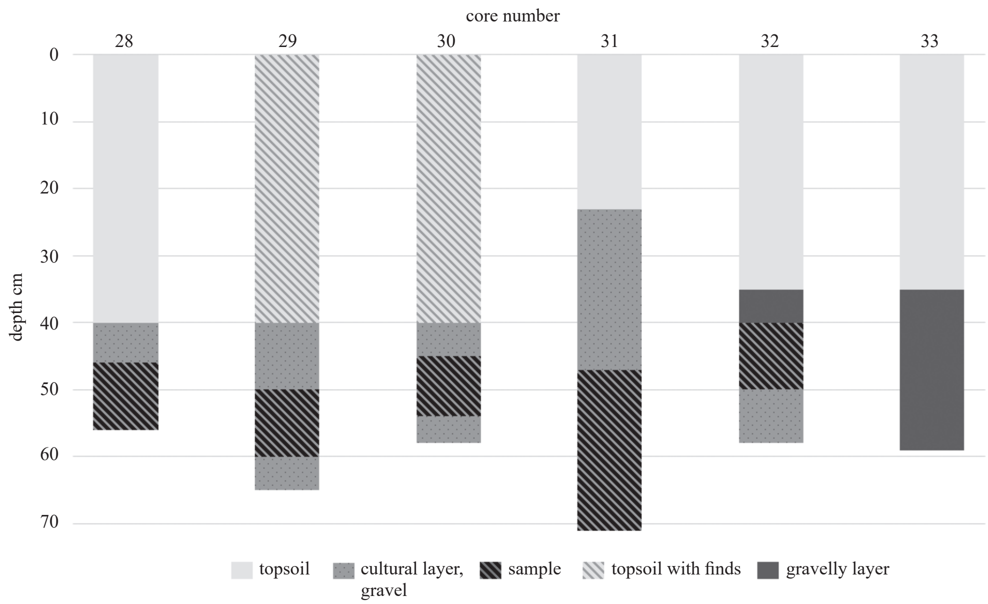

Fig. 9. The profiles of augering holes 28-33 in the field to the east of the dirt road.

of the dirt road, the phosphorous content was mainly low or moderate (25-148 mgP/kg), implying moderate to no enrichment as a result of human activity. The samples (nos. 19, 29-33) with natural, or close to natural, phosphorus content (25-53 mgP/kg) were located furthermost to the east (Figs. 4, 8-9). The topsoil is loose and stony, most likely the result of frequent tillage, and its thickness is ca. 35 cm in average. Below the plough zone, the soil is more consolidated and less stony, with an increased clay and moisture content. A cultural layer containing tiny tile and pottery fragments was met varyingly at the depth of 25-40 cm, and it extended to the depth of at least 65 cm from the surface.

Particularly in the northern part of the field, there is a distinct gravelly layer at a depth of ca. 40-60 cm, probably signifying the transport of erosional material from the hillslope by water flows. Pottery fragments continued through the gravelly horizon, indicating that it was deposited during, or after the Bronze Age. However, at places (augering holes 22, 29, 33) the finds appeared immediately on the surface, reflecting either deeper tillage and/or a change of landforms as a result of erosional processes and human activity after the Bronze Age. Towards the south and the east, with increasing distance from the slopes of Liminari, the soil is considerably less stony and more clayey. The increased clay content suggests deposition in standing water and at least seasonal presence of standing water in the area in the past, probably as shallow ponds during the wet season.

In the archaeological excavations at the site, high soil phosphorus contents were revealed to be closely related to the Early to Late Bronze Age human activity in different parts of the site.[20] The lack of enrichment of phosphorus in the samples from the field suggests that the cultural markers there mostly are redeposited. The site is, as already emphasised, located on the western edge of a wide, flat plain extending up to the Kokytos. This plain is known to have been a swampy, seasonally flooded area until it was drained in the latter half of the twentieth century. It seems probable that the edges of this swampy valley were cultivated and the cultural materials in the field to the east of the dirt road may partly be the result of manuring. The combined effects of agricultural practices together with erosional forces may explain the extensive spread of pottery fragments to the lower lying field to the east of the main site.

[20] Forsén *et al.* 2011, 79-82; Forsén, this volume.

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