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K. DECKERS (*)

GEOARCHAEOLOGICAL EVIDENCE FROM WESTERN CYPRUS: INDICATIONS ON THE IMPACT OF PEOPLE ON THE ENVIRONMENT AND OF THE ENVIRONMENT ON HUMAN COMMUNITIES

Abstract - An off-site geomorphological survey has been conducted in order to understand Cypriot archaeological sites in their landscape context. In this paper possible indications of former human impact on the environment and of the environment on human communities are suggested, but need to be further tested. Human induced erosion and subsequent deposition probably took place during Byzantine and Medieval times probably as a result of deforestation for copper production activities as well as for agricultural and herding activities. On the other hand, some possible indications of the impact of the environment on human societies have been found as well. More precisely, typical «Little Ice Age» torrential river behaviour probably took place at approximately 1600 AD and might have had some impact on the decline of the sugar industry. Additionally, the steep gradient and associated high energy channels of the Western Cypriot rivers possibly had an impact on the location and shape of settlements.

Key words - Environmental impact, deforestation, copper mining, agriculture, Middle Ages, Cyprus.

Riassunto - *Geoarcheologia di Cipro-Ovest: indicazioni sull'impatto delle popolazioni sull'ambiente e dell'ambiente sulle comunità.* Una campagna di ricognizioni *off-site* è stata effettuata per comprendere la posizione dei siti archeologici ciprioti nel loro contesto paesaggistico. Questo lavoro suggerisce indicazioni sul possibile impatto antropico sull'ambiente e sull'influenza ambientale sulle comunità, ma necessita di ulteriori verifiche. In tempi bizantini e medievali si verificarono erosione e conseguente deposizione, probabilmente a causa della deforestazione legata alla produzione di rame e ad attività agricolo-pastorali. Inoltre sono stati individuati alcuni probabili indizi dell'influenza ambientale sui gruppi sociali. Più precisamente, il comportamento torrenziale dei corsi d'acqua durante la «Piccola Età Glaciale», attorno al 1600 d.C. potrebbe aver avuto una certa influenza sul declino dell'industria dello zucchero. Inoltre, la notevole pendenza e la conseguente forte energia dei corsi d'acqua di Cipro occidentale potrebbero aver influenzato l'ubicazione e la forma degli insediamenti.

Parole chiave - Impatto ambientale, deforestazione, estrazione del rame, agricoltura, Medio Evo, Cipro.

INTRODUCTION

«The Western Cyprus Geoarchaeological Survey» was conducted in order to reconstruct the former Cypriot landscape and to understand the relations between people and their environment through time. The fieldwork took place in June 1999 and in April and August 2000. Two small teams with students from the University of Edinburgh and Glasgow investigated river terraces along several streams in Western Cyprus: the Stavros-tis-Psokas, the Ezousas, the Xeropotamos, the Dhiarizzos and the Agriokalamos. About 1,700 man-hours were spent in the fields cutting back sections, describing sediments, looking for datable material in the sections and sampling. About 30 sequences were recorded and about 300 sediment samples were retrieved for further laboratory investigations, which consisted of loss-on-ignition, particle size analysis with a Coulter LS230 analyser, particle shape analysis, pH, magnetic susceptibility and lithological identification. In this paper only a selection of sequences will be treated, especially those which raised hypotheses about the impact of people on the environment, and of the environment on human communities.

DATING METHODOLOGY

Interpreting the causality of fluvial and colluvial deposits depends strongly on the synchronicity of deposits with other proxy records. There are many interdependent variables, such as climate, people, tectonic activity and eustasy, which all may have caused increased deposition of fluvial sediments in the river valleys (*cf.* also Frederick, 2001). A temporal and spatial correlation of these proxy records with the geomorphological evidence may indicate causality. Therefore, achieving a tight chronological framework for the sequences is a prerequisite for investigating former people-environment interactions. In this study, a preliminary chronological insight into the fluvial/colluvial chronology has been gained through a *terminus post quem* date on off-site sherds from the deposits. Since most pot sherds were rounded through river action, they were undatable by typology. Therefore, a simple Thermoluminescence (TL)-screening method has been applied on the sherds (*cf.* in detail in Deckers *et al.*, 2005). This technique lacks the accuracy and precision of the full dating method but allows an approximation of the age of the sherds. Consequently, when these dates are used further in the paper, the term «approximately» is mentioned in front of the date. Besides this TL-application, additional chronological insight has been gained through Single Aliquot Regenerative Optically Stimulated Luminescence (SAR-OSL) dates on sediments (Spencer *et al.*, 2003). These dates provide a statistical date for the burial of the sediment. Furthermore, the

(*) Ur- und Frühgeschichte, Ältere Urgeschichte und Quartärökologie, University of Tübingen, Schloß Hohentübingen, Tübingen, D-72072, Germany.

sedimentological analysis, which improved the understanding of the degree of soil formation, improved the chronological insight as well. The chronological framework in this study is less tight than ideally needed for investigating people-environment relations and therefore all interpretations are preliminary and need to be further tested.

Indications of former anthropogenic impact on the western Cypriot environment

Sequence EZG at Kannaviou-*Potamos* is located at the edge of the present day Troodos Mountain forest, N of the village Kannaviou, off the main road before the bridge over the Ezousas, E of the track to Ayia (cadastral map XXXVI.49, at the W edge of plot 349) (Fig. 1 and 2). At the bottom of this 2.6 meters deep section a sherd was found which was approximately dated to 1300 AD. Hence, about 2.6 meters of fluvial gravels were deposited sometime after approximately 1300 AD. The grading at the bottom of the section, visible as 4 couplets, indicates that the velocity of the stream changed 4 times from high to lower. On the other hand, the poorly sorted structure of the unit above was a result of a single flood event. After the flooding, the river left this location and deposited overbank sediments. Some incipient soil formation took place since then as has been indicated through some preliminary laboratory tests, suggesting that some time has elapsed since the deposition of the sediments. According to the slightly higher organic matter in EZG1, an incipient A horizon formed, while the particle size analysis and a combined high magnetic susceptibility value in EZG2 indicate incipient B_t horizon formation. Additionally, an increase in alkalinity with depth suggests the downward movement of calcium carbonate. Hence, the soil on EZG suggests that some time elapsed since soil formation started and therefore that a Medieval date for the deposition of the sediments is plausible. Of importance for the further discussion is the frequent occurrence of chalk, silicified chalk and limestone in this section. The geological map indicates that these could only come from one location stream-upwards where Lefkara formation is outcropping (Fig. 3). Interestingly, in the neighbourhood of that outcrop location, at Asproyia-*Ayios Sozondas*, a Medieval mining and smelting site has been reported. This site consists of 24 adits in the pillow lava and 2000 square meters of slag heaps (Fox *et al.*, 1987: 170). The occurrence of slag heaps suggests the use of fuel wood and consequent deforestation of the area. Therefore, we can question whether the erosion at Asproyia due to mining and smelting activities resulted in the observed deposition of fluvial sediments at EZG. Further chronological studies are necessary for the geomorphological sequence as well as for the archaeological site. The erosion might also have been triggered by specific climatic conditions and increased tectonic activity. Indeed, several studies suggest that during the Frankish period a wet climate prevailed in the Near East which increased runoff, gully erosion and streamflood deposits (*e.g.* Frumkin *et al.*, 1991: 199; Bar-Matthews, 2003). Additionally, a major incidence of earthquakes took place during the Frankish period which might have favoured sedimentation in the river valley as well. More precisely, earthquakes are historically known to have taken place on Cyprus in 1160 AD, 1202 AD (Leonard *et al.*, 1998: 143), 1303 AD (El-Sayed, 2000: 341) and 1491 AD (Pantazis, 1996: 85). Another geomorphological sequence has been investigated at Ayia Varvara-*Pervoloudhin* at the edge of the modern Ezousas floodplain, 350 m W of Ayia Varvara (cadastral map LI.22, plot 51) (Fig. 1 and 4). Of the 4 meters of exposed deposits, the lower 3 meters are largely alluvial, while the upper 1 meter by contrast colluvial. An OSL-date has been performed on the sediment located 30 cm below these colluvial sediments, providing a burial date of 0.94 ± 0.07 ka BP (it is a date between 990 and 1130 AD) for the sediment. Since incipient soil formation separates the colluvial sediments from the dated sediment, the colluvial sediments were deposited quite some time later than 0.94 ± 0.07 ka BP. More precisely, an incipient A horizon had formed with a relatively high organic matter content (Fig. 4b: EZA4). Calcium carbonate translocation had taken place and an incipient B_k horizon had formed (Fig. 4c: EZA5, EZA6, EZA7). On the other hand however, the incipient soil formation on top of these colluvial sediments also suggests that some time has elapsed since the deposition of these sediments. An incipient B_t horizon developed (*cf.* the typical red colour related to periodic wetting and the higher percentage of clay). However, the upper unit was partially removed,

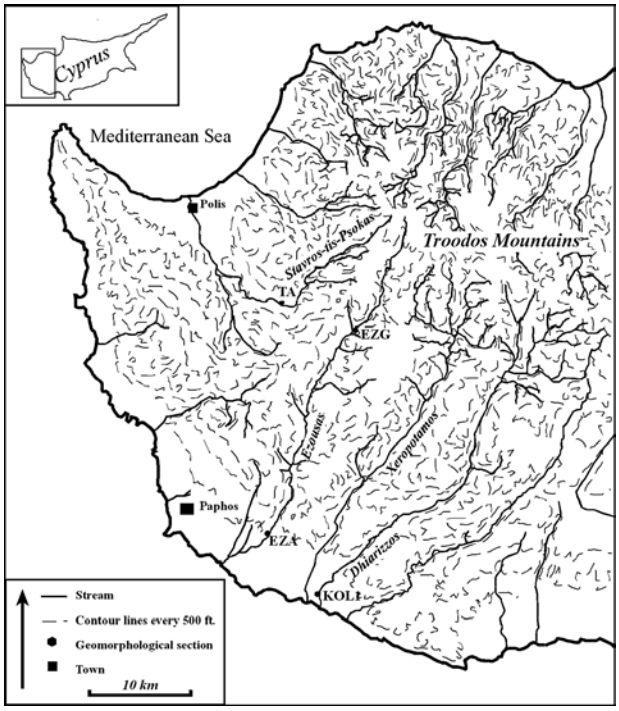

Fig. 1 - Location map of mentioned sequences and streams.

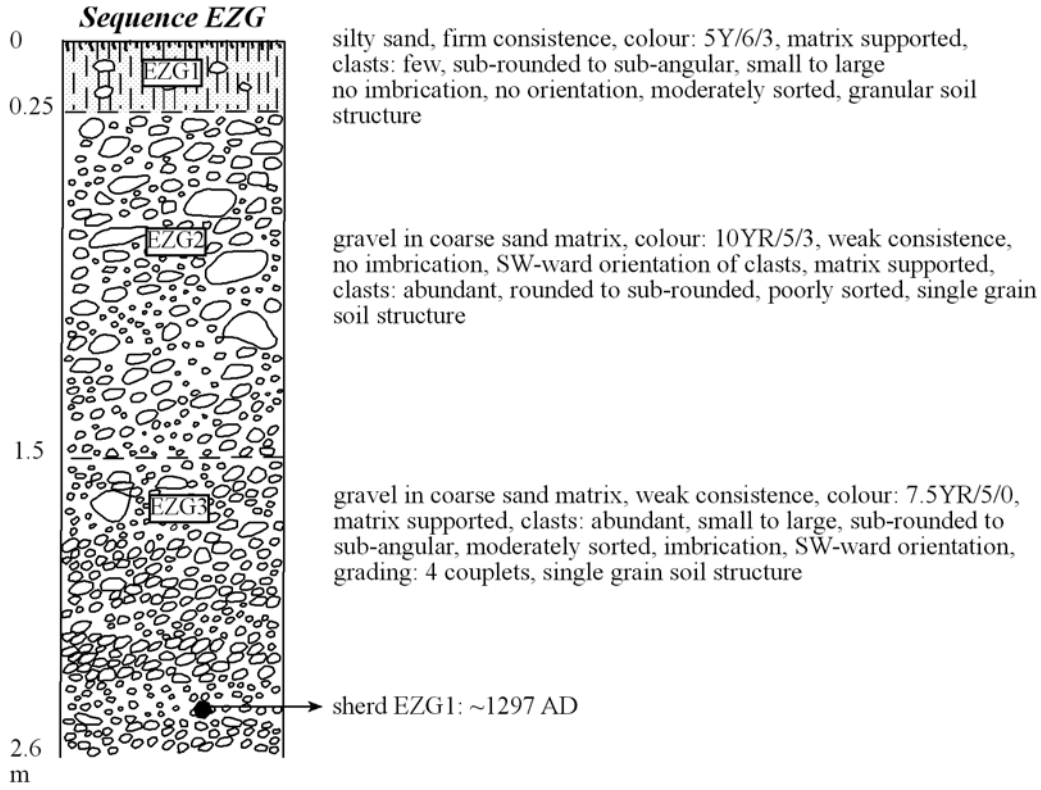

Fig. 2 - Sequence EZG along the Ezousas.

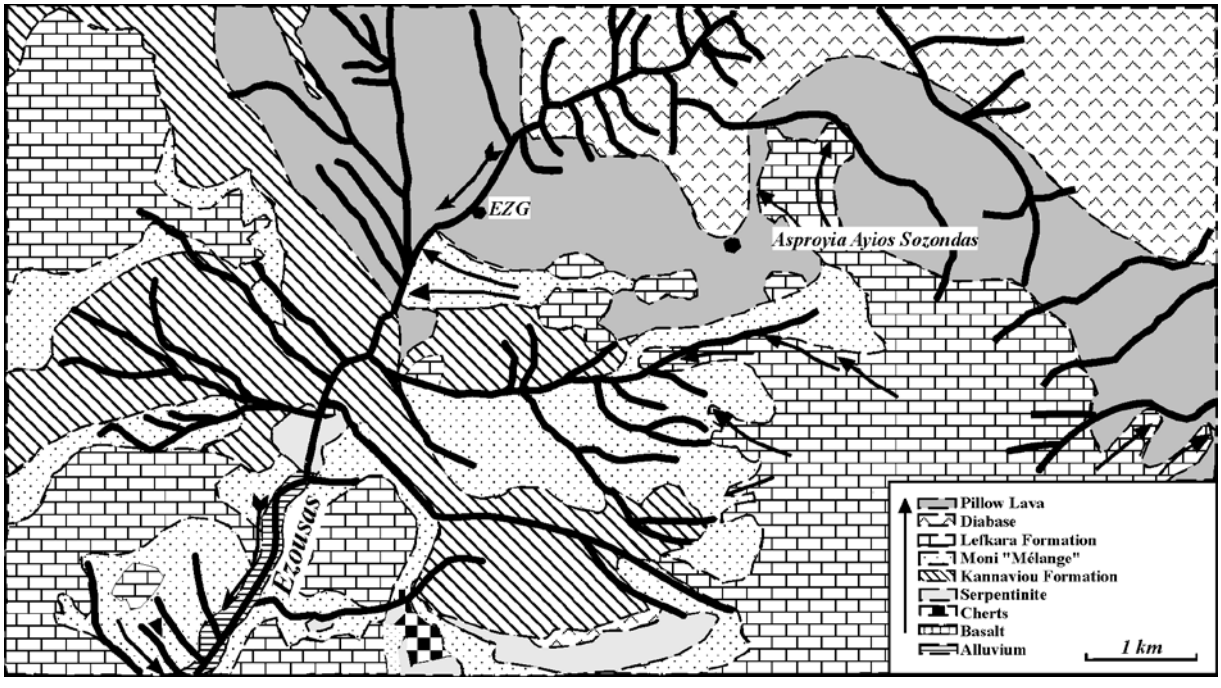

Fig. 3 - Geological map of the EZG region in relation to the site of Asproyia-*Ayios Sozondas* (adapted from the Geological Map of the Polis-Paphos Area, Geological Survey Department Cyprus).

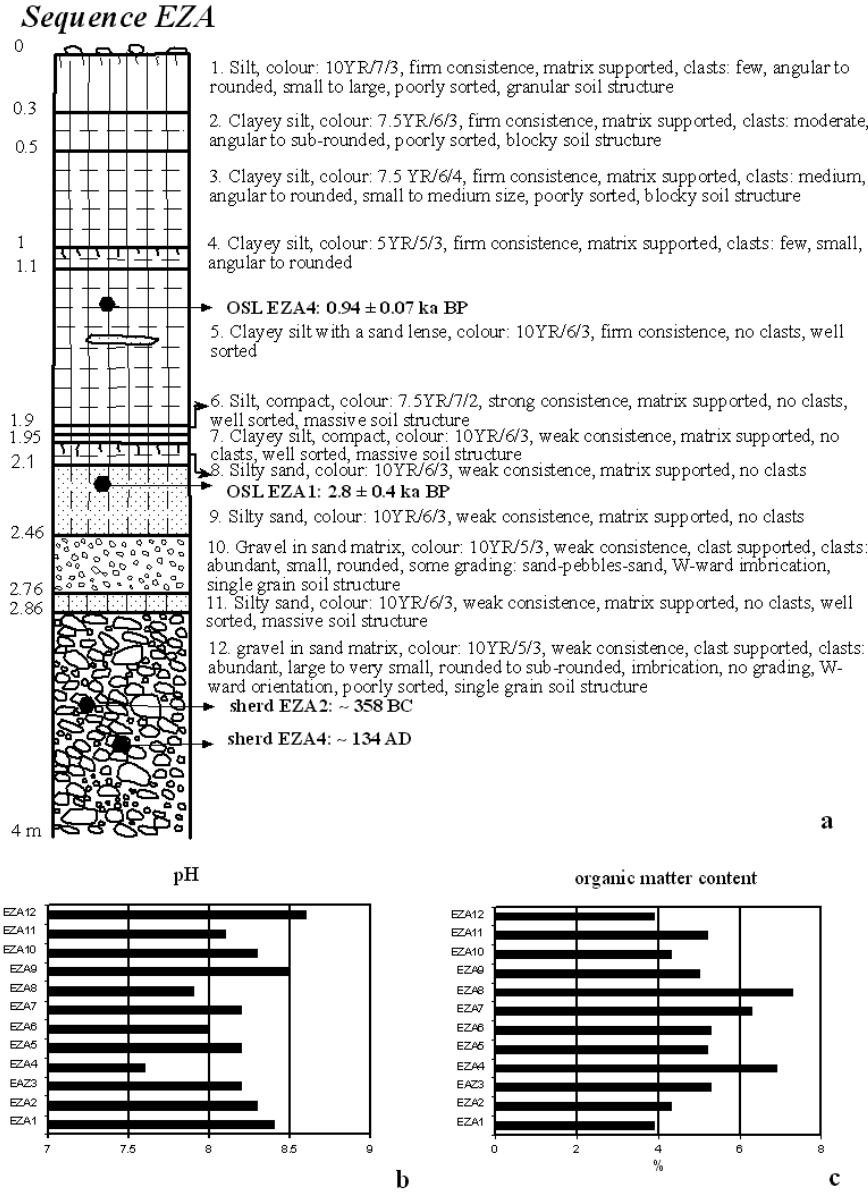

Fig. 4 - a) Sequence EZA along the Ezousas; b) pH measurements on sequence EZA; c) organic matter content measurements on sequence EZA (through loss-on-ignition).

probably for the construction of the track built on top of the section. Further soil formation took place and a new incipient B_t horizon developed (*cf.* the typical red colour related to periodic wetting and the higher percentage of clay). As a result of the degree of soil formation on top of the colluvial unit, it is clear that some time has elapsed since soil formation first started. Therefore, on the one hand the colluvial unit post-dates by quite some time 0.94 ± 0.07 ka BP, while on the other hand it was deposited also quite some time ago. Consequently, it can be extrapolated that the colluvial unit was probably deposited in Medieval times. Moreover, lithological identification of the clasts indicated that serpentinite was only present in the upper meter of sediments, indicative of local erosion which took place W of the Ezousas on the serpentinite outcrops (Fig. 5). In this context, of note is the large settlement site of Ayia Varvara-*Ambeloudhin* (Fig. 5, 80E10), located in the neighborhood of the serpentinite outcrops, with evidence of Late Medieval activity (Rupp, 1984: 150). Additionally, survey has located many Medieval sites within this area (Fig. 5), suggesting extensive land use during this period (Rupp, 1984). As a result of this apparently synchronous evidence, we can question

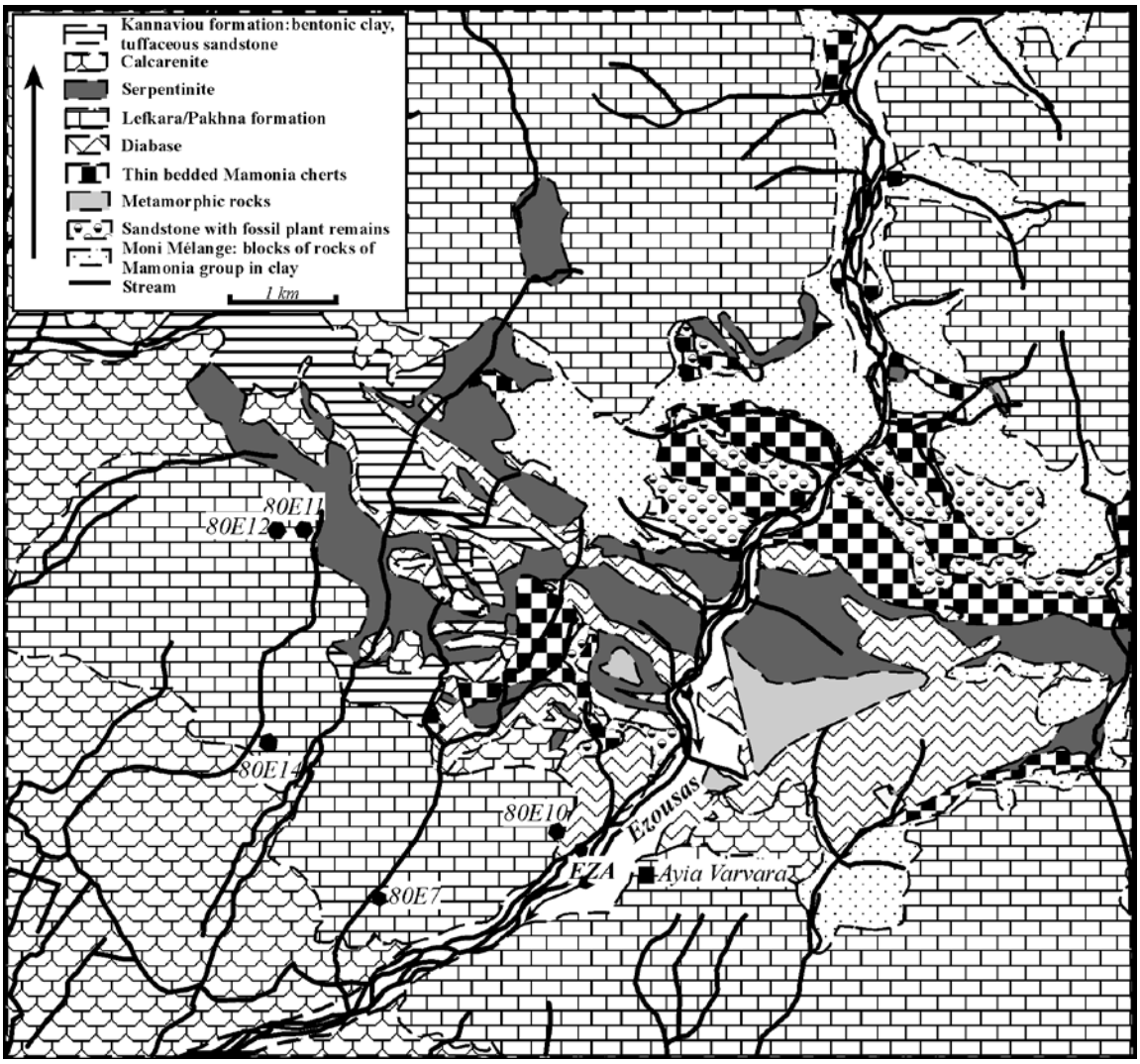

Fig. 5 - Geological map of the EZA region in relation to Medieval settlements. 80E10: Ayia Varvara-*Ambeloudhin*; 80E7: Ayia Varvara-*Argakin tou Karkoti*; 80E14: Ayia Varvara-*Ayia Marina*; 80E12: Armou-*Skamta/Louraeas*; 80E11: Armou-*Ayios Typhon/Kannotiris* (adapted from the Geological Map of the Polis-Paphos Area - Geological Survey Department Cyprus).

whether there is a causal relation between Medieval occupation and erosion, leading to colluvial deposits in the river valley. Further chronological research is necessary to investigate this question. Therefore, an OSL-date on the colluvial unit would be useful. Additionally, the chronology of the site at Ayia Varvara-*Ambeloudhin* and the Medieval occupation should be refined as well.

Another geomorphological sequence was investigated at Sarama-*Kamarin* (section TA), at the junction of the Stavros-tis-Psokas and the Argakin Pyroia stream (*cf.* cadastral map XXXV.38, plot 353) (Fig. 1 and 6). Evidence was found of two major phases of colluvial deposits, separated by a period of soil formation. While the first colluvial phase took place sometime after approximately 575 AD, the second erosional phase occurred sometime after approximately 919 AD. Some time has passed since the deposition of the sediments since a soil was able to develop on the present day surface. More precisely, the A horizon contains a relatively high organic matter content. Clay has illuviated from 0.72 m onwards. Moreover calcium carbonate has been translocated to a depth of 1.35 m. It is remarkable that an archaeological survey located substantial Byzantine metallurgical activities within the Stavros-tis-Psokas drainage in the neighbourhood of the investigated section (Baird, 1987: 16-17) (Fig. 7). The possible temporal correlation with the increased mining and smelting activities in the area and the increased erosion during these periods seems to suggest a causal relation. Further research is necessary to test this hypothesis.

As a conclusion, we may say that the above mentioned temporal and locational correlations between the deposition of sediments in the river valley and the archaeo-

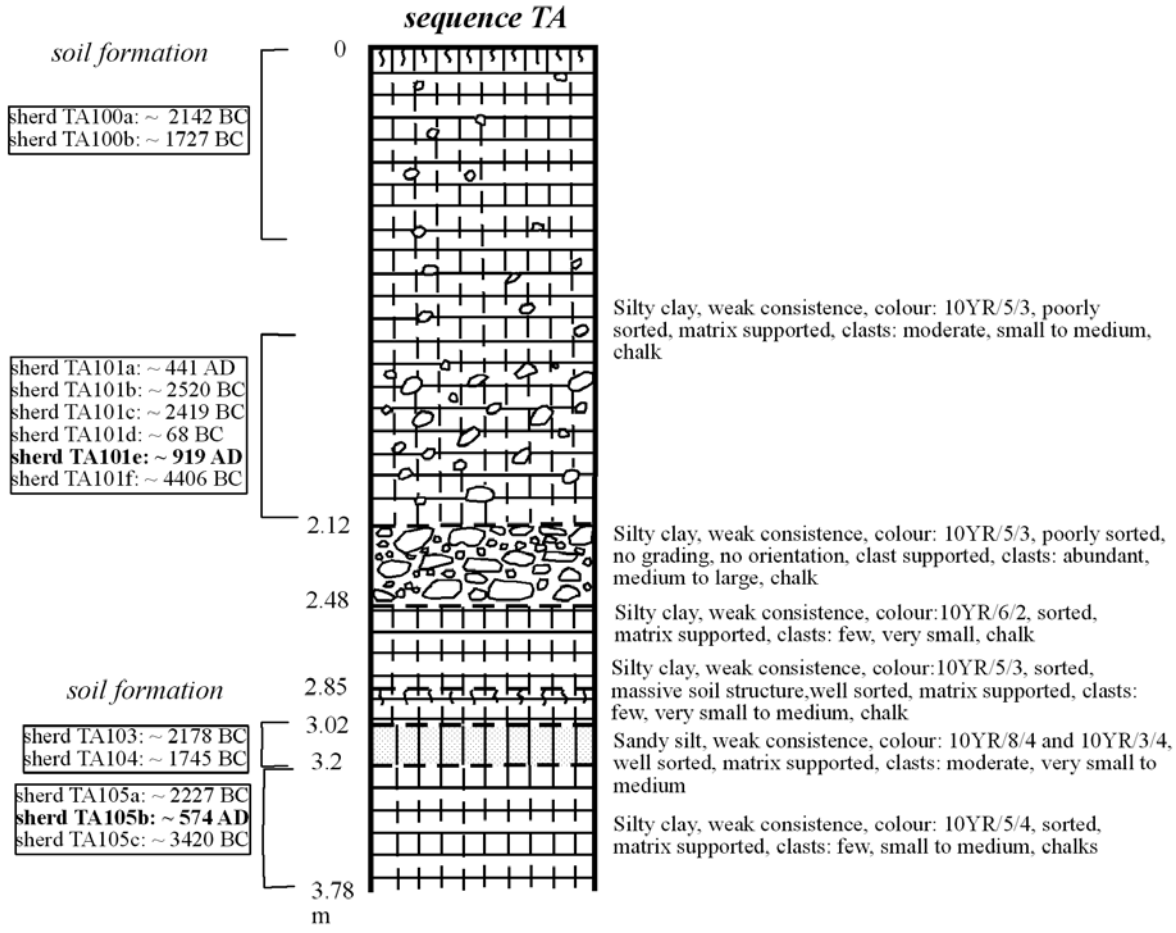

Fig. 6 - Sequence TA along the Stavros-tis-Psokas.

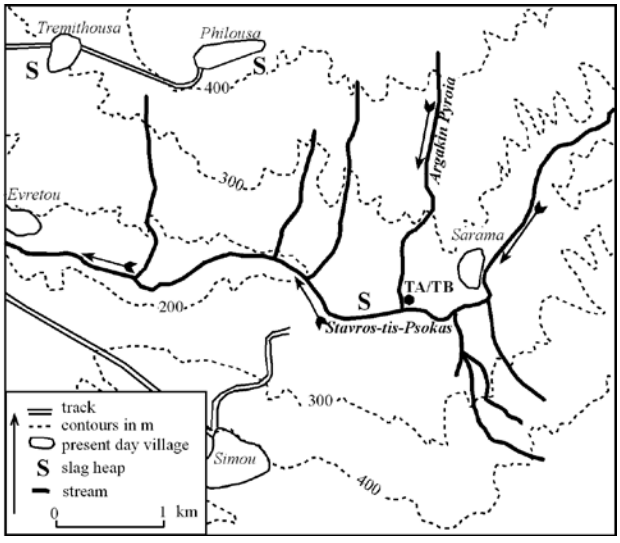

Fig. 7 - Metallurgical activities in the Stavros-tis-Psokas area.

logical evidence indicative of deforestation suggest a causal relation. However, further chronological studies are necessary to test these hypotheses. On one hand the dating of the geomorphological sections should be improved, while on the other hand more details need to be published on the chronological designations of the above mentioned archaeological sites.

Indications of the impact of the environment on former Cypriot human communities

The geomorphological survey also aimed to find indications of the impact of the environment on human societies, especially the impact of fluvial environments on people. Although rivers were a positively valued factor in settlement location and land exploitation, they also could cause problems. The 3.1 m deep sequence KOL1 at Kouklia-*Lakkos* represents a natural exposure on the W bank of the present Dhiarizzos river (cadastral map LI.48, border of plot 178 and 180) (Fig. 1, 7 and 8). The

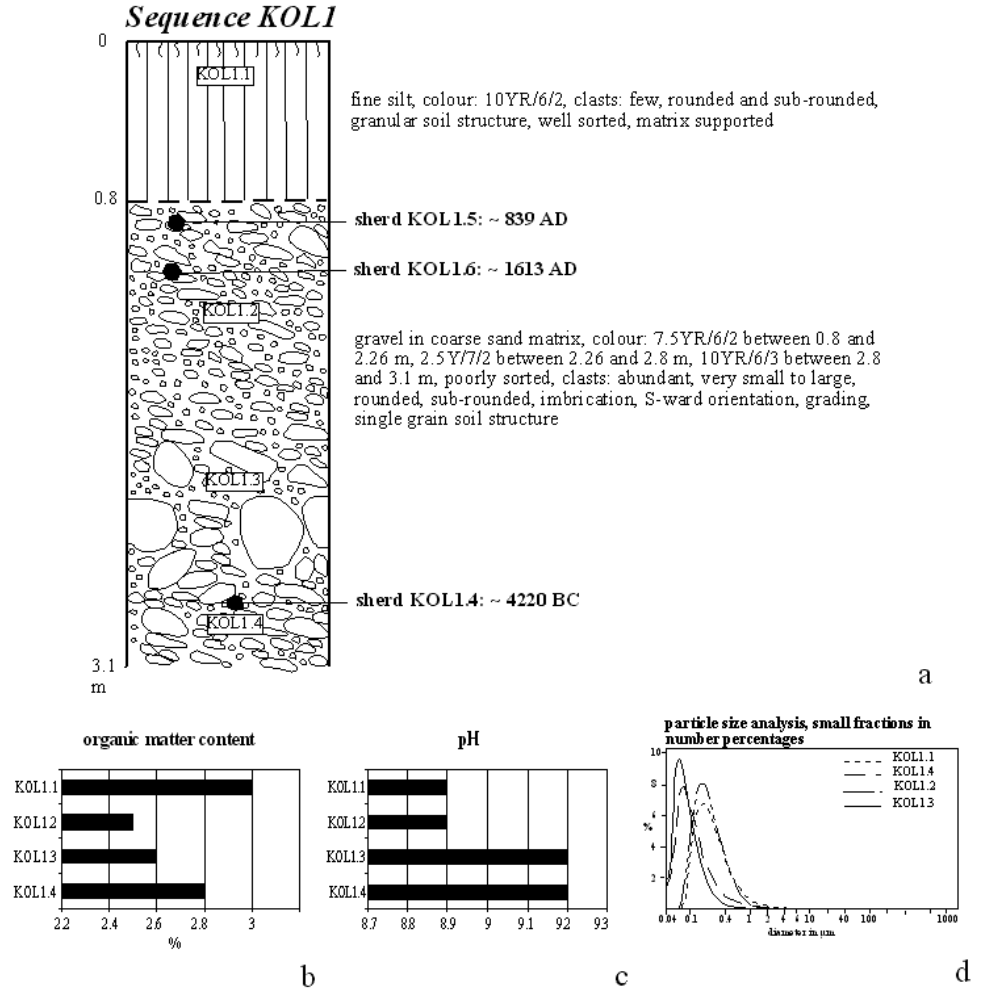

Fig. 8 - a) Sequence KOL1 along the Dhiarizzos; b) organic matter content of samples from KOL1 (through loss-on-ignition); c) pH of samples from KOL1; d) particle size analysis, small fractions of samples from KOL1.

rounded gravels indicate that a channel of the Dhiarizzos was situated at KOL1. The fining upward structure suggests that it was deposited in one episode. The large size of the clasts (up to 40 cm) indicates that it was a strong river, a bedload dominated stream. Moreover, the youngest sherd in the unit suggests a date after approximately 1613 AD. After a flood, the river probably became choked by its own alluvium and changed its channel. Subsequently, this location was still within the floodplain of the new river course. As a result of flooding, almost a meter of overbank sediments were deposited on top of the previous channel deposits. Although the amount of laboratory-tested samples is rather small, they suggest that some time elapsed since the deposition of the sediments, as indicated through soil formation on the surface. An incipient A horizon has formed, as is suggested by the high organic matter content in sample KOL1.1 (Fig. 8b). The particle size analysis indicates higher percentage of clay in samples KOL1.2, KOL1.3 and KOL1.4, therefore suggests the illuviation of clay (Fig. 8d). Additionally, calcium carbonate probably has been translocated to the depth of samples KOL1.3 and KOL1.4, as indicated by their relatively high alkalinity (Fig. 8c). The parent material of most part of the soil consists of gravel in a coarse sand matrix. This is probably why the soil formation is so deep in relation to the only short period during which the soil could develop. Although more samples need to be investigated, the preliminary laboratory tests suggest that the 3.1 meters of sediments were deposited shortly after the date of the youngest sherd in the section, at approximately 1613 AD. Although the «Little Ice Age» is best documented for north and central Europe, there is some historical as well as geomorphological evidence of cold and wet conditions throughout the Mediterranean associated with alternating seasons of drought and flooding. Does sequence KOL1 represent the results of a typical «Little Ice Age» flashflood? Only 200 m away from KOL1 at

the locality Kouklia-*Stavros* a 14th to end 16th/beginning 17th Century sugar production site was found (Fig. 9). Historical evidence indicates that the surrounding fields were intensively used as sugar plantations (von Wartburg, 2001: 328). Since the Mediterranean region is rather marginal for sugar cane plantations, large scale sugar production sites only could develop in a few areas, mostly in coastal plains and valleys where irrigation was possible. As a result of this necessary location of the sugar cane plantations in the Mediterranean, flooding and consequent sediment deposition probably took place periodically. Whilst siltation was advantageous because it increases the soil's fertility, the deposition of large gravels caused great losses (Blume, 1985: 56). Sequence KOL1 might represent the evidence of such a flood. We can question whether this flood had an impact on the sugar plantations and indirectly on the decline of the sugar industry which took place early in the 17th century AD. Further chronological refining, such as ^{14}C dates on humate fractions from the A horizon could test further the above suggested temporal and locational synchronicity.

As indicated in the example above, rivers acted as attraction pole as well as were possibly causing problems on Cyprus. The following part will explore briefly in how far different fluvial behaviour resulted in different social behaviour, more precisely through the lack of tell sites on Cyprus. It has often been mentioned as a curiosity that there is a suspicious absence of tell sites on Cyprus, unlike in all surrounding areas of the mainland. It can be questioned whether there is an environmental rationale behind the absence of tells. What struck me on leafing through some geoarchaeological reports from tell sites from the mainland is that quite a lot of tells contain, between mostly anthropological strata, occasionally evidence of flood events (*cf. e.g.* van Andel *et al.*, 1995; Peltenburg *et al.*, 1996; Oguchi & Oguchi, 1998; Marsh, 1999; Esin, 1999). As a matter of fact, most tell sites occur in broad alluvial floodplains shaped by rivers with relatively low gradients and along the edges of lakes whose levels were normally relatively stable. Tell sites were flooded only occasionally, especially more early in their formation. Therefore, building the settlement upwards rather than outwards would have had obvious advantages. A sloping site, raised above the plain (forming an artificial mound) would have been less likely to suffer from flooding. The geographical situation in Western Cyprus is different than on the mainland as the rivers are relatively short as a consequence of the insularity of Cyprus. Hence, the rivers have their source in the almost 2,000 m high Troodos Mountains and end shortly after in the sea. As a result, they have a steep gradient and a braided morphology. This is not conducive for long-term occu-

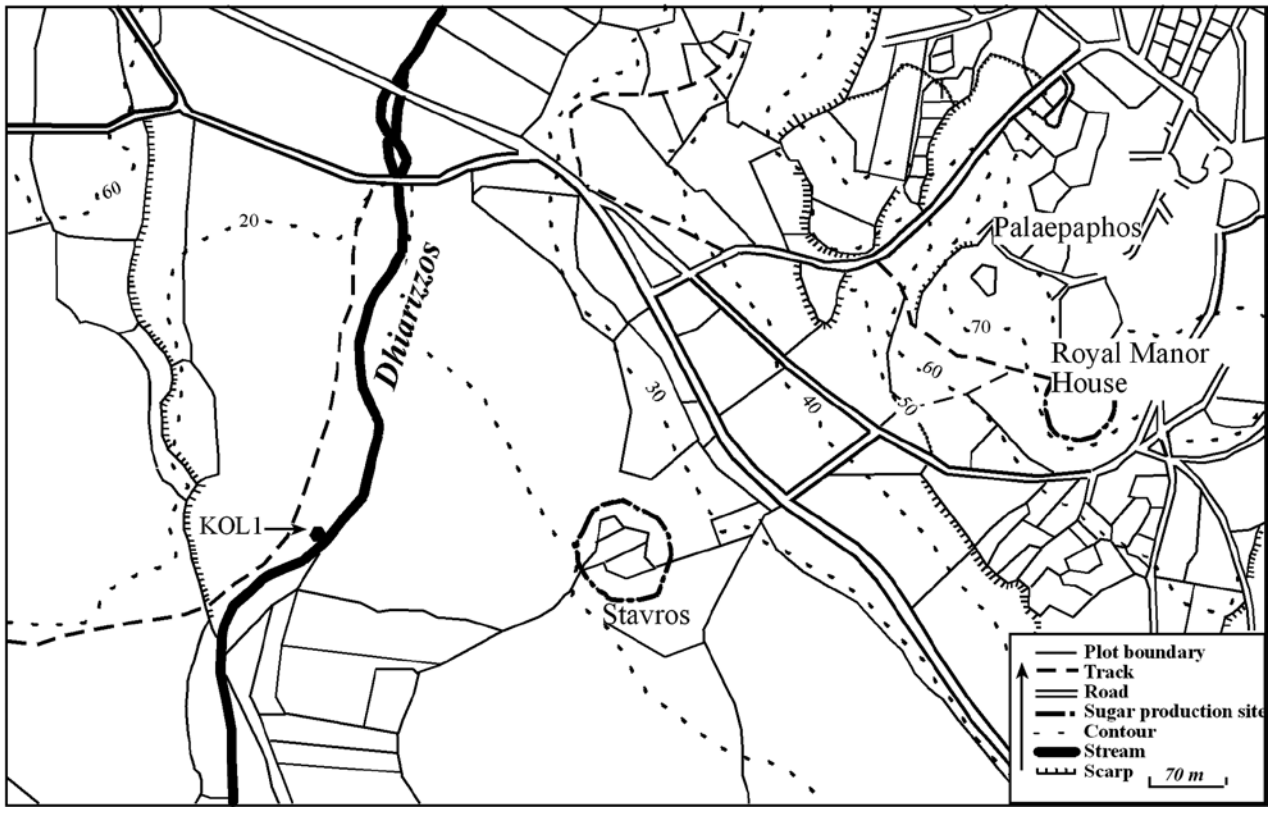

Fig. 9 - Location map of section KOL1 in relation to sugar industry sites (adapted from cadastral map: LI.48 and topographical map: 51.XXIV).

pation in the floodplain. Floods can be severe within the floodplain. As a result, it would be unfortunate to build a settlement in a Western Cypriot floodplain, as it is a very risky environment, even if the settlement would have been artificially heightened. If we were to doubt the erosive power of the Cypriot rivers, Christodoulou convincingly drew attention to this. «The steep gradients (*of the rivers*) lead also to great erosive power and exceptional floods frequently wash dams away or breach them. The Kouklia reservoir in 1949 was breached at twenty places» (Christodoulou, 1959: 115). Moreover, if seasonal settlements took place within the floodplain of the major Cypriot rivers, most evidence has been swept away by flashfloods anyway. Therefore, it is suggested that a different fluvial environment from the mainland, resulted in different human behaviour and adaptations.

CONCLUSIONS

The Western Cypriot Geoarchaeological Survey aims to understand Cypriot archaeological sites in their landscape context. In this paper indications of the impact of people on the environment and of the environment on human communities have been detailed. Although there are many difficulties in unravelling the complex causality of fluvial deposits, the above mentioned indications seem to suggest the impact of former Cypriots on the environment through the temporal and spatial synchronicity of erosion-causers upslope and depositional evidence in the river valley. Anthropogenic impact on the landscape in the shape of erosion and subsequent deposition probably took place during Byzantine and Medieval times at specified locations probably through deforestation for copper production activities as well as for agricultural and herding activities. On the other hand, some indications have been suggested on the impact of the environment on human communities as well. More precisely, indications exist of typical «Little Ice Age» torrential river behaviour approximately dated at 1600 AD, which might have had impact on the sugar industry. Additionally, the steep gradient and associated high energy channels of the Western Cypriot rivers probably also had an impact on the location and shape of settlements. It is suggested that the absence of tell sites is due to the impossibility to live in the Cypriot floodplains. Future chronological studies are needed to further test these hypotheses.

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