Seminar on Geo-archaeology
in Tropical and Mediterranean Regions
(Brussels, 24 April 1996)
Royal Academy of Overseas Sciences

Geo-Eco-Trop, 1996, 20(1-4), 91-107

GEOARCHAEOLOGICAL STUDY OF HISTORICAL ACCUMULATIONS ON THE PAXIMADHI PENINSULA (SOUTH EUBOIA, GREECE)

Etude géo-archéologique de depôts historiques sur la péninsule de Paximadhi (sud de l'Eubée, Grèce)

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RESUME

La genèse de dépôts alluviaux historiques (Younger Fill de VITA-FINZI, 1969) et leur relation avec des sites archéologiques sont étudiées dans trois régions - pilotes de la péninsule de Paximadhi (sud de l'Eubée, Grèce). Des datations au C^{14} *sur charbon et tessons contenus dans les dépôts, démontrent que l'alluvionnement est postérieur à la période Grecque Classique (*ca. *500 - 300 BC) et contemporain des périodes Romaine et Byzantine (début du Moyen - Age). L'érosion des terrasses de culture suite à leur abandon a joué un rôle majeur comme source des sédiments. Le rôle respectif de l'homme et des causes naturelles ainsi que la corrélation avec l'évolution dans d'autres régions grecques et méditerranéennes sont discutées.*

ABSTRACT

The genesis of alluvial deposits of historical age (Younger Fill, VITA - FINZI, 1969)) in relationship to archaeological sites is studied in three pilot areas on the Paximadhi peninsula in south Euboia (Greece). Radiocarbon datings on charcoal and sherds of ceramics show that the fill was deposited after the Classical Greek period (ca. 500 - 300 BC), during the Roman to Byzantine (early Medieval) periods. The erosion of abandoned conservation terraces played a major role in the sediment supply. The respective roles of anthropogenic and natural causes and the correlation with the evolution in other Greek and Mediterranean areas are discussed.

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INTRODUCTION

In his work on the Mediterranean valleys, published in 1969, VITA-FINZI developed a quite simple model of climatic evolution for the entire Mediterranean region marked by two major stages of sedimentation, namely the Older Fill and the historical Younger Fill (VITA-FINZI, 1969). This pioneering publication gave an enormous impetus and numerous geoarchaeological studies - combining geomorphology and archaeology - were subsequently focused on historical alluvial deposits in the Mediterranean basin. The conclusion of that more refined scientific corpus is that the reality is much more complex than the simplistic model of VITA-FINZI (BINTLIFF, 1992). Not only the hardly known Late Holocene climatic changes are important but also Man as a powerful geomorphological agent, has to be taken into account. The study of the precise relationship between the forms of human occupation and exploitation of the environment in the past (archaeology) and the ensuing processes of erosion, transport and deposition (geomorphology) responsible for the building of the river valley bottoms and coastal plains of the Mediterranean basin is therefore of primary importance.

Numerous such geoarchaeological studies have been published for the eastern Mediterranean basin. In the Peloponnese important work has to be mentionned: the studies done by BINTLIFF (1976a), POPE & VAN ANDEL (1984), VAN ANDEL *et al.* (1986), VAN ANDEL & ZANGGER (1990) and ZAMANI *et al.* (1991) on the Argolid and more specifically the development of the plain of Argos, DUFAURE's alluviation history of Olympia (1976), BINTLIFF's study of the plain of Helos in Laconia (1976a, 1981). Other studies are focused on Attica (PAEPE, 1976), on the gulf of Ambracia (DOUKELIS & FOUACHE, 1991), on the coastal area of Macedonia (BINTLIFF, 1976b; DAVIDSON, 1976, 1980) and on the Turkish coast of the Aegean sea (EISMA, 1978; BINTLIFF, 1981).

During the 1992 and 1994 field campaigns of a Global Change Project on past environmental degradation in the Mediterranean basin[1] geoarchaeological investigations were carried out in the southernmost part of the island of Euboia, more specifically on the peninsula of Paximadhi, bordering the plain of Karystos. Recent river deposits linked and interfingering with coastal accumulations could be observed in long and deep gullies; the deposits contained archaeological artefacts and fragments of charcoal, allowing for relative and absolute dating. Moreover the chronology and the genesis of the deposits could be directly linked to the location and evolution of the archaeological sites in the area, studied in detail by KELLER (1985) and KELLER & WALLACE (1987, 1988) in the SEEP b-project[2].

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[1] Global Change Project GC/02/027 'The Degradation of the Environment and more specifically the Desertification in the Past, Present and Future' funded by the Belgian State Prime Minister's Services for Science Policy.

[2] SEEP: 'Southern Euboia Exploration Project' under the direction of D.Keller, archaeologist of the Indiana University, Bloomington, USA.

The island of Euboia is situated (Fig.1) in the Aegean sea to the north-east of Attica and the south of Thessaly and is separated from the mainland by narrow straits. The southernmost part of the island is dominated by the massif of the Ochi mountain (1,398 m a.s.l.) and the hilly relief of the peninsulas of Paximadhi and Mandhili which enclose the bay of Karystos (the town of Karystos is situated at 38°N and 24°30'E). Our study is focused on the south-eastern part of the peninsula of Paximadhi.

Fig.1. - Situation of the Paximadhi peninsula in southern Euboia, Greece.

The geological and tectonical buildup of southern Euboia is framed in the Cycladic Massif (PAPAVASSILIOU, 1983) and the 'Neohelenic tectonic nappe' (KATSIKASTOS, 1991). It is formed by Mesozoic-Palaeogenic metamorphic rocks of great thickness which were overthrusted during the middle Eocene. Schistose rocks with some marble intercalations are predominant. The area is situated in an active seismic zone.

As already mentioned, the bay of Karystos is dominated by the steep and high relief of the Ochi mountain whose southern slopes, leeward of the prevailing northern winds, can be covered by snow during several months in winter. The small peninsulas however show a low relief and experience a pure mediterranean environment marked by hot and dry summers and mild and rainy winters. The mean annual temperature for Karystos is 18°C, with a minimum in January (10°C) and a maximum in July (27°C); the mean annual precipitation, concentrated from October to April, is about 600 mm (Fig. 2).

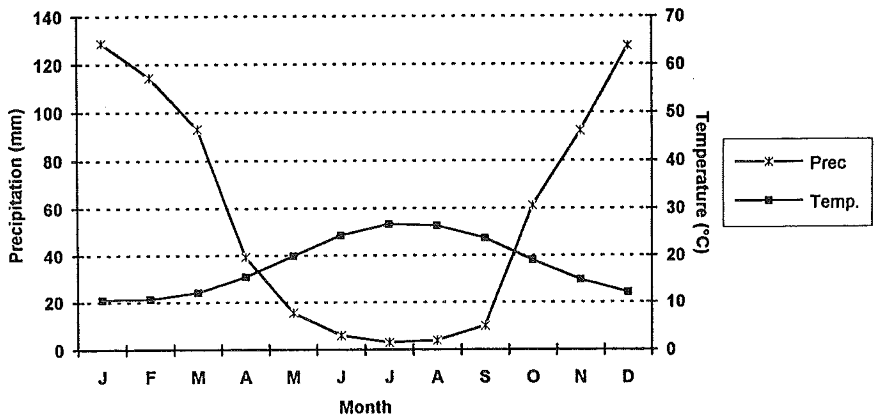

Fig.2. - Ombrothermic graph of the station Karystos for the period 1967 - 1988 (De Vliegher, 1991).

The Paximadhi peninsula forms a narrow, N-S-oriented, hilly promontory, enclosing the western side of the bay of Karystos. The hydrographic network (Figs. 3 & 4) is dense and deeply incised, but despite that fact, due to the rather monotonous lithology, the relief shows no important structural surfaces and narrow ramified interfluves prevail. A long and low (maximum altitude is 294 m a.s.l.) hill crest forms the backbone of the peninsula and separates three watersheds: (1) in the south-western one, short rivulets run steeply to an irregular rocky coastline set by plunging cliffs, (2) the northern one is drained by the head of a tributary of the Rigia river flowing in the plain of Karystos, (3) the eastern one drains towards the bay of Karystos. The last one is subdivided in three separate sectors by respectively: (1) a small promontory continued in the islet of Agia Pelagia, (2) Cape Mnima, (3) Cape Paximadhi with its tombolo; the central sector is the largest one.

Due to the strong stripping of the topsoil most of the hillsides on the Paximadhi peninsula show barren rock; what is left of the soil cover can be classified as lithosols. Entisols develop on small alluvial strips. The whole landscape is covered by a sparse 'phrygana' vegetation. The only agricultural activity in the area is extensive grazing of sheep and goats, resulting in severe soil erosion during the rainstorms of the wintertime.

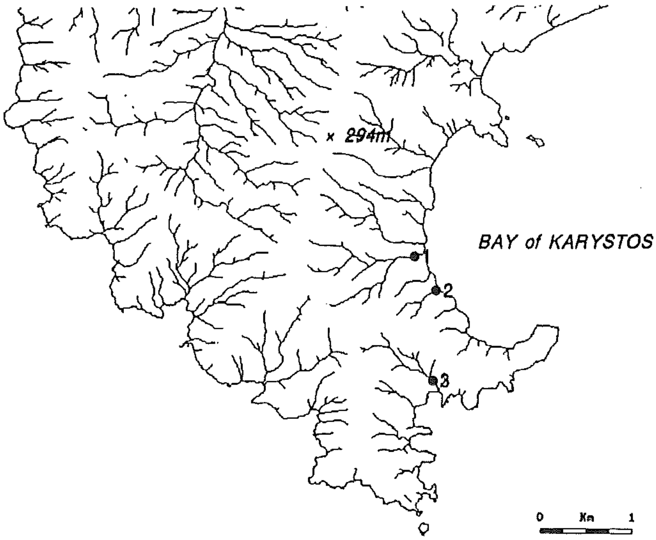

Fig.3. - The hydrographic network of the Paximadhi peninsula and situation of the studied pilot areas: (1) Palio Pithari, (2) alluvial fan of Mnima, (3) alluvial and coastal plain of Cape Paximadhi.

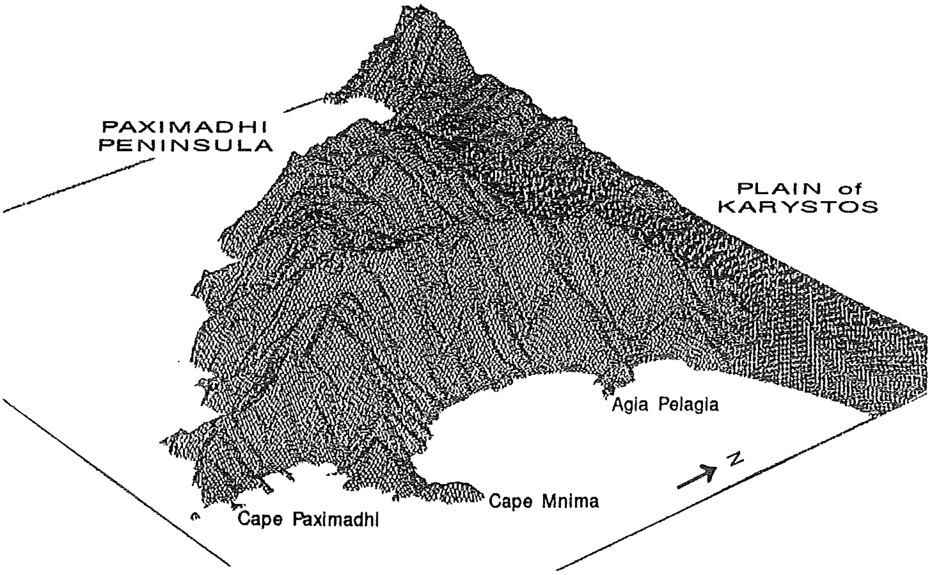

Fig.4. - 3D-view of the Paximadhi peninsula, generated from a DEM based on the 1/5,000 topographic map and a 20m contour interval (horizontal rotation: 50°, vertical rotation: 30°, vertical exaggeration: 4x).

Several Holocene accumulations were detected in the plain of Karystos as well as in the three sectors of the eastern watershed of the Paximadhi peninsula. We will focus however on three pilot areas of major interest centered around cape Mnima (situation on Fig. 3).

Palio Pithari

One of the archaeological sites studied by Keller & Wallace (1988) (site C-38) is situated at the lower end of a narrow schistose spur. It consists of a small farm dating of the Classical Greek period (ca. 500 - 300 BC) whose simple construction is formed by a corral, bordered by rooms. The site was abandoned in the 4 th century BC and was only occupied again in the Byzantine period (ca. 600 - 1200 AD), by building on top of the Classical remnants. Another Classical farm of the same age (site C-54; KELLER & WALLACE, 1988) is situated at the upper part of the spur; it is surrounded by a low stone wall. A broad accumulation surface, formed by the coalescing mouths of numerous subparallel rivulets surrounding and draining the spur, stretches at the foot of the sites.

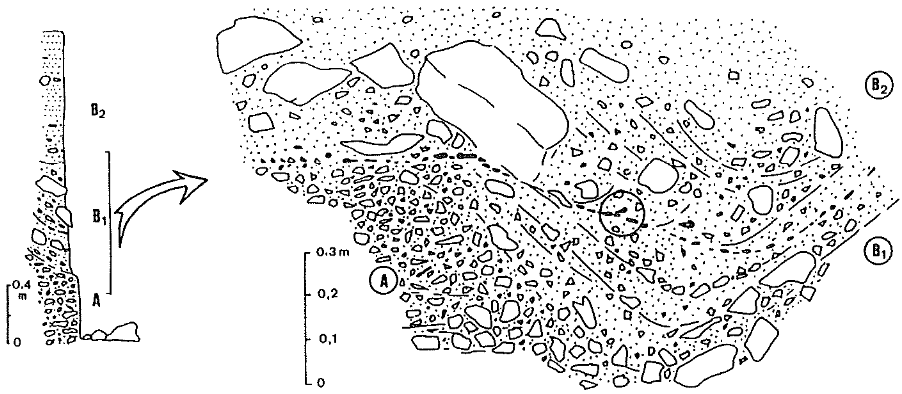

Fig.5. - Profile of the Younger Fill of Palio Pithari and detail of the level B_1. Organic material and charcoal fragments are indicated as black spots. The circle indicates the position of the charcoal sample dated by radiocarbon (Cal 58 BC).

A gully in the alluvial plain shows a long continuous section with a depth varying between 0.9 and 2.1 m; a typical profile is illustrated in figure 5. The basal level A has a thickness of 1.25m and is composed of strongly compacted and poorly sorted schistose pebbles, cobbles and small boulders; the aspect is mainly chaotic but some sedimentary structures are visible. The middle level B_1 is composed of a gravelly to coarse sandy channel infill cutting level A; some thin layers contain charcoal fragments. Locally, B_1 contains big amounts of large to medium parallelepipedal boulders which we link to the destruction and erosion of conservation terrace walls built on the surrounding hillslopes (GOOSSENS & DE DAPPER, 1990). The top level B_2 is composed of a homogeneous, light colored, clayey silt; it contains some lenses of coarse sand and fine pebbles and shows evidence of cultivation practices.

A radiocarbon dating on the charcoal fragments found in level B_1 provides an age of 2080 ± 40 BP (IRPA-1035)[1] and a calibrated age of 58 BC; the base of level B_1 thus dates from the Roman period (ca. 200 BC - 300 AD). In sections closer to the coast, level A as well as both levels B contain sherds of ceramics dating from the Classical Greek period; they are transported over a short distance and are almost certainly linked to the erosion of the nearby Classical farm sites. As a consequence, the whole section must be considered as of post-Classical age and the middle part of the profile, according to the obtained radiocarbon dating, is clearly of Roman age.

The alluvial fan of Mnima

This pilot area is located close to Palio Pithari but shows a much more distinctive sedimentological buildup. It does not consist of a simple alluvial fill, due to restricted axial river transport, but of an extended alluvial fan deposited by a torrential regime and penetrating far in the sea. Due to regularisation of the coast, the front of the fan has been eroded by wave action resulting in a low rectilinear cliff with a height of 1.3 to 1.6m (Fig.6).

The apex of the fan is composed of angular boulders, cobbles and pebbles. Due to downslope fining the texture of the material visible in the coastal cliff ranges from sand to clay with some dispersed pebbles of continental origin. The fan material also contains abundant sherds of ceramics which undoubtedly belong to the Classical Greek period (ca. 500 - 300 BC) and which most probably originate from a Classical cultivation and habitation site located on the slopes of the head of the torrent. On the other hand, remnants of a farm dating of the Roman period (ca. 200 BC - 300 AD)(site C-34; KELLER & WALLACE, 1988) are found on top of the flat lowermost portion of the fan surface. As a consequence, the fan was built in the Classical or, most probably, in the post-Classical period but was stabilised in the Roman period permitting the establishment of human

[1] sample prepared and measured at the Royal Institute for Cultural Heritage (KIK-IRPA), Brussels (Forest & Van Strydonck, 1993).

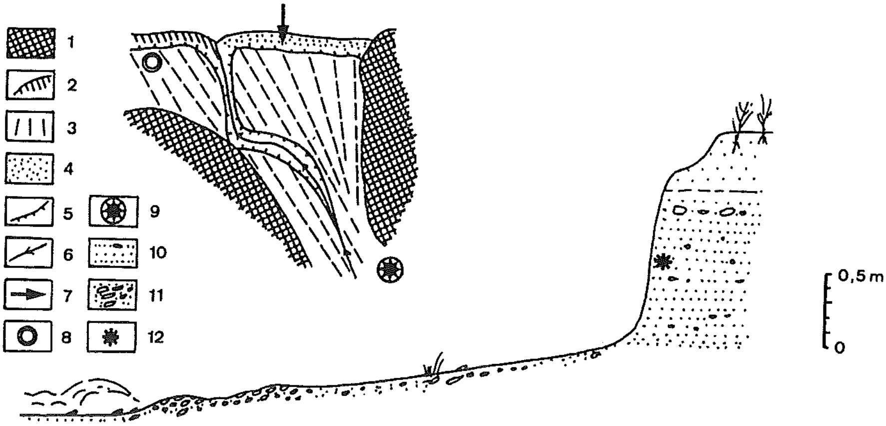

Fig.6. - Morphography and profile of the alluvial fan of Mnima.
1: slopes developed in schistose rocks. 2: rocky coast. 3: alluvial fan. 4: beach. 5: low cliff in Younger Fill 6: torrent. 7: situation of the sketched profile. 8: archaeological site of the Roman period. 9: archaeological site of the Classical Greek period. 10. Younger Fill of the alluvial fan. 11: present-day beach deposits. 12: ceramics of the Classical Greek period.

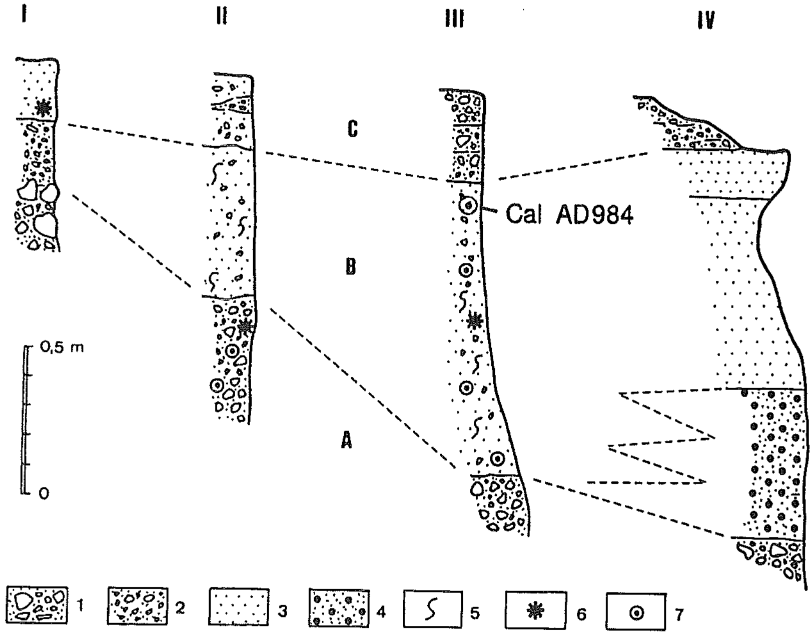

Fig.7. - Successive profiles in the alluvial (I - II - III) and coastal (IV) deposits of the plain of Cape Paximadhi showing three levels (A, B & C). 1: cobbles. 2: pebbles. 3: sand and silt. 4: beach of rounded pumice pebbles. 5: bioturbation. 6: sherds of ceramics. 7: charcoal fragments. The position of the charcoal sample in the upper part of level B in profile III, dated by radiocarbon (Cal 984 AD), is indicated by a black dot.

settlements; the accumulation phase of the fan is thus bracketed between ca. 300 BC and ca. 300 AD.

The alluvial and coastal plain of Cape Paximadhi

The third pilot area is situated between Cape Mnima and Cape Paximadhi (Fig. 7); it corresponds to an alluvial fill deposited in a broad valley bottom, extending up to the coast where it merges with marine sediments. A long meandering gully, deepening downstream, permits the observation of the longitudinal facies changes of the fill which thickens gradually toward the coast: 0.6 m in the upslope part (Fig.7, profile I), 1.2 m in the middle part (Fig.7, profile II), 1.5 - 1.6 m in the coastal part (Fig.7, profiles III and IV). Three levels can be distinguished in the alluvial fill. The base level A is composed of cobbles and pebbles over the whole length of the section. The middle level B shows a clear downslope fining with textures grading from small cobbles and pebbles to sand; the sandy deposits of the middle part show numerous bioturbations and contain charcoal fragments dispersed over the whole level. At the coast (Fig.7, profile IV), level B interfingers with sandy beach sediments. The coarse sandy beach sediments are deposited on top of a layer of rounded pumice pebbles; they grade in the upper part into a thin layer of dune sediments which show some features of incipient soil formation. Level B is blanketed by the top level C, composed of mostly gravelly deposits showing cut-and-fill sedimentary structures testifying to a torrential regime.

The pumice pebbles in the coastal profile are most probably linked to the Thera eruption which took place between 1500 BC and 1450 BC (RENFREW & BAHN, 1996). Sherds of ceramics dating of the Classical Greek period are found dispersed in all three levels. A radiocarbon dating on charcoal fragments found in the upper part of level B of profile III provides an age of 1080 ± 70 BP (UtC-3306)[1] and a calibrated age of 984 AD. The whole alluvial fill is post-Classical and level B was most probably stabilised in the Late Byzantine period. Level C and the incision possibly date of the end of the Byzantine period or later. The pumice pebbles in the coastal profile are clearly not in situ but are the result of repeated erosion, transport and deposition; a process promoted by the fact that the pumice fragments float on water.

INTERPRETATION OF THE YOUNGER FILL

All younger fill studied in the three pilot areas on the Paximadhi peninsula was deposited after the Classical Greek period (ca. 500 - 300 BC). Radiocarbon dates on charcoal show that the accumulation continued in the Roman period (ca.

[1]sample prepared at the Royal Institute for Cultural Heritage (KIK-IRPA), Brussels and mesured at the Van Graaff Laboratory, Utrecht (VAN STRYDONCK & VAN DER BORG, 1990)

200 BC - 300 AD) and the Byzantine period (ca. 600 - 1200 AD). The presence of a Roman farm on the alluvial fan of Mnima shows that there accumulation was completed short before or during the Roman period. Level C in the alluvial plain of Cape Paximadhi shows that there accumulation continued after the Byzantine period, possibly after a phase of stabilisation.

Before excessive human intervention the hillsides of the Paximadhi peninsula were most probably blanketed by a rather thin veneer of slope deposits held in place by a dense mediterranean vegetation cover and smoothening the irregularities of the rocky substratum.

During the Classical Greek period the Paximadhi peninsula was the focus of important agricultural activity. Some 80 farms, spaced at a walking distance of 15 to 30 minutes, were detected by KELLER (1985). The farms, comparable with those found in Attica, are often located on narrow rocky spurs.

At that time the alluvial lowland accumulations were not yet available, so the only alternative to sustain a stable agriculture was to cultivate on the hillslopes. To prevent soil erosion on the strongly sloping relief, conservation terraces were constructed. Many remnants of terrace walls can still be detected on the hillslopes of the Paximadhi peninsula (GOOSSENS & DE DAPPER, 1990). During his survey, KELLER (1985) found no indications of irrigation systems. A study of some well-conserved terraces on the peninsula (GOOSSENS & DE DAPPER, 1990) showed that the soil depth near the terrace walls varies between 0.75 and 1.2 m; it wedges out towards the foot of the next upslope wall. The volume of the soil body is large enough to store sufficient moisture during the winter in order to allow crops to develop and ripen during the partly dry growing season. The farmers most probably applied dry farming techniques such as shallow tilling to cut the capillarities of the topsoil in order to prevent excessive evaporation and wheat cultivation under olive trees.

The archaeological study of the Classical farms on Paximadhi shows that the occupation was not continuous and that most of the sites were abandoned after a few centuries (KELLER, 1985). Due to the unfavourable environmental settings the agricultural activity on Paximadhi must always have been marginal. So the slightest detoriation of the physical enviroment, such as loss of soil productivity or bad climatic conditions such as long droughts or excessive, devastating winterrains, could rapidly lead to abandonment of the fields. Also political reasons could have played a role. According to KELLER (oral communication) the development of the Paximadhi peninsula during the Classical Greek period, was part of a strategic colonial policy of Athens. Changing political interest ensuing lack of support or social unrest could also have quickly led to desertion in this marginal situation.

Whatever the reason, the change of a well-organised agricultural activity mainly based on cereal farming to marginal agricultural practices, most probably based on pastoralism, must have led to a quick degradation. Overgrazing and wild wood fires (DE VLIEGHER, 1991; DE VLIEGHER *et al.*, 1995) prevented regeneration of the natural vegetation. Especially the neglect of the conservation terraces created a very unstable situation. The terrace walls are very vulnerable to slope processes such as creep and piping and are easily delapidated by the trampling of cattle, especially goats. If the terrace walls are not regularly maintained, the oversteepened loose soilmass behind the walls will be easily subject to mass movements and accelerated erosion. The presence of parallelepipedal boulders in the Palio Pithari profile (Fig. 5) testifies to such erosion during the Roman period.

Changing climatic conditions may also have played a role. The climatic deterioration around the Sub-Boreal/Sub-Atlantic transition was also critical in the Mediterranean (ROBERTS, 1989). The rainfall regime became highly intensive and erosive. Deforested lands or lands colonised by *phrygana* - the only vegetation formation adapted to summer dryness and wild fires linked to pastoralism (BARBERO & QUEZEL, 1983) - were highly erodible, especially on steep slopes. Due to the combination of both, even a few exceptional events ensued important accelerated soil erosion. Such exceptional discharges may have built the alluvial fan of Mnima (Fig. 6) or deposited level C of the Cape Paximadhi profiles (Fig. 7).

The present-day morphology on the Paximadhi peninsula, marked by small alluvial plains merging in coastal landforms, is the result of intensive slope erosion, short transport and subsequent deposition. This morphology was mainly achieved during the Roman period and allowed the establishment of Roman farms (e.g. site C-34 on the alluvial fan of Mnima) on the new land. The large plain of Karystos itself - in whose deposits also numerous sherds of Classical and Roman ceramics are found - is most probably the result of similar processes of erosion and deposition. However, the radiocarbon dating obtained for the level B of the Cape Paximadhi profile shows that accumulation there continued up to the Late Byzantine period.

VAN ANDEL *et al.* (1986) describe similar situations in the Argolid and present several alternatives to explain the relationship between demographic-cultural expansion and accelerated anthropogenic morphogenesis. However, erosion of conservation terraces, mostly during the Hellenistic period and the beginning of the Roman period, subsequent to a peak of human occupation, played a major role. In another study the erosion-sedimentation processes are directly linked and synchronous with the human concentration and exploitation of the land (POPE & VAN ANDEL, 1984). BINTLIFF (1992) however finds it difficult to correlate in all cases excessive erosion to overpopulation.

In a 'Global Change'-project it is important to make distinction between the natural and anthropogenic components causing environmental change. This is not an easy task in this area where slow neotectonic forces and acute seismic activity may play an important regional and even local role in determining the intensity of processes (BOUSQUET *et al.*, 1983). Most authors however, point to the importance of human intervention (BRUCKNER, 1986, 1990; NEBOIT, 1977, 1979; VAN ANDEL & RUNNELS, 1987, ROBERTS, 1989, VAN ANDEL & ZANGGER, 1990, etc.). Many arguments sustain this assumption: the diachronical nature of the processes in the whole of the Mediterranean basin; the fact that erosion rates are much higher in historical times than it was the case during the Pleistocene when river terraces were built by pure natural causes; the absence of clear natural indicators such as fluvial terraces or pedogenesis (BRUCKNER, 1986). VITA-FINZI (1969) invoked mainly climatic fluctuations to explain the formation of the fills. His arguments were based on the assumption that the fills were synchronous and that their formation was correlated to the climatic changes detected in northern Europe. The model of VITA-FINZI is certainly too simple, in its interpretation as well as in the number of accumulation phases considered. However, numerous authors , in spite of the undeniable primary importance of human factors, judge that climatic changes cannot be disregarded completely (JORDA & VAUDOUR, 1980; BINTLIFF, 1981, 1982; NEBOIT, 1983; PEÑA *et al.*, 1993). Studies in the northeast of Spain have shown that during the Holocene climatic changes played an important role in the formation of alluvial plains (BURILLO *et al.*, 1985, 1986; GUTTIEREZ & PEÑA, 1992) and that climatic changes are the only valid explanation for the formation of stepped slopes (SANCHO *et al.*, 1988; PEÑA & GONZALES, 1992).

The deep gullies observed in all three test areas, are the result of a new dynamic phase resulting in linear incision, which started, according to the radiocarbon date obtained in the alluvial plain of Cape Paximadhi, in the Late Byzantine period or later and still continues today. The explanation may be simple in the case of the Paximadhi peninsula. Since most of the slopes are stripped of their cover and show barren rock, the sediment supply for the fluvial system is almost exhausted and rivers can use most of their energy to incise. However, renewed linear erosion is a quite general phenomenon in the Mediterranean basin, also in areas where sediment supply is still high. In ancient Pessinus (Central Anatolia, Turkey), for instance, a generalised incision affects the younger fill, even with a high sediment input from the accelerated erosion of very erodible marly slopes (BRACKMAN *et al.* 1995).

ZAMANI et al. (1991) explain this rejuvenation in the Argolid by a climatic cause. The incision of Holocene alluvial plains in Lucania and Sicily is explained by NEBOIT (1977, 1983, 1991) by changes in the rainfall regime; high peak discharges, ensuing torrential rainfall, initiate channel cutting and once the flow is confined in banks, incision continues and overbank flow is prevented. For JORDA & VAUDOUR (1980) the incision is due to a climatic detoriation during the Little Ice Age (ca. AD 1590 - 1850).

CONCLUSIONS

Holocene accumulations found in the southern part of the Greek island of Euboia, testify to important environmental changes during historical times. After the abandonment of small isolated farms and conservation terraces which were in use during the Classical Greek period (ca. 500 - 300 BC) an intensive degradation process started, leading to slope denudation and creation of new accumulation surfaces in river valleys and adjacent coastal plains. Most of the accumulation took place from the Roman period (ca. 200 BC - 300 AD) to the Byzantine period (ca. 600 - 1200 AD). The accumulation was followed by channel incision which continues at present-day.

Despite the undeniable major role of the human factor, the environmental change cannot be exclusively explained by this cause. The accelerating role of Man in the geomorphological processes, shaping the landforms in the Mediterranean basin during historical times, was played against the background of significant climatic shifts initiated around the Sub-Boreal/Sub-Atlantic transition. The fact that the environmental effects are not synchronous throughout the Mediterranean basin may be explained by the variable human intervention with place and time. To disentangle this problem the geoarchaeological approach, combining geomorphology and archaeology, is the most appropriate one. Only when all unfavourable conditions - human, as well as natural, such as steep slopes, slope aspects favouring wild fires, degraded vegetation cover, torrential rainfall, abandonment of conservation terraces, overgrazing, etc. - combine, tresholds may be trespassed leading to major environmental degradation.

We agree with NEBOIT (1983) that without human intervention the environmental degradation would not have been so intense. However, the generalised incision which took place after the Byzantine period shows that human intervention is not the sole cause but that a combination with a climatic shift leading to a higher rainfall erosivity most probably also played a role. After a long series of studies, initiated by the work of VITA-FINZI (1969) and focusing on the role of Man in shaping the Mediterranean landscapes, it may be useful to draw the attention again to the possible role of holocene climatic changes.

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