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## Articole/Papers

# River-bed evolution during the Holocene in Kalavrita region (Northern Peloponnese, Greece)

L. STAMATOPOULOS[1] & N. EVELPIDOU[2]

**Abstract:** Environmental history often reveals the contribution of humans in the modification of natural environment, always in relation with the climatic factors. Archaeological settlements may be preserved through desiccation, however, they are commonly found in floodplain sediments. Archaeological evidences may provide with useful information about the processes and extent of environmental changes, but they may also be used as tools for the analysis of floodplain sedimentation, relative chronology of sedimentation events and for the geomorphological evaluation of the particular archaeological site. The characteristics of archaeological indicators and the deposits in which they occur, may indicate important aspects of their source, transportation way and age. Evidence of river migration may be found in alluvial plains, through careful observations. The study area is located in Kalavrita region in northern Peloponnese. The archaeological excavations carried out revealed the fortification wall of the ancient city of "Kleitor" which is dated between the 3rd and 2nd century BC (Hellenistic Period). It may also provide clues for land surface development, reworking of sedimentary deposits, paleoenvironmental and climatic conditions. Sediments indicating considerable climatic changes are alluvial deposits of considerable thickness, covering areas with human impact. All the aforementioned become a tool for dating the course changes of the rivers and consequently a geomorphological instability. The relationship between geomorphology and history is recognizable also in the settlement distribution. This close relationship between environment and man provides a tool to understanding the landscape evolution from a geomorphological and historical point of view.

**Key words:** Kalavrita region, Hellenistic Period, Holocene, climate change, geo-archaeology, river migration, fluvial geomorphology

## 1. Introduction

The wider region of Kalavrita, northern Peloponnese, is characterized by the presence of plenty archaeological findings of the periods between the 10th century BC (Early Protogeometric Period) and 2nd century BC (Hellenistic Period) (Pausanias texts), buried under fluvial sediments.

The study area is located near the SW border of Chelmos (Aroania) mountain, 2341 m a. s. l. in northern Peloponnese, about 14 Km South of the Kalavrita city, and lies about 3 km west of Kleitoria village. The area belongs to the ancient Kleitor city and is rich in archaeological findings from the Hellenistic period (Petritaki, 1996).

The first archaeological stray findings from ancient Kleitor city were reported during 1940 and a systematic archaeological survey of the area started since 1987 (Petritaki, 1996). **A**rchaeology may often date the landscape evolution at the timescale through site formation or destruction processes (Schiffer, 1987) or the use of artifacts and sites in the studies of river channel changes (Brown 1997). Environmental changes and particularly denudation history in the Mediterranean has also been approached by using archaeological data (Vita-Finzi 1969) whilst only recently archaeological tools have been extensively used to interpret the morphogenetic evolution. Environmental histories often reveal the role of humans in modifying the physical environment, although this is not inevitable, as climate may be the overwhelming factor.

The main objective is to combine the archaeological information and environmental development in a direct chronological framework, to be able to interpret the morphogenetic evolution of the study area during the Holocene.

## 2. Study area

The ancient Kleitor city is situated on the fluvial terraces of Karnesios and Kleitor rivers valleys (Fig. 1).

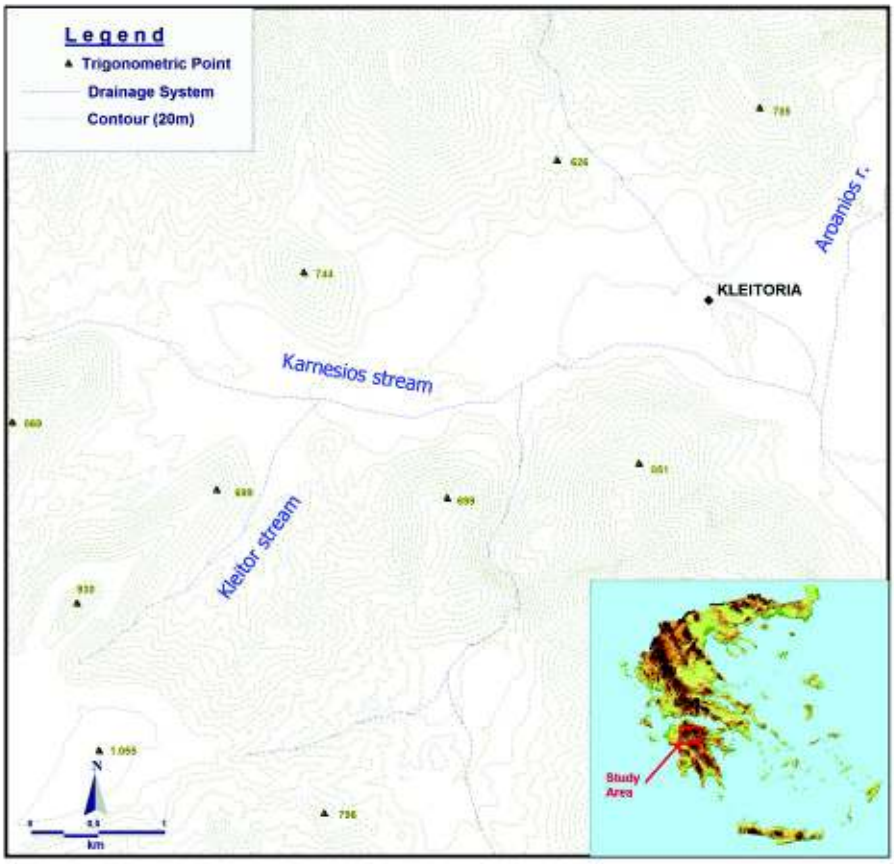


*Figure 1*. **Topographic map of the study area** (b), **Location of the study area** (a)

The study area is mainly composed of Eocene Flysch, Mesozoic (Upper Triassic - Cretaceous) limestones and dolomite basement of the Olonos - Pindos unit (External Hellinedes) and Pleistocene fluvial sequences (Dercourt 1978). During the Plio-Quaternary, Peloponnese was affected by systems of North- South active normal faults, which have created rising and lowering blocks. The tectonic style of the Peloponnese is characterized by thrust napes and normal faults (Doutsos and Poulimenos, 1992).

The area is characterized by Mediterranean climate conditions, with the period of limited rainfalls i.e. dry period, during summertime. Moreover the mean lowest temperature during January is about $4^0$C and the mean highest temperature during July is lower than $22^0$C.

## 3. Methods

Geological and geomorphological investigations through field observation during the years (2008/09), interpretation of aerial photographs (scale 1:33,000; year 1982) existing maps and satellite images were accomplished.

The used maps were geological and topographic maps (scale 1:50,000). The maps were imported into MapInfo GIS, were registered and digitized, in order to develop information layers concerning the drainage network, the geology and the topography of the area.

Information layers related to topography were analyzed with the use of Vertical Mapper software in order to create a digital elevation model (DEM) and specifically the algorithm "Triangulation with Smoothing". Data derived from interpretation of aerial photos and satellite images as well as from field work was also imported into GIS and were used in order to develop the geomorphological map of the study area. Finally, all developed information layers with their databases were used for the palaeogeographical reconstruction of the study area.

## 4. Historical events and Geomorphology

The wall is estimated to have surrounded the ancient city in total length of approximately 2500 m, enclosing an area of 577 $m^2$. The excavated parts are dated between the 3rd and 2nd century BC (Hellenistic Period) (Petritaki, M., 1996).

The ancient city was surrounded by a fortification wall reinforced with semi-circular towers, whose foundations are preserved on all the sides, except the Eastern, where the river bed of

Karnesios stream existed. This torrent carried them away, before it joined with the Kleitor stream in the southeast of the ancient fortification wall.

Between the two streams and about 2.5 m westwards to the current flow of Karnesios stream and internally to the fortification buried parts of the ancient "Klitor" city are observed (Photo 1), 1-2 m below the present land surface, which is covered by silty gravels, fluvial sediments (Photo 2).

According to the above dating, it may be supposed that before and during the settlement, the study area was a fluvial terrace of Karnessios stream. Communities were located in the inner alluvial terraces, close and around the river channels.

During the Late Holocene, as observed in many locations worldwide, the study area underwent a rapid improvement of climate, marked by a widespread development of thick fluvial sedimentation and consequently of the river migrations. The new environmental conditions drastically reduced slope degradation processes and related aggradations of riverbeds. Maximum developments of deposition took place on the river beds. Fluvial deposition persisted in the belt, where river valleys extended from the present flow, as indicated by the stratigraphical analysis. All aforementioned conditions caused the complete or almost complete disappearance of the ancient "Klitor" city fortification and consequently the settlement.

## 5. Discussion

The geological–geomorphologic map (Fig. 2) presents the surface topography and the different types of deposits in the investigated area. The chronology of the identified environmental and morphogenetic variations is based on archaeological data.

The present investigation has provided with new information concerning the development in the floodplain area, which was influenced by the strong climatic changes. The morphological evidence reveals that during the Late Holocene the study area was represented by an archaeological settlement. Notable flood events with contemporary fluvial migration of Karnessios stream are responsible for burial of the settlement.

Environmental history often reveals the contribution of humans to the modification of the natural environment, always in relation to the climatic factors. Archaeological settlements may be preserved through desiccation, while they are commonly found in floodplain sediments. Archaeological evidence may provide with useful information about the processes and extent of environmental changes, but they may also be used as tools for the analysis of floodplain sedimentation, relative chronology of sedimentation events and for the geomorphological evaluation of the particular archaeological site.

The characteristics of archaeological indicators and the deposits in which they are found, may provide with important information about their source of alimentation, transportation way and age of the sediments that compose the investigated area. Moreover evidence of river behavior, such as migration, may be found in alluvial plains through careful observations.

While the most obvious way in which archaeology may be used as a tool in geomorphology is by dating sedimentation or erosion and thereby establishing rates of flux, there are more applications, including the identification and reconstruction of factors on the earth system (e.g. climate) and the history of human influences on the landscape evolution.

*Photo 1*. **Archaeological finds, buried during the Holocene alluvial deposits of the Karnessios stream**

*Photo 2*. **Middle – Late Holocene alluvial sediments of the Karnessios stream**

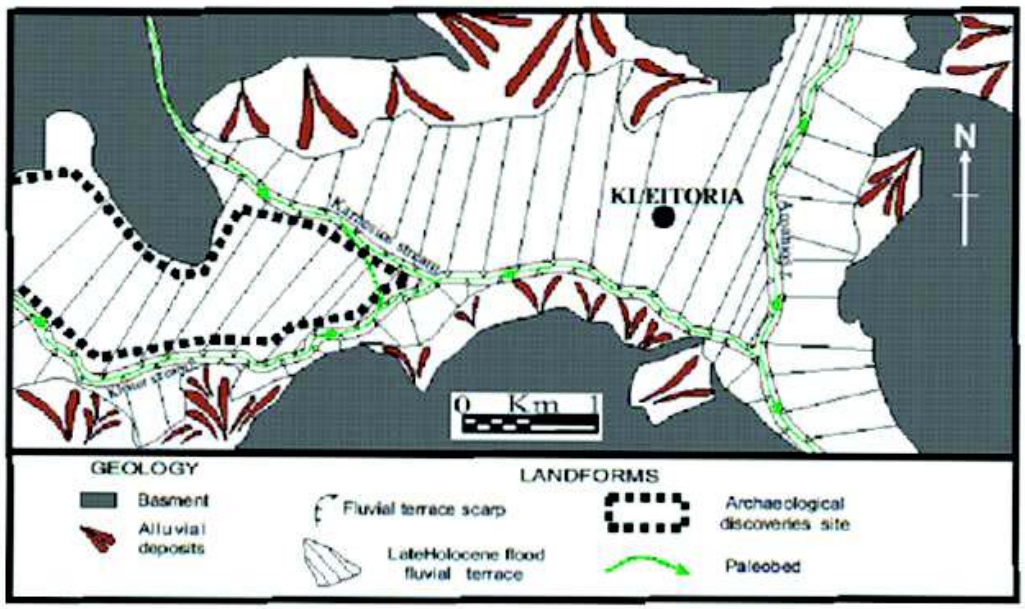


*Figure 2*. **Geological and Geomorphologic Map of the study area**

The evaluation of the aforementioned data provides with the geomorphological tools for the study of fluvial processes and hydrological conditions. Additionally, it may provide with evidence for the geomorphological evolution, through the palaeogeographical evolution and climatic conditions.

Considerable climatic changes may also be recognized in sediments from alluvial deposits of considerable thickness, in areas with human impact.

The stratigraphic evidence found in the area clearly indicate that, in the Late Holocene, human life was heavily affected by climate-induced environmental changes, such as flooding events and sediment deposition on the river sides. The scattered debris deposited at the foot slopes in the mountain sectors indicate how during the phase of climate deterioration, human impact significantly contributed to the enhancement of slope erosion and riverbed aggradations.

The phase of fluvial deposition suggests that, before recent historical times, the morphogenetic role of human impact was generally sub-ordinated to that of climate changes.

## 6. Conclusions

Interdisciplinary studies including geomorphologic and archeological data have produced new information concerning the environment in Kalavrita region during the Holocene, after the depositional processes and river migration on the channels induced by climate changes.

In the alluvial plains, it is possible to recognize several evidence of the river migration. The study of this evidence from a historical point of view may help to understand the role of man and the history of the landscape.

During the Late Holocene communities dominated the area, and natural factors were the main cause of the changes that took place.

Settlements in the lower valley sectors were destroyed as a consequence of the recurrent flooding episodes. The role of human impact on landscape evolution in Kalavrita region during the Early Holocene seems to be relatively limited.

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