STUDYING THE FLOW OF ASOPOS AND NEMEAS RIVER SYSTEMS USING AIRPHOTOS AND GIS.

Konstantina Mexia[1]
[1] University of Patras, Department of Geology, mexiak@yahoo.com

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ABSTRACT

The object of the present paper is to study the flow of river systems Asopos and Nemeas- which are in the wider area of the Nemea archaeological site - in order to understand how the evolution of these rivers in time affected the whole area.

The study area is a section of the NE part of the Peloponnese, specifically the zone between the villages of Velo and Vrachati.

In order to access our goal aerial photographs and GIS analysis were used. The geomorphological and tectonic analysis of the area and the development and evolution of settlements therein (based on archaeological studies) gave us clues about the shape of the terrain over time. The main factors affecting the shape of the terrain (intense tectonic activity and retrogressive erosion) were not adequate reasons - in our case - to effect immediate abandonment of the area (since they are fairly slow processes – in the human timescale). Their effect, however, is evident over time, in the form of gradual abandonment of sites, movement of settlements or the creation of new settlements.

INTRODUCTION - METHODOLOGY

The study area is located in the northeastern part of the Peloponnese, between the villages of Velo and Vrahati, in the prefecture of Corinthia. It is bounded west of the watershed of the basin of Asopos river, east of the watershed of the basin of the Nemeas river, north of the Corinthian Gulf and south by the mountains Xerovouni, Megalovouni and Tritos.

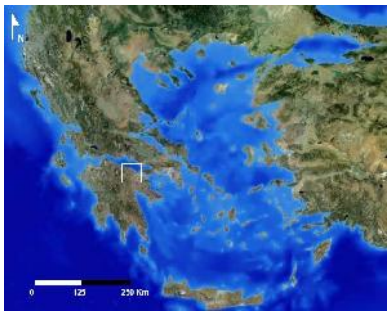

Figure 1. Study Area

The purpose of this paper is to investigate the flow of the river systems of Asopos and Nemeas and the surrounding archaeological sites situated there, in order to understand the physical processes affecting the area (e.g. Sakellariou - Faraklas 1971; Bengston 1991; Seger and Alexander 1993; Zelilidis 2000; Miller 2005). For this study we used GIS software, in order to construct a simplified geological map, a geomorphological map of scale 1:50,000, topographic maps and fieldwork. We also created maps showing the locations of archaeological sites, as they developed over time in the area, with the help of archaeological literature.

ARCHAEOLOGICAL POSITIONS

In the western part of the study area, lays the plain of Phlius, hosting the city of modern Nemea and to the east lays the lower valley of Ancient Nemea. The plain of Phlius is the largest of all Corinthian inland plains and shows traces of habitation back from prehistoric times up to the Roman period.

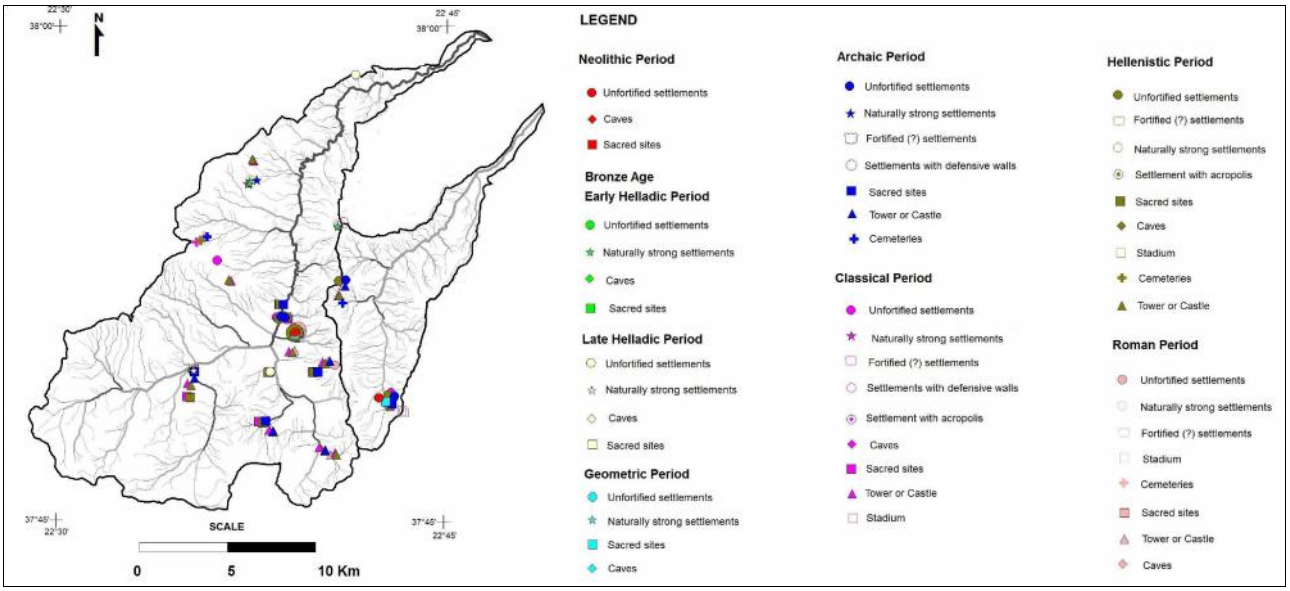

Figure 2. Archaeological Sites in the plain of Phlius and the valley of Ancient Nemea

The position that was selected for the settlement of Phlius - which is the most important settlement in the area - was the hill of Panagia. The suitability of soil and adequacy of water in the region, caused in the course of time the spread of life in other parts of the basin. The image of the area over time shows no change (figure 2).

The choice for the settlement of Phlius is mainly associated with the lithology of the area. Erodible and practically impermeable deposits enabled the construction and agricultural work that would serve and facilitate the lives of residents. The creation of the settlement between the two branches of the river (III6 and IV2), which received a significant number of smaller streams, provided the required water supply for the settlement (figure 3).

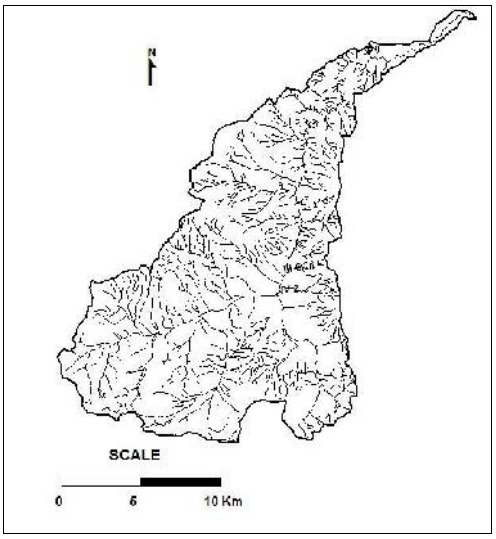

Figure 3. The III6 and IV2 branches of Asopos river

East of the plain of Phlius extends the small valley of Ancient Nemea. This valley was inhabited from prehistoric times up to the classic years. The two neighboring plains (plain of Phlius and plain of Ancient Nemea) are separated by the Trikarano mountain. Southeastern, the valley borders the hill Evaggelistria. This highland valley is long and narrow, with a width of 1600m along the E-W axis.

The modern village in the center of the valley is called Ancient Nemea (Heraklion), and extends to the southern and eastern slopes of the hill Tsoungiza (Miller 2005). The plain is crossed by the river of Nemea. The elevation at the center of the valley is 333m about above sea level.

The most important archaeological site in the valley is the temple of Nemean Zeus , which experienced two major periods of activity , the 6th-5th century BC and then, in the late 4th century BC (330 BC). At a distance of 450m east - southeast of the temple is the stadium, where every two years the famous Panhellenic games of Nemea took place. The configuration of the site of the temple of Zeus and the stadium, the restoration of the temple of Zeus and the excavations were conducted in the area for many years, from the year 1973 onwards, from the University of California at Berkeley, under the direction of Professor Stephen G. Miller (Miller 2005) (figure2).

GEOLOGY - GEOMORPHOLOGY - TECTONICS OF THE STUDY AREA

In the southern section of the study area, the geological zones of Tripolis and Pindos appear. They are represented almost exclusively by Triassic age limestone of Tripolis zone and Upper Cretaceous limestones of Pindos, in the Eastern area. In places, Eocene age flysch formations appear (zone of Tripoli) and Maistrichtean - Paleocene flysch formations (Pindos zone). In the rest of the region Pleistocene formations occur. Specifically, in the central part : conglomerates, marly conglomerates, marls, sandstone marls, and sandstones are found. These sediments were derived mainly from the southern mountains. The quaternary deposits occupy a large part of the lowland of NE Peloponnese, in the form of conglomerates and deposits, while in the same time new and old talus cones develop with significant extent, on the outskirts of the alluvial plains of Nemea and Phlius (Papanikolaou 1986) (figure 4).

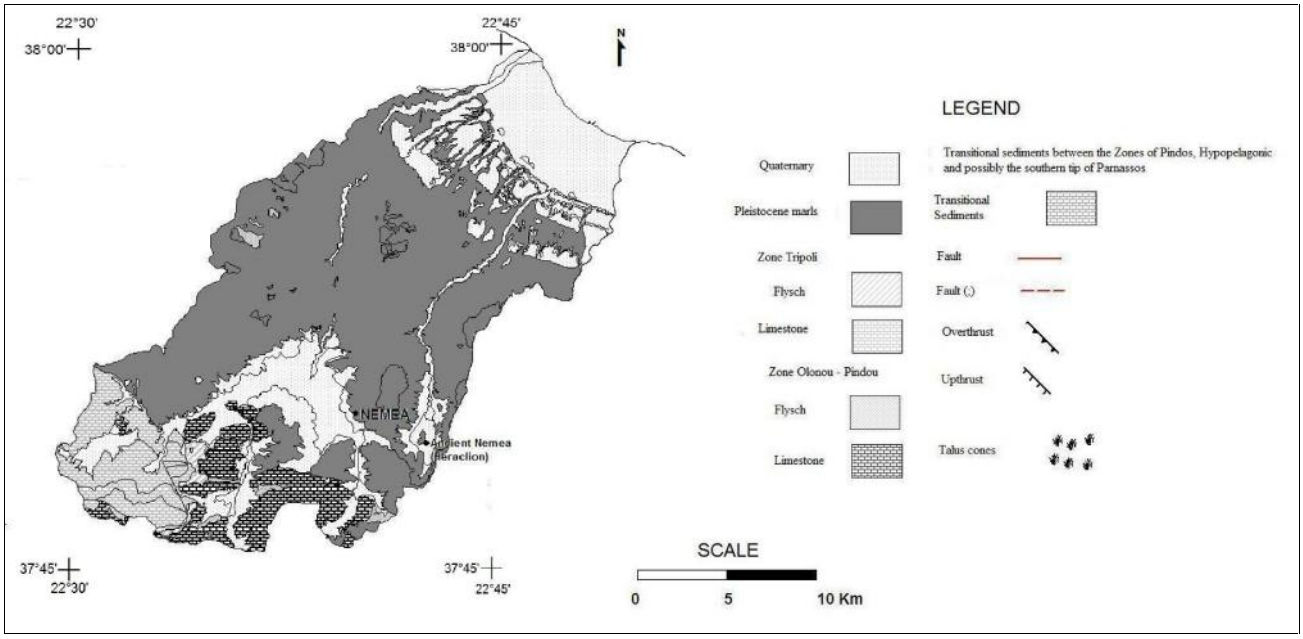

Figure 4. Simplified geological map of the study area

In the study area, lie the plains of Nemea (Phlious field) with an area of 28,6 Km2 and Ancient Nemea (6,07 Km^2), while downstream the valleys of the rivers Asopos and Nemeas or Zapantis are found. The erosion of alpine formations, derived from the southern mountain, named

Megalovouni, supply the plains of Asopos and Nemeas with large volumes of clastic material.The Asopos river originates from the mountain of Megalovouni, crosses the easily erodible Neogene deposits and flows into the Corinthian Gulf, east of the city of Kiato (figure 5). The catchment area of the river is 270.39 Km^2. The network of Asopos has a complex form that reflects the tectonic and lithological conditions prevailing in the region and cannot be classified into a specific type. There is a well developed hydrographic network, as the whole region is covered by the practically impermeable marl deposits.

To the east, the stream Nemeas or Zapantis, begins to flow from the south rim of the Ancient Nemea valley (it stems from the mounain Megalovoyni) and flows in the Corinthian Gulf (figure 5). The catchment basin of the Nemeas river has an area of 68.73 Km^2. It crosses the Neogene deposits where the retrogressive erosion is strong and flows into the sea near the village Vrahati. This is a relatively new, small drainage basin, which continues to evolve in time.

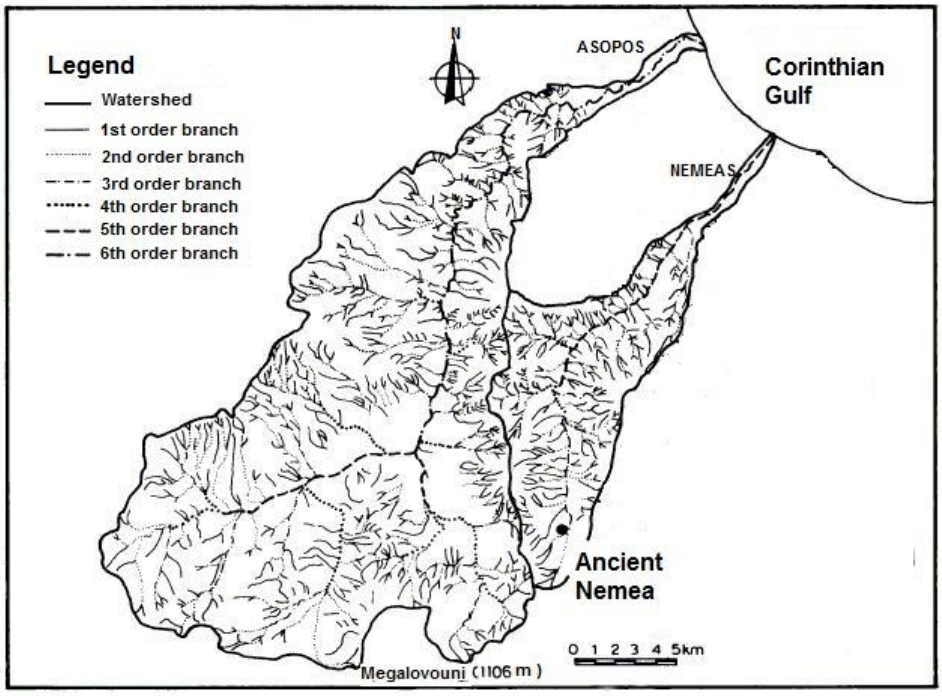

Figure 5. The two hydrographic networks: Asopos and Nemeas

THE FORMATION AND EVOLUTION OF THE AREA IN THE COURSE OF TIME

Based on the geomorphological map we charted and the presence of wind gaps and knick points, it is confirmed, that in the early Holocene, the relief was different. The tectonic activity - as evidenced by the relatively high percentage of faults, which are the result of seismic movements - caused significant changes in the course of river systems. Thus, the hydrographic networks draining the region have recorded this tectonic activity and the geomorphological processes that led to their current form. Specifically, the Asopos river in order to correspond to the lifting and backwards tilting of the southern margin of the Corinthian Gulf (which is part of the Corintian basin), reversed its course in the past to the south. An important role in the evolution of this network was played by the tectonic uplift of the region. In the early Quaternary, the network of Nemeas river and the northern parts of Asopos river did not exist. The existing part of Asopos network flowed northwards into the Corinthian Gulf. Because of the elevation of the northern Peloponnese, the coastline of the Corinthian Gulf shifted northwards and the drainage network elongated, in order to find an outlet to the sea. The high rate of elevation prevailed against deep erosion, resulting in the separation of the upstream parts of the Asopos network. This separation resulted in the reversal of flow to the south, as shown by the wind gaps which are mapped in the

boundaries of the basin. Then the evolution of the downstream part of the network, due to the rise of the northern Peloponnese and subsequent extension of it, expanded the network to the north. In the land, which emerged, the hydrographic network of Nemeas was created. The river Nemeas grows exclusively on Pleistocene deposits. At the same time, the retrogressive erosion led to the capture of the remaining streams and to the change of flow of Asopos river, once again towards the Corinthian Gulf. The wind gaps identified at the southern foot of the mountain Megalovouni, south of the city of Nemea, confirm the reversal of this network (figures 6,7). The presence of wind gaps on the southern edge of the Asopos basin, shows that this river system was unable to respond to the elevation of the area.

Specifically, the wind gaps were located at positions with the following coordinates:

a) 22°35'24" E and 37°46'48" N (figure 6)

b) 22°38'24" E and 37°45'36" N (figure 7)

Respectively, knick points in the catchment basins of river networks, show the places where, at present, there is intense retrogressive erosion. These points were found in the following locations with the coordinates:

a) about 2200 m. from the village of Leriza 22°39'00" E and 37°52'48" N (Asopos River) (figure 8)

b) about 1800 m. SW of Chalki village 22°42'36" E and 37°52'12" N (Nemeas River) (figure 9)

Figure 6.Wind gap in Asopos River

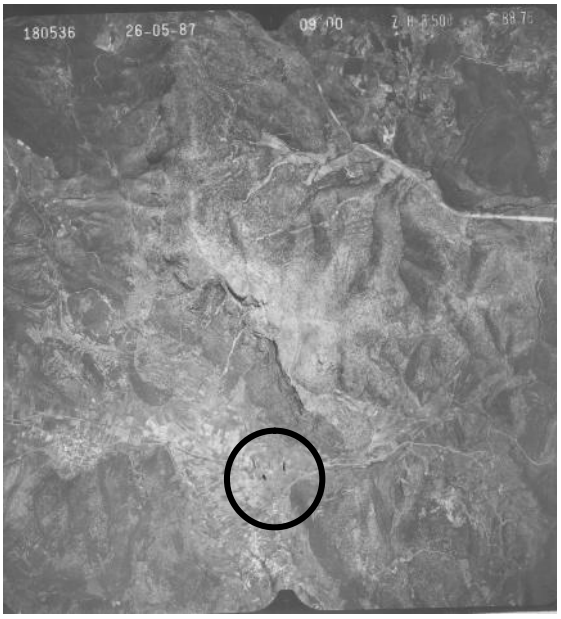

Figure 7.Wind gap in Asopos River

Based on this geomorphological regime, in Upper Holocene (5000 years BP), we witness human activity (Neolithic Age) in the area. The flow of the river has not changed significantly. The region, however, as evidenced by this study, has changed appearance, as new river branches have been created and others have been abandoned. The effect of retrogressive erosion, aided by existing fault lines and lithology, lengthened the branches of streams and differentiated the extent of the watersheds.

Going east, to the adjacent area of Nemeas river, it is likely that this valley has a different shape presently, compared to the Lower Holocene. A number of first order branches were not created back then and the lengths of branches of larger order were smaller.

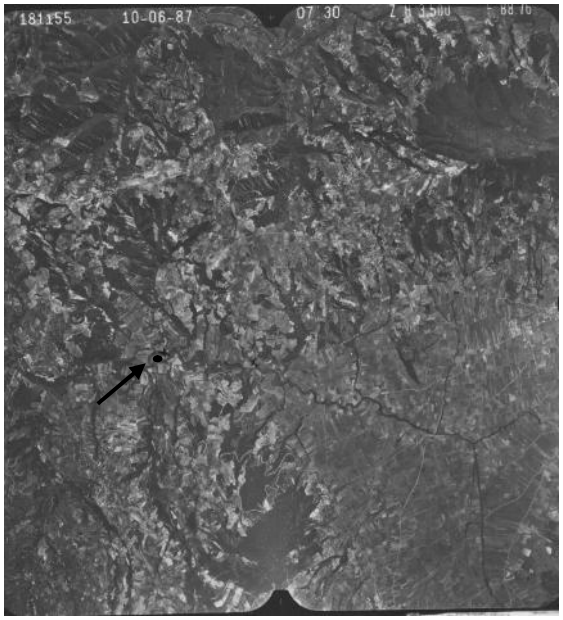

Figure 8. Knick point in Asopos river

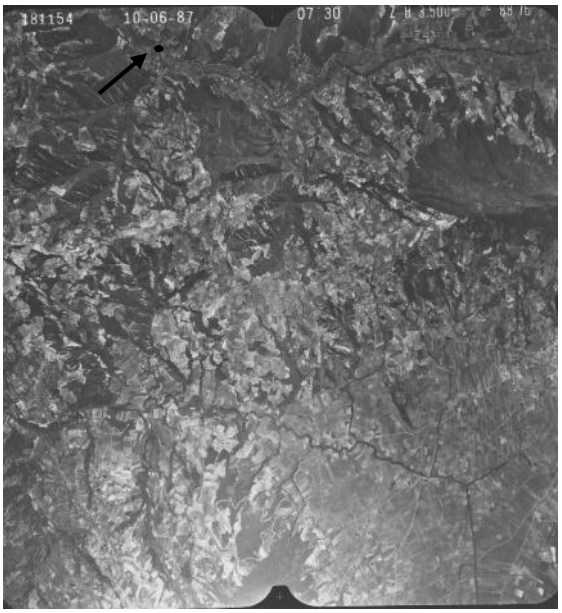

Figure 9. Knick point in Nemeas river

CONCLUSIONS

The study of the aerial photos and the GIS maps that were created, lead us to the following observations :

1. The Asopos river was created in the recent geological past (Pleistocene), with an initial flow direction to the north, ending in the Corinthian Gulf. Upward movements of northern Peloponnesus in combination with intense rift tectonism could not be compensated for by downwards erosion and this resulted in the reversal of the course of Asopos to the south.

2. In particular, the reversal of the course is attributed to secondary faults, that caused lifting and turning of individual tectonic blocks to the south (Seger and Alexander 1993, Zelilidis 2000). This procedure led to the capture of the inverted branches from the remaining rivers, which continue to flow northward. The lithology and tectonic activity of the area allow for the creation of new river branches, while retrogressive erosion, aided by other parameters, continues to be active and shapes the current relief. The effect of retrogressive erosion - as a result of corrodible marly deposits - is responsible both for the capture of Asopos river and for the shape of the northern edge of the valley of Ancient Nemea.

3. Before the Holocene (Late Pleiocene - Early Pleistocene) the river system returned to its original direction. The easily erodible Neogene deposits caused the activation of retrogressive erosion. The intense action of retrogressive erosion of pleiopleistocene deposits in the basin of Asopos allowed the capture of the remaining branches by the remaining atrophic river and the return of the flow in the original direction.

4. A significant number of new branches were created in the Holocene. This was the effect of the action of retrogressive erosion, while in the future, it is likely that new branches will be added to existing river networks, aided by lithology and tectonic activity.

5. In the Asopos basin, the presence of prehistoric residential facilities, occurs as fortified and unfortified settlements throughout, while in historic times, the area shows intense residential development. The archaeological remains (defensive walls, temples, castles, settlements) until the Roman period , are now showing the existence of organized societies .

6. In the drainage basin of Nemeas, we witness human presence throughout the Neolithic period and the Bronze Age. Specifically, on the hill of Tsoungiza archaeologists have found traces of unfortified settlements throughout the Neolithic period and the Bronze Age. During the transition to

the Geometric period, the area seems to change, with the construction of a temple in the nearby area. In the years that followed, the human presence becomes stronger as shown by the important public installations (stadium of Nemea - classical period).

7. The study area was a place with intense human presence. The residential development seems to have benefited from the geological formations (fertile and impermeable deposits - marl and marly conglomerates) which form the subsoil, presence of water courses and the proximity to the sea. The configuration of the valleys over time influenced the choice of installation positions of the residents. The shape of the two basins over time shows the suitability for inhabitation of the site and the construction of infrastructure.

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