Jan Kochanowski University of Kielce,
Faculty of Natural Sciences,
Institute of Geography and Environmental Sciences,
Dissertation supervisor – Prof. UJK dr hab. Tomasz Kalicki

Slawomir Chwalek

ABSTRACT OF PhD DISSERTATION

Environmental conditions of the location and the functioning of Nea Paphos (IV BC - IV AD) in Cyprus - geoarchaeological study

INTRODUCTION

Cyprus is located in the eastern part of the Mediterranean Sea, in the Mediterranean zone, which is a clearly distinguished physicogeographical region (Fig. 1). In contrast to the rest of the eastern Mediterranean, the island is located between the Anatolian plateau and the foreland of the African Plate. This area is characterized by high neotectonic activity, varied relief and subtropical climate. The uplift rate of Paphos region, calculated from the high of MIS 7 and MIS 5 maritime terraces, is 0.35-0.39 mm/year during the Upper Pleistocene.

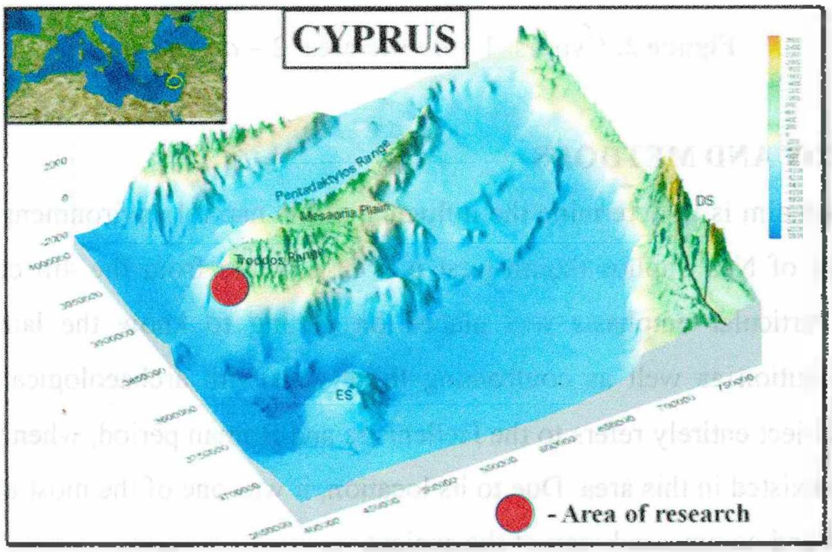

Figure 1. Cyprus, location of study area. Digital elevation model (DEM) of the eastern Mediterranean Sea region combining bathymetry and topography (in meters).

The research region is located in the southwestern part of Cyprus. Geologically, it is located in the Mammonia terran, surrounded by the Mesozoic Circum Troodos and the Troodos Mountains. The study area cover the ancient site of Nea Paphos with its immediate surroundings, i.e. the ancient necropolis located approx. 3 km north of Nea Paphos and the ancient port, as well as the modern city of Paphos (study *on-site*, Fig. 2:1). The second area is located in the Ezousas River valley, approximately 6 km to the east of Nea Paphos (study *off-site*, Fig. 2:2).

Figure 2. Cyprus: 1 – *on site* area, 2 – *off site* area.

AIM OF STUDY AND METHODS

The main aim is to determine the influence of the natural environment of the location and functioning of Nea Paphos (south-west part of Cyprus) from the 4th century BC- 4th century AD. Particular emphasis was placed on getting to know the landscape and its Quaternary evolution as well as confronting these data with archaeological and historical sources. The project entirely refers to the Hellenistic and Roman period, when the ancient city of Nea Paphos existed in this area. Due to its location, it was one of the most important places on the political and commercial map of the ancient.

Other purpose of the research include:

1. Identification of the site of the second port of Nea Paphos, known from the sources of ancient writers.
2. Identification of the settlement stratigraphy of Nea Paphos.
3. Stratigraphy of the alluvial phases of the Ezousas Valley.
4. Typology, regionalization and valorization of geoecosystems in the Paphos region.

The field work included geological mapping and sedimentological analysis of sandy gravel alluvium of various terraces levels and flood plains. Grain size field analysis based on Rutkowski's method, petrographic analysis using a polarized light microscope and samples for TL dating were also done. Dating of alluvium by TL method was conducted in the Geomorphological and Hydrological Laboratory of the Institute of Geography and Environmental Sciences of Jan Kochanowski University in Kielce.

RESULTS

Paleogeographic reconstruction

The results of the research allowed to reconstruct the Quaternary evolution of the Paphos region (*off-site* area), conditioned by neotectonic movements and climate change, and to determine the state of the environment at the time of the settlement of this area by the founders of Nea Paphos ("zero point", *on site* area).

The uniqueness of Cyprus is partly due to the fact that, as a preserved ophiolitic complex with a hydrated core and it's like a diapirically uplifting entity. Coupled with the near shore tectonic activity of the Cyprus arc collision zone, there exists a dynamic environment of landscape evolution. Repetitive Quaternary sea level change has created coastal features that due to continuous uplift have been preserved as maritime and fluvial terraces.

The Paphos region gradually emerged from the sea from the Pliocene, but the coastal area only in the Quaternary. In this period, high neotectonic activity caused the area to be raised (0.39 mm/year in the Upper Pleistocene) and the formation of subsequent ones, elevated to over 400 m a.s.l. interglacial maritime terraces (MIS 15, MIS 13, MIS 11, MIS 9, MIS 7-5) for at least more than 620 ka. These levels are one of the dominant forms of relief in the study area and are clearly marked in the coastal landscape by flattening at the height of approximately 410, 300, 190, 130, 60 m a.s.l. respectively on the foreground of the hills formed on the rocks of the Mesozoic edge of Troodos and the Mammonia terran. With the

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exception of the highest preserved in residual form, the others form extensive, flat or slightly sloping plains separated by edges, the clearest in form rock walls or rock-weathered slopes with a relative height of up to 50 m between the MIS 9 and MIS 7-5 terraces.

The abrasion has cut maritime terraces in the rugged Miocene carbonate rocks of the Mesozoic Circuum Troodos. On the abrasive and accumulation levels of these terraces there are dusty sediments, which were probably accumulated here as an aeolian. On the MIS 9 terrace, the dusty series (aeolian?) sedimented from about 200 ka in several phases separated by the formation of fossil soils (Koskinas 2) until the end of the Pleistocene (Paphos Quarry). On the lowest terrace MIS 5 near the Nea Paphos archaeological park and the Kings Avenue Mall shopping center, there are erosive outliers of poorly lithified carbonate-sand rocks. During weathering, provide sandy sediments that are subject to further morphogenetic processes.

Each lowering of the sea level associated with successive Quaternary glaciations triggered karst processes at the same time. During the last maximum glaciation, at a lowered sea level (approx. 100-150 m), underground karst void formed in limestones on the MIS 5 terrace (under the Nea Paphos agora) were routes of intensive karst water flow towards the sea. Along with the gradual rise of the sea level and the decrease in the transport power of karst waters, the void was filled with *terra rossa* sediments (TL from filling the well under the agora 17.9 ± 2.7 ka) scouring from the surface.

There are numerous faults in the coastal, southern part of the Mesozoic Circuum Troodos. In the Paphos area, those active in the Quaternary are parallel to the coast. The varied movements have resulted in the formation of clearings and tectonic ditches through which the large rivers of Troodos flow, such as the Ezousas. High tectonic activity led to numerous earthquakes in the Quaternary. They are responsible for the formation of landslides and rockfalls in mountainous areas, e.g. in the Episkopi region in the Ezousas valley about 28.6 ± 4.3 ka., and in coastal areas for tsunami waves (e.g. in historical times 76-77 and 342 AD) attacking and flooding the coast and throwing large blocks of rocks found at two sites in the Paphos area on the lowest abrasive terrace. These catastrophic events eventually led to the destruction of Nea Paphos.

River valleys are the second characteristic feature of the coastal landscape. Maritime terraces cut both short, steeply sloping watercourses springs in the Mesozoic Circuum Troodos (eg Koskinas), as well as long periodic rivers starting in these mountains (eg Ezousas). In these valleys, strong alluviation was found in the Pleistocene and small in the

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Holocene, which was caused by climate change. Two main phases of alluviation have been distinguished: 75–48 ka and 25–13 ka (Fig. 3). At the same time, gravel inserts in the Paphos quarry document torrential flows occurring on the surface of the MIS 9 terrace several thousand years ago. This may have occurred during the younger alluvial phase, when the alluvial plains accumulated in the lower part of Ezousas river about 16.1 ± 2.4 ka. Accumulation of alluvia in the river valley, as well as the presence of torrential flows transporting gravel on sea terraces, could have been favored by climate humidity and an increase in rainfall typical for the Mediterranean climate in summer.

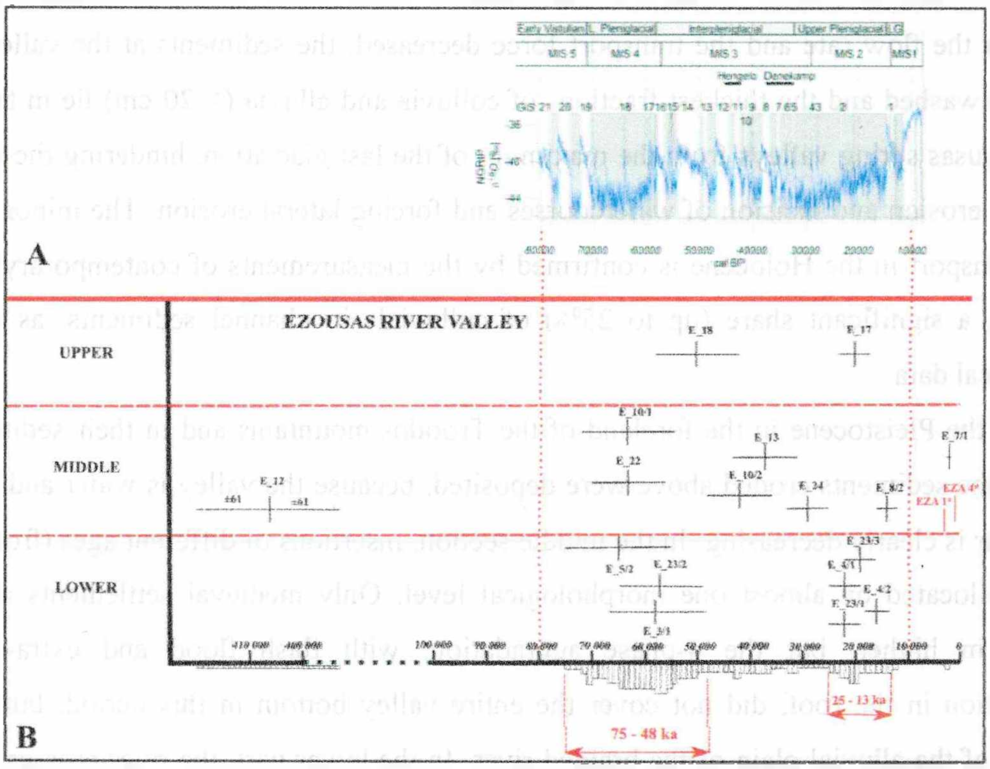

Figure 3. A: Greenland ice core records, **B:** TL records from Ezousas river valley

The older of these phases was marked in both types of valleys, while the younger one only in large valleys (Ezousas). This may be due to the fact that in small valleys during the LGM, a very large decrease in the erosion base as a result of the sea level drop by 100-120 m resulted in intensive cutting of the bottoms progressing upstream. Backward erosion has not yet reached the MIS 11 terrace, while on the lower terraces it has created deep river "canyons" cutting the flat abrasive surfaces of these terraces. Large drops and the transport power of these watercourses as well as the specificity of eroded sediments (dust) caused that the products of this intense erosion were carried to the sea and did not form a series of alluvials in these valleys.

Differently, the erosion-accumulation cycles were marked in large and longer valleys, where in the upper course of the river with the predominance of erosive processes, a few alluvial covers were preserved, while the sediments were deposited in the middle and lower part of the river with the dominance of accumulation.

The rapid rate of Cyprus uplift meant that in the upper, mountain section, the rate of river indentation in the period from approx. 60–20 ka was approx. 30 m. An erosion and accumulation terrace was formed then, and the river reached the present level. At the same time, in the wetter period of LGM, there was a large crosswise supply to the main bed, both from the tributaries (inflow cones - a coarse-clastic series with colluviums) and from the slopes. As the flow rate and the transport force decreased, the sediments at the valley floor were only washed and the thickest fractions of colluvia and alluvia (> 20 cm) lie in the beds of the Ezousas spring valleys from the maximum of the last glaciation, hindering the process of bottom erosion and incision of watercourses and forcing lateral erosion. The minor role of fluvial transport in the Holocene is confirmed by the measurements of contemporary fluvial processes, a significant share (up to 25%) of colluvials in channel sediments, as well as hydrological data.

In the Pleistocene in the foreland of the Troodos mountains and in their sedimentary margins, the sediments eroded above were deposited, because the valley is wider and the fall of the river is clearly decreasing. In the middle section, insertions of different ages (from 400–2 ka) are located on almost one morphological level. Only medieval settlements are here about 2 m higher, but the 4-phase aggradation, with flash flood and extra-channel accumulation in the roof, did not cover the entire valley bottom in this period, but only a fragment of the alluvial plain of the braided river. In the lower part, the river crosses several tectonic edge, which were uplifted about 30 m during the last 20 ka, and the alluvial series from two Pleistocene alluvial phases are superposed here on the erosion-accumulation terrace. In its lowest part, the river crosses uplifted maritime terraces, and the uplift here can be estimated at about 11 m during the last 60 ka. Various centuries of alluvial series create accumulation terraces here. In all these sections, a small role of fluvial transport in the Holocene was also found, which is confirmed by petrographic studies (the maximum length of transport is 7 km), measurements of contemporary fluvial processes (no transport of gravel, but only a small suspension fraction), as well as hydrological data (flows do not occur each year). Only in the lower section, Holocene alluvials from the Roman period were found, covered with Roman and medieval colluvia.

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While in the Troodos Mountains, the climatically conditioned phase of increased mass movements has been identified, probably attributable to LGM in their foreground, two other periods of increased activity of mass movements were identified. The first of them, in the middle part, was related to the interpleniglation climate, when slope sediments dated at 63.2 ka were covered with alluvial deposits. The older alluviation phase is also dated to this period found in both large (Ezousas) and small valleys (Koskinas). In turn, after the LGM, a landslide (break) was formed on the erosion-accumulation terrace in the lower reaches of Ezousas (22.5-19 ka each), but the factor that triggered it is unknown. The second phase of mass movements is known only from the lower part of Ezousas and was associated with human activities in the Roman and medieval periods. Slope sediments with a thickness of 2.5 m were covered with alluvials from the Roman period. The youngest modern colluvia were recognized in the Koskinas valley.

Environmental analysis of the location

An analysis of the environmental factors that could have influenced the location and functioning of the ancient city of Nea Paphos in the period IV BC-IV AD showed that terrain type I is the most favorable in this respect, and terrain 1 within it. Apart from political factors and geographical location, were probably one of the most important aspects in the search for a new place for settlement, the environmental conditions of the site 1 ensured the possibility of founder and operating Nea Paphos for many centuries. These conditions included:

1. Availability of water, conditioned by the existence of periodic flow, underground karst waters and shallow groundwater on river terraces.
2. Soils suitable for cultivation and breeding in the areas of fluvial terraces.
3. Outcrops of older rocks that could have been used as quarries for the exploitation of building material.
4. A slight slope of the land, which it is relatively easy to build residential and other buildings related to the proper functioning of the city.
5. Large physical and geographical diversity of the area.

The valuation shows that area 1 and 2 (67% of the maritime terraces) have all the best environmental factors necessary for the location and functioning of the city in antiquity. In area 3 and 4, the area of episodic watercourse geosystems is clearly growing at the expense of periodic ones. This can cause specific problems in the water supply and thus in the

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agricultural and livestock activities. Therefore, these are areas less attractive for the location of a city. However, as the cities developed, they could also serve as places from which the access to the mountain areas, where there were mines of mineral resources, was much easier. Terrain 5 is the area where there is the smallest number of periodic flow (2%) and the highest number of episodic flow (10%). Poor access to water and relatively steep slopes (approx. 20^o) make it the least favorable area for settlement.

To sum up, area 1 and 2 can be considered an ecumene (61% of valuation points), area 3 and 4 as a subecumene (23% of evaluation points), and area 5 as an anecumene, the so-called badlands (16% of valuation points).

Agora

Ancient Nea Paphos is located on the uplifted maritime terrace MIS 5-7 in the geosystem terrain 1 - the lowest maritime terrace. It is located on two sub-types of forest areas 1.6 and 1.7. It is located on the sediments of maritime terraces with episodic and periodical surface waters and underground karst waters. The absolute height is 0 - 55 m, and the slope is 0 - approx. 2^o. In this area, there are carbonate lithosole and *terra rossa*. The morphogenetic processes on the subtypes include: abrasion, karst processes, physical and chemical weathering, cliff fall and stripping, periodic surface scouring and anthropogenic processes. Subtype 1.6 also shows the greatest fragmentation (19%) in the area 1 which proves the great diversity of the area.

The city was built on the bedrock with Holocene soil in the ceiling, without anthropogenic levels and with the use of natural relief. The GPR echograms show a clear boundary between the anthropogenic layers and the bedrock at a depth of about 1 m, and TL dating of the weathering in the top of the gassed limestones below the anthropogenic layers gave a result of 6.7 ± 1.01 ka.

Second port hypothesis

The results of detailed interdisciplinary research both *on site* and in its surroundings (*off site*) unequivocally refuted the hypothesis of the existence of a second port north of Agora Nea Paphos in the quarries and the area of the modern city beach because:

1. Dusty deposits on the raised sea terraces and in the pedestals of Koskinas erosion and accumulation terraces, eroded and cut from approx. 40 thousand years, they were transported in suspension to the sea, where they dispersed and could not land where the ancient harbor was supposed to be.

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2. The sediments in the "Kamieniołom" profile near Agora are a very young weathered cover ("modern" terra dew) almost from the surface with fragments of limestone 8-10 cm in size. The rough and uneven limestone surface is already located at a depth of 1.2 m - 3 m, which contradicts the existence of port docks in this place according to the Balandier concept (2014). GPR echograms from the so-called the ramps and the quarry itself show anomalies that may be remnants of existing anthropogenic structures, not necessarily related to the port.

3. The GPR profile made on the western border of the quarry shows too shallow anomalies that could constitute a channel supplying water to the quarry where the port would be located. This contradicts the hypothesis of French archaeologists about the existence of a connection between the sea and the quarry.

4. On the city beach in Paphos, contemporary fluvial sands (AMS and TL dating) were found with algae intercalations up to a depth of about 1 m, lying on karst weathered ("*terra rossa*") in the top of the carbonate bedrock (from 1.5 m deep), although locally, on the profile cuts of the beach made by GPR, the rock occurs already at a depth of 0.4 m. These sands, resulting from the destruction of carbonate, sandy erosive outliers, are fluvially washed away and deposited on the beach at the mouth of a dry valley, which is the northern border of the archaeological reserve. Then they are redeposited, on the one hand, by the undulating surface of the abrasive platform and, on the other hand, by the inland westerly winds onto the windward slopes of the MIS 5 sea terrace, which resulted in filling the test trench with 1 thick layer of aeolian sands.

Negative verification of the hypothesis about the existence of a second port, however, does not exclude the functioning of the marina here, which could be favored by the morphology of this section of the coast and "slippery" clay deposits (*terra rossa*), which could facilitate the transport of boats to the shore, and were covered by sands only after the fall of Nea Paphos.

Final conclusions

Nea Paphos is an example of a city that, despite not very favorable environmental factors, such as limited access to water or poorly fertile soil, was able to exist, function and compete with other ancient cities in the Mediterranean region and beyond. In the case of Nea Paphos, the main factors determining the founding of the city were purely economic and political reasons (access to the port), on the basis of which the city developed and functioned

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for about 800 years. Only the two earthquakes in Nea Paphos in 342 CE and 394 AD led to the fall of this city, and the capital was moved to Salamis.

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