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A geographical analysis of the Atalanti alluvial plain and coastline as the location of a potential tourist site, Bronze through Early Iron Age Mitrou, East-Central Greece

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ABSTRACT

Tourism accounts for 15% of Greece's gross domestic product. In the wake of a struggling economy many of Greece's coastal villages have turned to tourism to supplement local economies. Preliminary analysis of structural and cultural materials recovered from an excavation on Mitrou, a small islet near the coastal village Tragana located 140 km north of Athens has established the site's contribution to a fuller understanding of settlement practices in Central Greece from the end of the Bronze Age through the Early Iron Age. The site's historic importance combined with its scenic coastal setting has considerable potential to be developed into an important tourist site. The physical geography of the region is the product of the complex interaction of coastal, alluvial, fluvial, and seismic processes. This investigation integrates the archaeological material with a geographical analysis employing a variety of geographical techniques (soil and sediment analysis, past climatic data, environmental surveys, and geospatial modeling) to reconstruct the geomorphological history of the site and to evaluate the area as a potential tourist site.

Introduction

Greece has invested tremendous energy and resources to preserve and promote its historical heritage. Displayed among its modern cities, villages and countryside are the countless remains of ancient peoples and societies. Before the recent financial struggles, Greece's natural beauty and Mediterranean setting combined with outstanding archaeological sites made Greece "one of the world's top 20 tourist destinations" and accounted for nearly 15% of the nation's gross domestic product (Granitsas & Parkinson, 2010). In the wake of its recent financial challenges and a fishing industry that is plagued by environmental and anthropogenic threats, many of Greece's coastal villages have turned to tourism to supplement their local economies (Collins-Kreiner, 2010; Gaughan, Binford & Southworth, 2009; Loumou et al., 2000; Oikonomou & Dikou, 2008, cf. Walford, 2001). Early analysis of data collected from an excavation and geoarchaeological investigation on and around the small islet Mitrou located near Tragana, a small coastal village located 140 km north of Athens, make a strong case for the development of this site as a tourist destination.

Tragana is located along Central Greece's East Lokris coastline. East Lokris spans a coastal area in Central Greece north of Athens that extends southeast from the Malian Gulf along the North Euboean Gulf to a point southeast of Mitrou (Fig. 1). The main plain of East Lokris, now called the Plain of Atalanti was referred to as Opountian Lokris in ancient literature (Cox, 1876; Van de Moortel, 2007). The region served as the main north-south road along the coast in antiquity. "Friends and allies, enemies and conquerors" all passed through the area (Dakoronia, 2006: 483). East Lokris is familiar in ancient literature as the site of Heracles' death and funeral pyre, the home of the Homeric heroes Patroklos, Ajax of Lokris, and the mythical huntress Atalanta (the only woman to join Jason and the Argonauts), and the home of Deucalion and Pyrrha the sole survivors of a mythical flood (Van de Moortel, 2007; Mitrou in Prehistory).

The exit for Tragana is unnoticed by most traveling north out of Athens on Interstate E75. Those that exit the freeway find a small village with a local economy sustained through agriculture, fishing, stone quarrying, and nurseries. The few narrow streets that criss-cross Tragana are lined with small shops, a bakery, fruit and vegetable stands, small restaurants, and a grocery store. Two kilometers north of downtown Tragana is a narrow public beach with three beachside taverns/restaurants. And like most villages across Greece, Tragana has a long religious heritage. Overlooking Tragana

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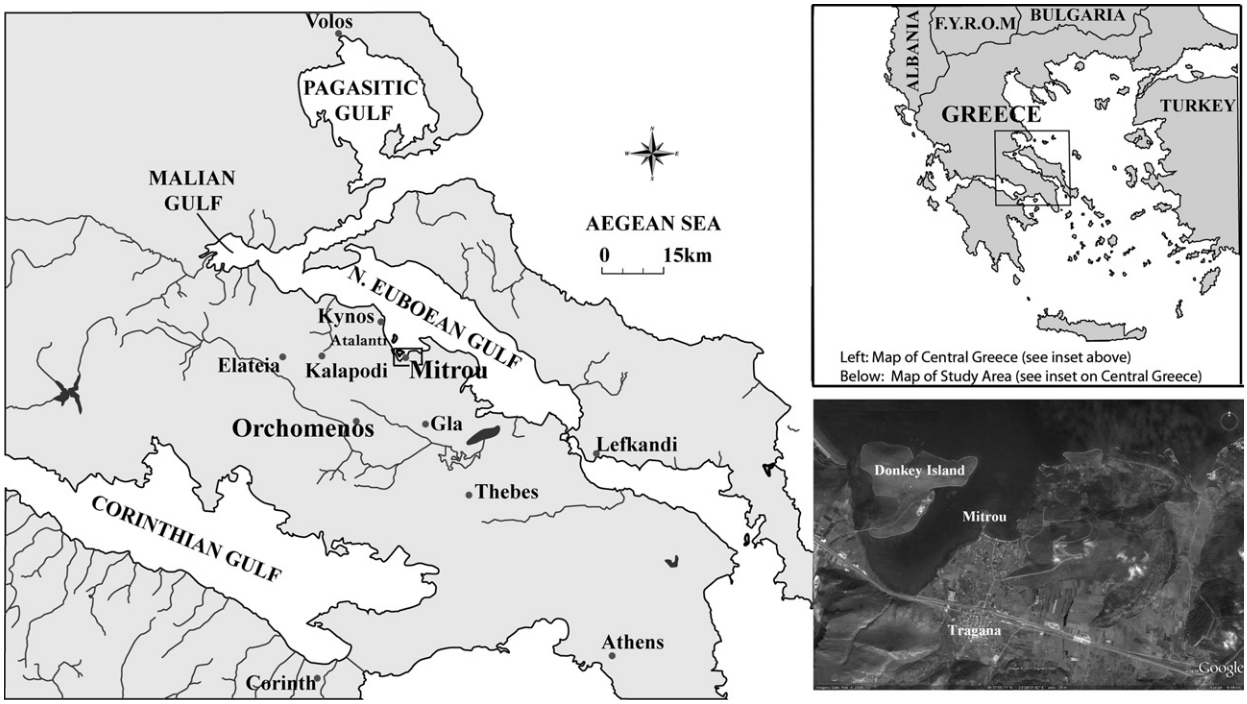

Fig. 1. Map of Central Greece with the location of Bronze Age sites. The modern village Tragana is located 1.5 km south of Mitrou. Inset photo of Study Area from Google Earth. (Maps Courtesy of Bartlomiej Lis and Tina Ross, Mitrou Archaeological Project).

from a vantage point in the mountains several hundred meters above the village stands the old Monastery of the Holy Trinity and on a hillside a few hundred meters east of Tragana's beach is the newly constructed church of St. Catherine and the Foundation of the Monastery of St. Catherine's on Mount Sinai, which serves as an international research and retreat center. However, the location's most important treasures are the cultural remains found on a small islet named Mitrou located 50 m beyond the public beach. Mitrou is home to the remains of a large Bronze through Early Iron Age settlement that until recently laid buried beneath a meter or more of soil (Fig. 2).

In 2004, the Mitrou Archaeological Project (MAP) began work on the small islet (Van de Moortel & Zahou, 2004).[1] The islet lies at the terminus of a large, fertile alluvial plain. With uninterrupted settlement throughout most of the Bronze and Early Iron Ages (2400–900 BCE), Mitrou is one of a few sites where one can study the successive cycles of rise and decline of Greece's prehistoric societies.[2] MAP is a multifaceted archaeological and geoarchaeological project combining a traditional excavation and archaeological surface survey with numerous geophysical disciplines and techniques, including physical geography, climatology, geomorphology, electrical resistivity 2D mapping and tomography, magnetometry, geographical information systems, and the interpretation of aerial photos and satellite imagery. Five seasons of excavations and geoarchaeological analysis have established the importance of Mitrou (Van de Moortel & Zahou, in press). Numerous buildings from several architectural phases along with ancient burials have been discovered on the islet (Fig. 3). Burial remains include both adults and children. Excavations have recovered numerous crates of human and animal bones, shells, pottery, stone tools, architectural fragments, and small finds. Among the more important items recovered are fragments of elite warriors' boar's tusk helmets, arrowheads, gold and bronze ornaments, clay figurines, textile tools, fine dining pottery and cooking utensils,and ceramic roof tiles. The unique vase-painting style employed at Mitrou suggests that Mitrou, like Lefkandi and Kynos, may have also been a "production center for a distinctive school of pictorial vase-painting." (Rutter, 2007, p. 295). The combined weight of this evidence has led Van de Moortel to hypothesize that in the early part of the Late Bronze Age (ca. 1600–1400 BCE) a local elite rose to prominence and changed the character of the settlement from rural to urban. Sometime after 1400 BCE, this elite was defeated and Mitrou was absorbed into a larger palatial society.[3] After the fall of the Mycenaean palaces (ca. 1200 BCE), Mitrou revived but before the end of the 12th century BCE it reverted to a rural settlement for reasons yet unknown (Van de Moortel & Zahou, in press).

To totally understand past settlement decisions on and around Mitrou one must reconstruct the elements of the physical environment that were at work (Bachhuber & Roberts, 2009; Lis, 2009). Shaped and modified by coastal, fluvial, alluvial, and tectonic processes, a geographical reconstruction of the formation of this complex coastal environment must consider tidal processes (deposition and erosion), local geology and sea level change (Masselink & Hughes, 2003; Snead, 1982). This investigation employs the analysis of stratified deposits, past climate,

[1] The Mitrou Archaeological Project is a cooperative project of the University of Tennessee and the Greek Archaeological Service, co-directed by Aleydis Van de Moortel and Eleni Zahou, 14th Ephorate of Prehistoric and Classical Antiquities at Lamia. It is carried out under the auspices of the American School of Classical Studies at Athens.

[2] The Bronze through Early Iron Ages correspond to Greece's Early Helladic through Late Protogeometric periods.

[3] A palatial society was an autonomous political entity, typically possessing a central court building with distinct architecture.

Fig. 2. The Mitrou islet from the air. North is up. The primary excavation site is located near the center of the barren eastern half of the islet. (Balloon Image 2008; Konstantinos Xenikakis, Mitrou Archaeological Project).

Fig. 3. The walls from numerous building phases, including several tombs (e.g., the small rectangular depressions located near the bottom of the photo) can be seen in this oblique aerial photo looking north over the primary excavation site. The excavated area is approximately 400 m^2 (Balloon Image 2008; Konstantinos Xenikakis).

Fig. 4. Looking eastward towards the study area across the mountains above Atalanti, several fault valleys can be seen (highlighted with white lines).

environmental surveys, and geospatial modeling to reconstruct the formation of the islet and coastal plain (cf. Pacione, 1999).

Physical setting

Mitrou is located near abundant natural resources (arable soils, building materials, aquifers, plants, and animals). The site is approximately 10 km from the Bronze Age harbor site Kynos and approximately 50 km from the important Bronze Age site Lefkandi (Lemos, 2006). Preliminary reports indicate that Mitrou functioned as a major economic center throughout the Bronze and Early Iron Ages (Kramer-Hajos & O'Neill, 2008). Due to the islet's sheltered location near the shore in a small alcove off the North Euboean Gulf with easy access to the Gulf's deep waters, Mitrou, like Kynos, may have served as a harbor and port city for the powerful Mycenaean city Orchomenos that was located 20 km southwest of the site (Mitrou in Prehistory; cf. Van De Moortel, 2007).

The study area is located in one of the most tectonically active regions in the Mediterranean. It is positioned between the North Euboean Gulf and the Knemis Mountains that are part of the Sub-Pelagonian continental margin (Higgins & Higgins, 1998; Krohe, Mposkos, Diamantopoulos, 2010). The mountains immediately surrounding the study area reach a height of 600 m above the coastal plain and are located approximately 2 km inland from the coast. Crustal stretching along the Sub-Pelagonian Zone formed a series of parallel grabens expressed today as the Corinthian Gulf, Kephissos valley, and the Euboean Gulf (Higgins & Higgins, 1998). Mitrou and the adjacent alluvial plain lie within a network of faults associated with the Atalanti Fault system (Buck, 2006). Evidence of tectonic disturbance, both past and present, is seen throughout the region. Numerous fault valleys crisscross the mountains west of the modern town of Atalanti located 10 km west of the study area (Fig. 4).

Eleven earthquakes with an estimated magnitude of at least 6.0 MS (surface wave magnitude) are recorded in ancient literary sources. The oldest event (an estimated 6.6 MS in 426 BCE) associated with the Atalanti Fault was reported by Thucydides, Didorus of Sicily and Strabo (Buck, 2006). A pair of earthquakes on April 20 and April 27, 1894 (M6.2 and M6.9 respectively) that caused widespread destruction in the study area killed 250 people, destroyed thousands of homes, and submerged tens of meters of the coastline, and resulted in 30–80 cm of permanent subsidence (Cundy et al., 2000; Ganas Sokas, Agalos, Neontakianakos & Pavlides, 2006). Prior to the 1894 events, Donkey Island (see Fig. 1) was connected to the mainland by a marshy land-bridge. Following the 1894 earthquakes, it became the detached island seen today (Buck, 2006).

The Mitrou islet lies just beyond the terminus of an alluvial plain that is part of a 43 km^2 system that includes a catchment basin providing runoff and sediments to the lower plain, three mountain rivers/streams, and a colluvial terrace. The southern end of the Mitrou islet (the islet measures 330 m north to south, 180 m east to west) gradually descends into the coastal waters with its underlying bedrock buried beneath several meters of soil and sediment. The northern end of the islet rises 12 m above sea level where uplifted bedrock (max dip of 40°) exposed the islet's northern and eastern scarps is covered by thin soils (Fig. 5). Within the eastern scarp is a normal fault, presumed to be associated with the Atalanti system, where there bedrock is displaced by 80 cm.

Higgins and Higgins (1998) suggest that the regional sea level at the onset of the Bronze Age was several meters lower than today,

Fig. 5. The Mitrou islet (center of photo) and the Bay of Atalanti that surrounds the islet. The photo was taken from a hillside 1 km east of the islet. The islet measures 330 m from its southern tip (left in the photo) to its northern tip (right in the photo). Inset Photo: The uplifted bedrocks at the northern tip of Mitrou. The northern tip rises 12 m above the local sea level.

Fig. 6. A section of wall extending into 0.5 m of water off Mitrou's western shore.

whereas Kramer-Hajos and O'Neill (2008) estimate that the local sea level at the end of the Bronze Age was at least 10 m lower than the present (cf. Vouvalidis, Syrides, Pavlopoulos, Papakonstantinou & Tsourlos, 2010; and also Porqueddu et al., 2001, for similar findings in Italy). Evidence from survey data collected along the current shoreline, snorkel surveys, and hand auger samples were consistent with a significantly lower Bronze Age sea level. A large section of what is believed to have been the wall of a building now extends several meters into the bay below the current sea level. Snorkel surveys in the Bay of Atalanti by the author in 2008 found numerous building stones located several meters from Mitrou's eastern shore in 3 to 4 m of water (Figs. 6 and 7; cf. Van de Moortel, 2009). In a core collected along Mitrou's eastern shoreline, the vertebra from an unidentified animal species was recovered in a sample taken 1.8 m below the low tide level. While it is likely that local tectonic uplift has contributed to some of the local sea level change (Flemming & Woodworth, 1988), the extent of its impact is impossible to determine. It is suggested that the local sea level has changed very little in the past 2000 years as local tectonic uplift has been keeping pace with global sea level rise (Kouli et al., 2009; cf. Anzidei et al., 2011).

Methods

Data for analysis was collected from a 1:50000 geological map, ground surveys, and sediment cores collected with a 3 ½" standard hand auger. 40 m contour lines from the geological map were used in a GIS to map the catchment basin (i.e., a watershed model). Soil/sediment cores were collected from multiple locations in each major geomorphic feature, along the coastline, and on the Mitrou islet. The cores were analyzed in the field on the basis of their environmental setting, horizon, Munsell color, texture, structure, consistence, inclusions, and free carbonates.

The alluvial plain

The rapid retreat of glaciers at the end of the last glacial maximum combined with the then lower sea level produced rapid erosion that resulted in the deeply cut mountains and river channels found in the study area today (Palacios, de Marcos & Vázquez-Selem, 2011; Triantaphyllou et al., 2009). The ensuing erosion produced a tremendous amount of sediment that was transported from a 35 km^2 catchment area to the lower plain by a network of three mountain river/streams (Revenikos, Traganoremo, and Plithsas) (Fig. 8). The deep sediments that underlie the gently sloped alluvial soils we find on the plain today were deposited during this period. An apron of colluvium that continues to be deposited today forms a transition zone between the lower alluvial plain and the surrounding mountains.

The Revenikos system continues to be the primary conveyor of sediment to the lower plain. Though fluvial and alluvial activity are virtually non-existent in the study area today with no contiguous channels connecting the mountain streams with the coastline, a 300 m section of the Revenikos channel located 1200 m inland from the coastline provides evidence for the scale of past fluvial activity (cf. Wharton, 1992) (Fig. 9). In contrast to the size of the channel that precedes it (2–3 m deep and 15 m bank to bank) this segment of the Revenikos is 13 m deep and 50 m bank to bank. A small underfit stream flows through the channel today. The stratigraphy exposed within the deep channel walls preserves a record of hundreds of depositional and erosional events of varying intensity (Fig. 10). Curiously, the channel abruptly ends with this

Fig. 7. Building stones located several meters off Mitrou's eastern shore in two to 3 m of water.

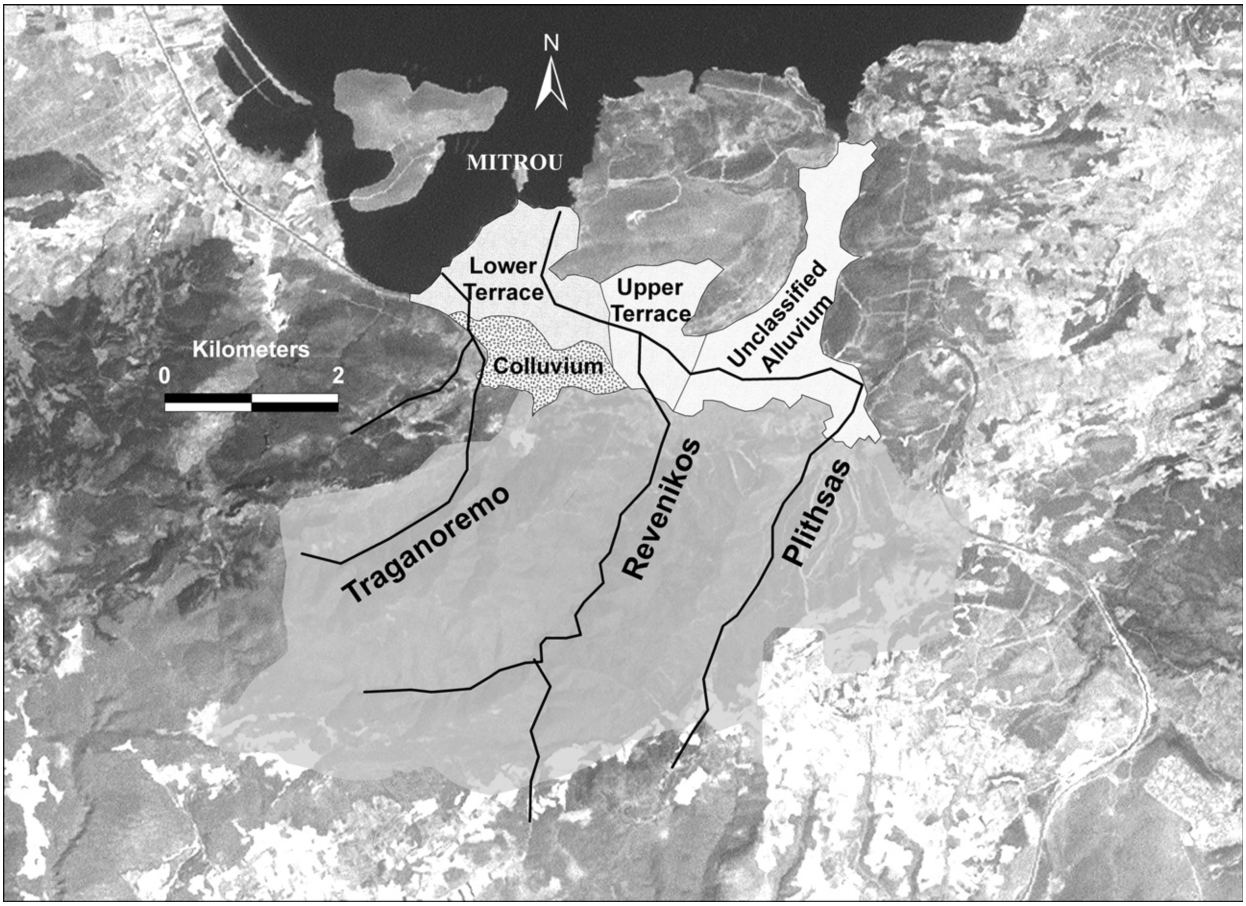

Fig. 8. Major geomorphic features. Catchment area (large translucent feature in center of image) generated from 40 m contours digitized from the Geological Map of Greece (1965). Base image is a Landsat ETM + Scene P183R033_20000824, NASA Landsat Program.

300 m section. There was no opportunity to collect cores beyond this section, so it remains unknown whether the destruction of the channel is due to infilling by humans, normal alluvial processes, a collapse from tectonic activity or a combination of processes. The Revenikos does not appear again until near the current coastline as an ephemeral channel (completely dry in the summer) that is much more modest in scale (10 m wide, 3 m deep). During the summer, the Revenikos flows into the gulf through a narrow marshy tributary located 180 m east of the ephemeral channel that is supplied by springs. Though fluvial activity is modest across the alluvial plain today, karst springs emerge near the coastline and as fountains (of very cold water) flowing up from the floor of the bay surrounding Mitrou. The karst system is supplied by porous Jurassic (Kimmeridgian) limestones (Geological Map; cf. Panagopoulos & Lambrakis, 2006; cf. Kramer-Hajos & O'Neill, 2008; observed by author during 2007 and 2008 field seasons).

The alluvial plain separating the Knemis Mountains and Mitrou is 7 km^2 of deep alluvial sediments. On the basis of soil color, horizon development, and the presence of free carbonates, the surface soils are estimated to be late Pleistocene to early Holocene aged. This investigation focused on the stratigraphy of two terrace features: a lower terrace extending inland 2 km from the coastline and an upper terrace extending beyond the lower terrace an additional 1.5 km. Alluvial soils extend well beyond the upper terrace, but were not analyzed or classified in this investigation. The upper terrace is older than the lower terrace. Instability stemming from the abundant outwash generated by the high precipitation storms that dominated the entire Mediterranean region (Greece, Northern Africa, Middle East) during the Chalcolithic and Early Bronze Ages delayed the development of the lower terrace soils, especially near the coastline until the Middle Bronze Age (Bar-Matthews, Ayalon, Kaufman, 1998; Geraga, Ioakim, Lykousis, Tsaila-Monopolis & Mylona, 2010; Green, 2004; Kanicwski et al., 2010; Neumann, Kagana, Schwabd & Steina, 2007; Niemi & Smith, 1999; Riehl, 2009; Riehl, Byrson & Pustovoytov, 2008; Triantaphyllou et al., 2009).

The 1.5 km^2 upper terrace is slightly higher in elevation than the lower terrace (2–3 m). The feature's soils have strong argillic (Bt) horizons and strong brown colors (7.5 YR 4/6) that extend to a depth of at least 2 m.[4] The soils are strongly leached and acid throughout their profile. The lower 2–3 m of this unit are very red and deeply weathered with no free carbonates indicating they have been in place since the Late Pleistocene. Though the unit as a whole is old, younger sediments are frequently found on the surface (Foss & Green, 2008). The entire upper terrace is very productive. Grain crops, olive groves, and numerous nurseries blanket the feature.

The 2.3 km^2 lower terrace is estimated to be early Holocene aged. The soils are brown to dark brown (7.5 YR 4/4) with an argillic horizon. The soils have a clay loam texture with a solum depth (A and B horizons) of approximately 1 m. Like the upper terrace, the lower terrace soils are very fertile and used predominately for agriculture. The coastline of the lower terrace is sheltered from the

[4] All soil colors are based on Munsell, 2000.

Fig. 9. An 300 m section of a Revenikos channel preserves a record of former fluvial activity within the system. A small underfit stream flows through the channel today. The author and a colleague can be seen near the center of the photo along with a vehicle parked along the channel bank on the right. (2007 photo by Terry Eddinger).

full brunt of Aegean storm surges and experiences very subtle local tides. As a consequence, numerous salt marshes are found along the lower terrace coastline.

The salt marshes located are 15–40 m from the shoreline and are recessed approximately 0.5 m into the surrounding landscape. The surface level of the marshes are high enough that rain and runoff leaches out superficial salts. The marshes are dominated by the freshwater reed species *Phragmites communis* and *Needle Grass* and have standing water in their interiors (Fig. 11).

The Mitrou islet

Though physically separated from the lower terrace and disturbed to a much greater extent by human activity, the soils on the Mitrou islet are similar to the lower terrace soils (somewhat more yellow, 10 YRs). A three meter profile exposed along the islet's western scarp revealed at least 14 surface horizons (including a burn layer) with artifacts distributed throughout the profile. A 3.5 m profile exposed along the islet's eastern scarp revealed a similar number of surfaces with artifacts. Within the excavation site, there is structural damage preliminarily attributed to earthquakes associated with the Atalanti Fault (Vitale, 2008).

The location and topography of the islet (it is separated from the mainland and rises 12 m above the opposite coastline) leads some to consider the possibility that Mitrou's soils were carried onto the islet by humans,rather than having developed from sediments transported onto the islet through natural processes. Though it is impossible to eliminate a human element in the delivery of the islet's soils and sediments, the transport and deposit of tremendous amounts of sediments to the coastal inlets following the last glacial maximum is the more likely agent (Higgins & Higgins, 1998).

The coastline

Cores were collected from three marsh locations and two shore/beach locations (Fig. 12). The cores were analyzed in the field on the basis of their environmental setting, horizon, Munsell color, texture, structure, consistence, inclusions, and the presence or absence of free carbonates. The salt marsh cores were taken near the perimeter of the marshes where there was no standing water. At all sites except one (GR09), cores were taken to the depth of the water table. Water saturation prevented collecting samples below the water table. Augering at site GR09 was discontinued at a depth of 180 cm after collecting 45 cm of the same sand and gravel feature

Fig. 10. Taking measurements of the preserved channel wall.

Fig. 11. Salt Marsh site GR13 with dense growth of *Phragmites communis* (background) and *Needle Grass* (foreground).

Fig. 12. Sample Locations. Salt Marshes: GR 9, 12 and 13. Shore/Beach: GR 6 and 11. Base Image Source: 38°37'44.14" N and 23°07'19.26" E. Google Earth. February 4, 2006.

Table 1
Salt Marsh and Beach Sample Sites.

Site No	Setting	DFS[a] (m)	ASL[b] (m)	UTM North	UTM East[c]
GR06	Beach	15	0.50	4278175	685441
GR09	Tidal marsh	30	0.25	4278087	684784
GR11	Beach	2	0.50	4277231	683786
GR12	Tidal marsh	40	1.00	4277247	683895
GR13	Tidal marsh	16	0.25	4277853	684394

[a] Distance from shoreline.
[b] Above mean sea level.
[c] Zone 34, NAD83 Datum.

observed at the other sites. A deposition/erosion profile of the coastline was constructed from the stratigraphy of the five sites (Table 1).

A well developed A horizon is found on the surface across the entire coastline, indicating that the area has been stable for many years. Beneath the surface horizon, individual site stratigraphies preserve a record of an environment that formed through multiple episodes of erosion and deposition, with intervening periods of stability of sufficient duration for surface horizons to develop. Comparisons of individual stratigraphies reveal that in addition to system wide events, there were site specific events triggered by localized fluvial, alluvial and tectonic activity that left distinct deposits (Fig. 13).

The soils at all sites are characterized by fine-textured, silt loam and silty clay loam in the upper units with a very gravelly and sandy layer at the bottom of the profile near the current water table. With the exception of site GR09, the sites shared a common gravelly sandy feature at a depth that varied by only 17 cm across the 1.7 km coastline (GR09's stratigraphical anomalies are discussed in detail later). The gravelly sandy layer represents a common chronological period in the formation of the coastline. The gravelly sandy layer is the oldest deposit recovered from the coastal sites.

Discussion

Apart from a slight difference in elevation (upper terrace is 1–2 m higher) and the general age of the units (upper terrace soils are older), soils across the alluvial plain are very similar. Their differences are due to the upper terrace's greater distance from the higher energy environment of the coastline. While the upper terrace probably offered a more stable environment for agriculture in the past, this is no longer true. Today, the entire alluvial plain supports a robust agriculture.

More striking differences were observed in the stratigraphies of sites along the coastline. Of these, the absence of a B horizon (accumulation zone) underlying the surface A horizon at sites GR06, GR09 and GR13 was most apparent. In contrast, sites GR11 and GR12 located near the southern end of the study area's coastline have well developed B horizons. This difference is apparently the result of a more stable environment near the southwestern coastline when compared to instability along the north and eastern

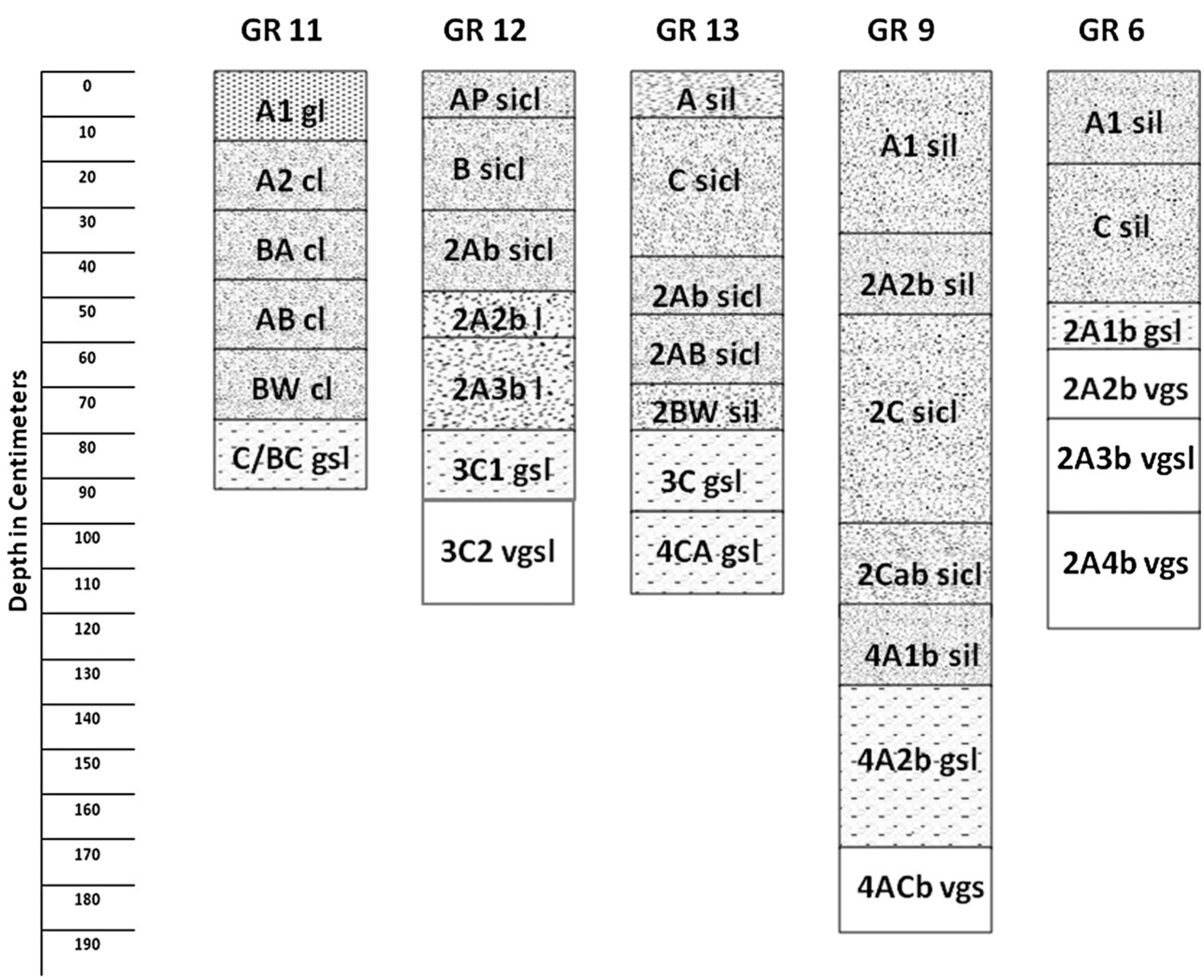

Fig. 13. Marsh and shore/beach site location stratigraphies (c – clay, g – gravel, l – loam, s – sand, si – silt, v – very).

coastline where the Revenikos system remains active and meanders through the lower terrace soils before it enters the Bay of Atalanti (Fig. 14). This is consistent with the incidence (observed visually in the field) of a higher percentage (>50%) of medium sized gravels (>4 mm) high in the profile (i.e., chronologically recent) of site GR06. Since the Traganoremo river system currently operates through underground karst processes near sites GR11 and GR12, there is no fluvial and/or alluvial gravel in their profiles.

Another noteworthy difference is a buried C horizon high in the profile (i.e., chronologically late) of sites GR06, GR09, and GR13. This records an event where either a surface horizon or more likely the B horizon found at sites GR11 and GR12 was completely removed and replaced by the deposit of new silty clay loam sediments. Assuming a pre-event stratigraphy similar to sites GR11 and GR12, this event eroded several centimeters of developing soils. To allow adequate time for the 10–20 cm surface horizon overlying the C horizon in GR13 and GR06 to develop, this event probably occurred in the past two centuries (cf. Zielhofer, Espejo, Granado & Faust, 2009). Though anecdotal, this feature may be associated with a flood event that resulted in substantial bank overflow along the Revenikos system in the early 1900s that was reported in a 2007 interview with an elderly resident of Tragana.

The soils of GR11 and GR12 were less red (predominately 10 YRs) than at the other sites and the depth of their gravelly sandy layers differed by only 5 cm. As a result of GR11 being located only 2 m from the shoreline, the upper 15 cm of the GR11's stratigraphy included small gravel deposited by overbank wash during storms. Overbank deposits are not present in the GR12 stratigraphy.

No datable evidence (e.g., cultural materials) was recovered in the marsh or coastal cores from which to date the sand and gravel layer found at the base of each site. However, the discovery of this common feature spanning the entire coastline along with the evidence on and around Mitrou for a considerably lower Bronze Age sea level leads this investigation to conclude that the sand and gravel is the remnant of a beach that extended several meters inland from the current shoreline during the Bronze Age; a beach that was eventually buried under alluvium following the onset of a much drier climate in the Late Bronze Age. With the onset of the drier conditions, low energy alluvial processes transported and deposited the sediments that constitute the current coastline (Bar-Matthews et al., 1998; Lam & Boyd, 2003; Wilkinson, 2003).

The locations of stratigraphical features shared in common among the sites were located at a considerably different depth in GR09's profile. Two distinct deposits that functioned as stratigraphic markers were found to be much lower in the profile of GR09 than at the other sites. The "recent" high energy erosion/deposition feature (buried C horizon in GR06, 09 and 13) and the gravelly sandy layer at the base of all sites are displaced several centimeters downward when compared to the other sites. The displacement is 44 cm and 58 cm respectively when compared to site GR13. GR09's C horizon is also much denser and approximately 15 cm thicker than at sites GR13 and GR06.

GR09's close proximity to sites GR06 and GR13 suggest that the deposit of GR09's C horizon occurred at the same time as at sites GR06 and GR13 (within the past two centuries). The buried A horizon positioned between GR09's C horizon and the surface A horizon that is common to all sites suggest that the event which resulted in the downward displacement of GR09's C horizon left a depression that was quickly filled with sediments. Sometime later, this feature along with the entire coastline was blanketed

Fig. 14. The current Revenikos where it empties into the bay 700 m east of Mitrou. The stream extends approximately 100 m inland and is fed by underground springs.

with a new layer of deposits, from which the current surface A horizon formed. When the amount of the downward displacement of both the C horizon and the gravelly sandy feature are considered in the context of the study area's proximity to the Atalanti Fault and the proximate time period for the event, it is the conclusion of this investigation that the 40–60 cm displacement observed in GR09 occurred during the 1894 earthquakes that resulted in 30–50 cm of subsidence in other locations near the study area (Cundy et al., 2000). Because the salt marshes in the study area are sheltered, the preservation of a stratigraphical record of the 1894 subsidence is not unexpected (Allen & Pye, 1991; Bird, 1993; Cavatorta, Johnston, Hopkinson & Valentine, 2003; cf. Bird, 2000). Since none of the cores collected from the other sites exhibit this displacement, the spatial extent of the subsidence within the coastal sediments is unknown. In the 100 years since the 1894 earthquakes, natural weathering and human disturbance have erased all surface evidence of the 1894 event.

Conclusion

The landscape surrounding Mitrou has changed dramatically since the Bronze Age. During the Bronze Age, the Mitrou islet was an earthen hill connected to the mainland by a gravelly sandy beach that extended several tens of meters inland. The shallow bay currently off Mitrou's eastern shore was a tidal beach that extended several meters beyond the current shoreline. It was the onset of much drier conditions along with a rising sea at the end of the Bronze Age that led the landscape changes we see today. By the Early Iron Age, shallow coastal waters began to claim the eastern tidal beach and the Revenikos system had been reduced to little more than a network of small tributaries along the coastline. No longer a high energy environment, alluvium began to blanket the coastline and the first soils began to form.

As the surrounding landscape evolved in response to climatic changes, erosion and seismic activity were also transforming Mitrou. Without additional surveys in the bay surrounding Mitrou, it is impossible to estimate the size of Bronze Age Mitrou. However, based on the amount of erosion occurring today, the amount of detritus at the base of the scarps, the number of building stones located in the water surrounding Mitrou, and the structural remains (e.g., walls) exposed within the islet's scarps, it is certain that Bronze Age Mitrou was several hectares larger than the current islet.

Excavations on Mitrou are already increasing our understanding of the rise and decline of Greece's prehistoric societies. Geoarchaeological evidence has established the importance of the Mitrou as a site that rivaled its coastal neighbors Kynos and Lefkandi during the Bronze and Early Iron Ages. The unique setting of the site is ideal for sharing what is being learned with the larger public. In addition to the usual display of surface features (e.g., walls and tombs) exposed through excavations, erosion along Mitrou's eastern and western scarps reveal several meters of stratigraphy spanning three millennia (e.g., building phases, streets and roads, destruction layers, burn layers, environmental deposition and erosion, and refuge deposits). In combination, these offer a unique opportunity to learn about site development in Bronze and Early Iron Age Greece. Unfortunately, the same erosion that created this unique setting is also destroying it. It will be important to take immediate action to stabilize the scarps and protect them from additional erosion if the cultural and environmental records exposed within them are to be preserved and made available for future study. If successful steps are taken, future visitors to the islet will have the rare opportunity to see multiple phases of site development spanning three millennia from both the traditional perspective of a surface excavation and through the 3000 year timeline revealed in the stratigraphy of the scarps.

As a contributor to the local economy, tourism around Mitrou has the potential to be significant. The site's location on a small islet surrounded by the emerald blue waters of the Aegean is picture postcard ready. Without new development, the local beachfront offers ample parking, a public beach, and three restaurants. And to those seeking a respite from the commercialization that accompanies Greece's more popular tourist sites, downtown Tragana offers tourists numerous small shops, taverns and restaurants.

Should the local community decide it wants to expand its tourist offering, there is a considerable amount of undeveloped agricultural land located along the road between the beach and Tragana. However, a decision to expand the local tourist offerings and develop this land should carefully consider the following: the impact of the underlying morphology (e.g., numerous springs, buried channels, marsh deposits, and tectonics), the recharge rate of the local aquifer and the level of usage it will support (Kent, Newnham & Essex, 2002; Lambrakis & Kallergis, 2001; Voudouris, 2006), the impact of tourism on the local ecosystem (Zacarias, Williams & Newton, 2011), and the appropriate level of capital to invest (cf. Wellings & Crush, 1983).With proper attention to these factors, tourism around Mitrou has the potential to become a major contributor to Greece's tourist industry.

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