The non-existing seas; Finding marine molluscs in inland Basins. Are they secure marine indicators?

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Abstract

Fossil marine molluscs are considered by geologists as indicators of marine presence into an area. Findings of marine molluscs spark theories of palaeogeographical evolution however the presence of marine molluscs into the soft surficial strata of an area is not always a safe indicator of marine presence. In two intermountain areas, Philippi and Vromolimnes basins, in northern Greece marine presence have been proposed after the discovery of marine molluscs. In this paper these areas are re-examined however recent data do not confirm the previous hypothesis of marine presence. In Philippi basin sediments containing marine molluscs were described as "Intermediate Pleistocene Terrace". Investigation of these sediments showed that they are of anthropogenic origin containing among others marine molluscs as food litter. In Vromolimnes basin a Pleistocene marine invasion has been proposed after the discovery of few marine molluscs supported by the high salinity (soil and ground water) and the presence of halophyte vegetation. However, this hypothesis cannot be accepted since the mollusc fauna consists of only 4 mixed species; it includes marine but also fresh water shells which is impossible to naturally co-exist. The shells are possibly of anthropogenic origin because all molluscs are edible and commonly found in many prehistoric settlements. Discovery also of scattered pottery shards in the area further supports the human origin of the molluscs.
For a long time and in many cases the possibility of the presence of molluscs due to human activity was generally underestimated by geologists resulting sometimes into erroneous interpretations of the findings. Overall; deciding the presence of marine environment on the basis of fossil molluscs found into recent surficial unconsolidated sediments should be treated with caution and in this work simple criteria are proposed for this.

Keywords: Marine indicators, mollusks, archaeological strata, geological strata, inland basins

Introduction

The prospecting for palaeoenvironmental indicators, i.e. fossils into the sedimentary strata, in order to determine the depositional environment is a standard practice among geologists (Triantaphyllou et al., 2010; Koukousioura et al., 2012). Fossils of vertebrates or invertebrates, macrofossils or microfossils, are widely used in many cases for the successful determination of the geological age and the depositional environment of the various sedimentary strata. Discovery of fossil marine molluscs is a very strong indicator of deposition of the fossiliferous strata into marine environment and subsequently the verification of marine transgression into an area.
After the determination of the depositional environment of a group of fossiliferous sediments exposed in the morphological relief of an area, valuable conclusions can be obtained for the

palaeogeographical evolution of the area during the geologic time. Even if the area at present is a dry land, a hilly/mountainous terrain or even an intermountain basin, models of significant palaeogeographical and morphological changes of the area, during recent geologic time, can be realistic due to active tectonics.
But discovery of fossil marine molluscs in an area, and especially into the recent sediments is not always a safe indicator of past marine presence.
In this paper the cases of two intermountain basins (Vromolimnes and Philippi) in Northern Greece (Fig. 1), are considered. In both cases fossil marine molluscs were reported and the basins were considered to be connected to the sea during the past.

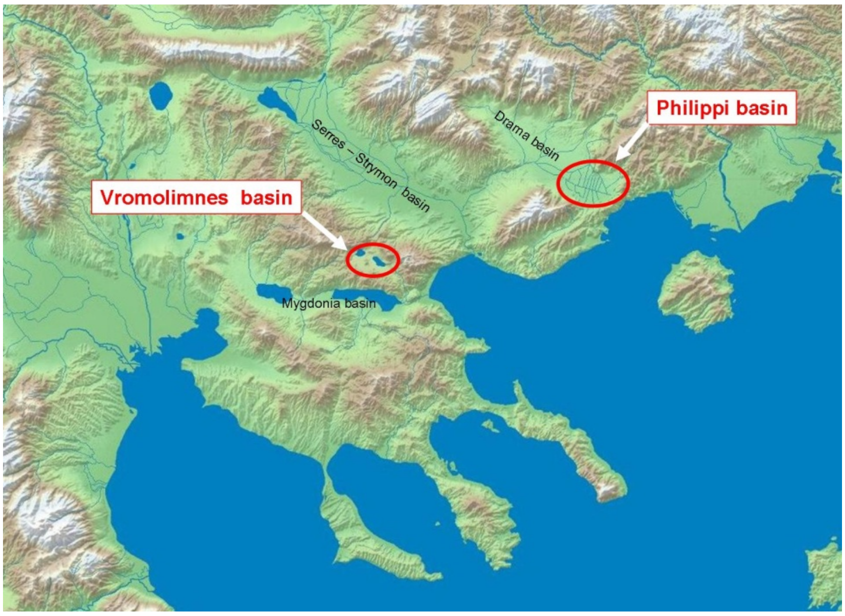


Figure 1: Site areas in northern Greece.

Philippi basin
Philippi basin is situated at the eastern Macedonia and includes the SE part of the broader intermountain basin of Drama, surrounded by Pangeon, Symvolon and Ori Lekanis mountains (Fig. 1, 2). The area was covered by extensive marshlands (Philippi Marshes) that were reclaimed during 1930's; and the area is currently a fertile plain at ~40m a.s.l. Geological prospecting and numerous boreholes determined thick (>100m) strata of peat and lignite into the subsurface of the Philippi basin, that were deposited during Plio-Pleistocene up to Holocene into a diachronic shallow lacustrine to marshy palaeoenvironment.
Melidonis (1966a, 1966b, 1969), was one of major researchers involved with the extensive drilling exploration of the peat deposits by Institute for Geology and Subsurface Research (IGEY), during 1960's. A detailed Geological mapping at 1:20,000 scale was undertaken for the whole area of Philippi basin. The final geologic map that also accompanies the report (Melidonis, 1969) was printed at reduced scale 1:50,000.

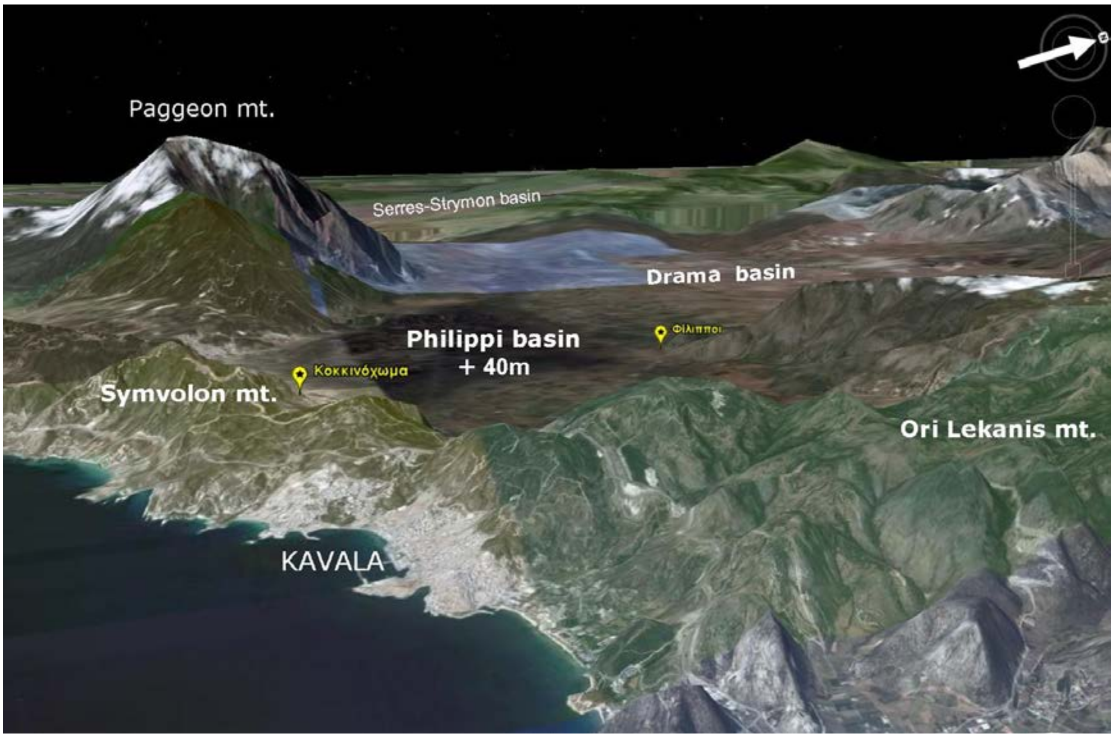
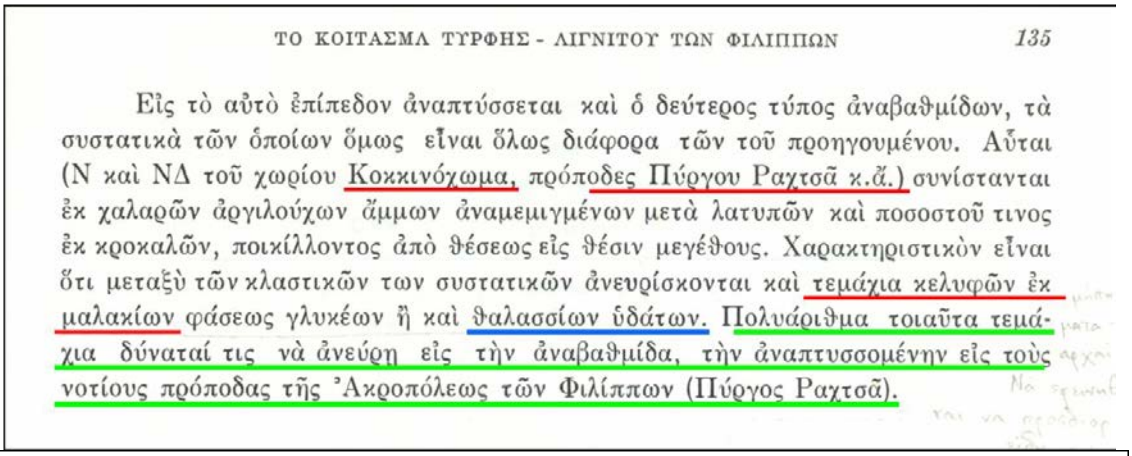


Figure 2: 3D visualization of Drama basin with Philippi basin on the foreground, (image from Google Earth). The places where "Intermediate Pleistocene Terrace" exposes are depicted with yellow pointers, at Kokkinochoma (Κοκκινόχωμα) village, and Filippi (Φίλιπποι).



ΤΟ ΚΟΙΤΑΣΜΑ ΤΥΡΦΗΣ - ΛΙΓΝΙΤΟΥ ΤΩΝ ΦΙΛΙΠΠΩΝ 135

Εἰς τὸ αὐτὸ ἐπίπεδον ἀναπτύσσεται καὶ ὁ δεύτερος τύπος ἀναβαθμίδων, τὰ συστατικὰ τῶν ὁποίων ὅμως εἶναι ὅλως διάφορα τῶν τοῦ προηγουμένου. Αὗται (Ν καὶ ΝΔ τοῦ χωρίου Κοκκινόχωμα, πρόποδες Πύργου Ραχτσᾶ κ.ἄ.) συνίστανται ἐκ χαλαρῶν ἀργιλούχων ἄμμων ἀναμεμιγμένων μετὰ λατυπῶν καὶ ποσοστοῦ τινος ἐκ κροκαλῶν, ποικίλλοντος ἀπὸ θέσεως εἰς θέσιν μεγέθους. Χαρακτηριστικὸν εἶναι ὅτι μεταξὺ τῶν κλαστικῶν των συστατικῶν ἀνευρίσκονται καὶ τεμάχια κελυφῶν ἐκ μαλακίων φάσεως γλυκέων ἢ καὶ θαλασσίων ὑδάτων. Πολυάριθμα τοιαῦτα τεμάχια δύναταί τις νὰ ἀνεύρῃ εἰς τὴν ἀναβαθμίδα, τὴν ἀναπτυσσομένην εἰς τοὺς νοτίους πρόποδας τῆς Ἀκροπόλεως τῶν Φιλίππων (Πύργος Ραχτσᾶ).

THE PEAT-LIGNITE DEPOSITS OF PHILIPPI 135

"In the same level is developed and the second type of terraces, but their constituents are totally different from the previous one. These terraces (S and SW of Kokkinochoma village, foothills of Pyrgos Rachtsa hill) consist of loose clayey sands mixed with angular and rounded pebbles - cobbles varying in size from place to place. It is characteristic that among the other clastic constituents broken shells of molluscs of lacustrine or and marine waters are found. Numerous of these fragments can be found in the terrace developing at the south foothills of Philippi Acropolis (Pyrgos Rachtsa hill)."

Figure 3. Extract from Melidonis 1969, page 135.

Among others Melidonis (1969, page 135) refers the presence of shell fragments from marine and lacustrine molluscs into the sediments of the "Intermediate Pleistocene Terrace" that appears along the margins of Philippi basin (Fig. 3). More specifically two areas are referred:

i) The area south of Kokkinochoma village (Fig. 2, 4 A) and
ii) The foothills of Philippi Acropolis *, (foothills of Pyrgos Rachtsa hill)* (Fig. 2, 5 A).

Elaborating information from the literature

Although no paleontological determinations were made and no other dating was performed, a Pleistocene age is given to the "Intermediate Terrace" that contains marine shell fragments. It is obvious that the broken marine shells are considered as natural constituents of the "Intermediate Terrace" since they are clearly referred into the text (Melidonis, 1969) as well as into the legend of the Geologic map. In this way the presence of broken marine shells is transformed into lithological criteria of recognition-distinction of the "Intermediate Terrace". An indirect argument of a Pleistocene marine regime in Philippi basin possibly resulted after the phrase in page 138:"*in any case no Holocene marine deposits are found*" (Melidonis, 1969). It is very strange also that only in these two places the "Intermediate Terrace" is mapped and nowhere else.

Although Philippi basin have a low altitude (~40m a.s.l.), the so far collected data do not verify any marine presence during Pleistocene-Holocene into the broader area of Drama - Philippi basin. On the contrary all the stratigraphic data (Melidonis, 1969), as well as the natural environment before 1930's reclamations, strongly indicate an extensive and diachronic shallow lacustrine – marshy environment.

But the presence of marine shells into the "Intermediate Terrace" poses a larger question about the origin of these shells as well as the nature and the characters of the "Intermediate Terrace". Careful studying of the Melidonis (1969) text, leaves the impression that this is something that possibly did not originate from natural processes.

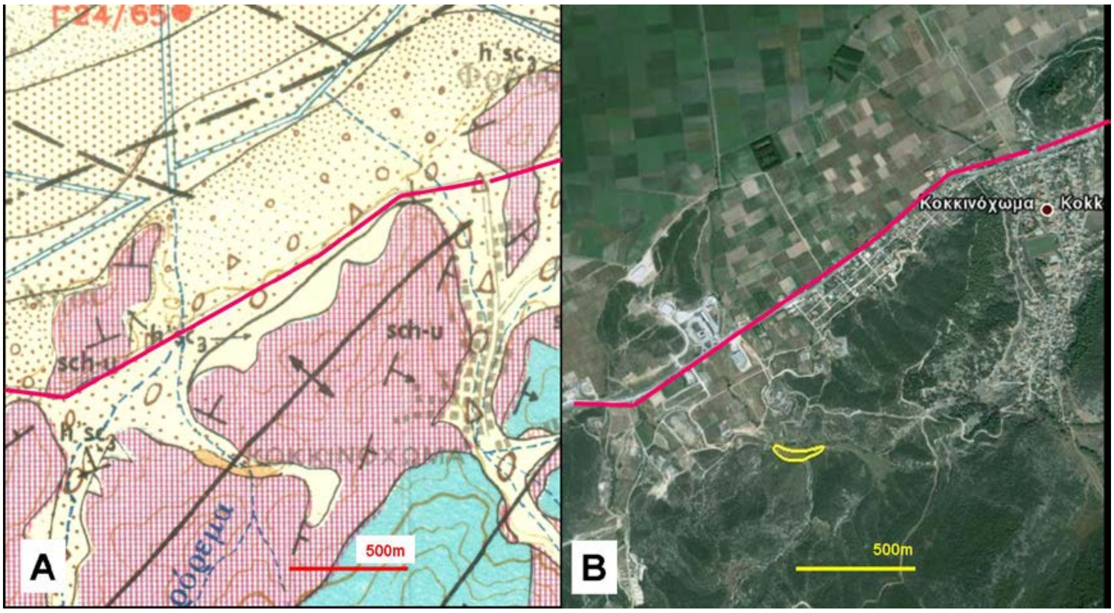


Figure 4: The "Intermediate Terrace" (light brown colour / yellow outline) in the area of Kokkinochoma village (**A**: extract from Melidonis (1969) map. **B**: image from Google Earth). Red line depicts the asphalt road.

Field work

Geological reconnaissance was carried out in the two areas: i) Kokkinochoma village, ii) ancient Philippi.

Kokkinochoma village

The investigated area is situated ~1km SW of the village where "Intermediate Terrace" was located (map of Melidonis, 1969) (Fig. 2, 4). No terrace morphology was observed, but a mixture of clastic material (brownish silty clayey sands with gravel and pebbles) cover the area. Few small fragments of marine shells were spotted on the ground surface. But these shell fragments are not included into the "Pleistocene" sediments; on the contrary they appear into younger debris covering the "Pleistocene" sediments. They mainly consist of fragments of the edible bivalve *Cerastoderma glaucum* and in some places are accompanied by pottery fragments; so they must be considered as human food litter of older (prehistoric?) time. In any case they are almost certainly human relicts and not natural sediments.

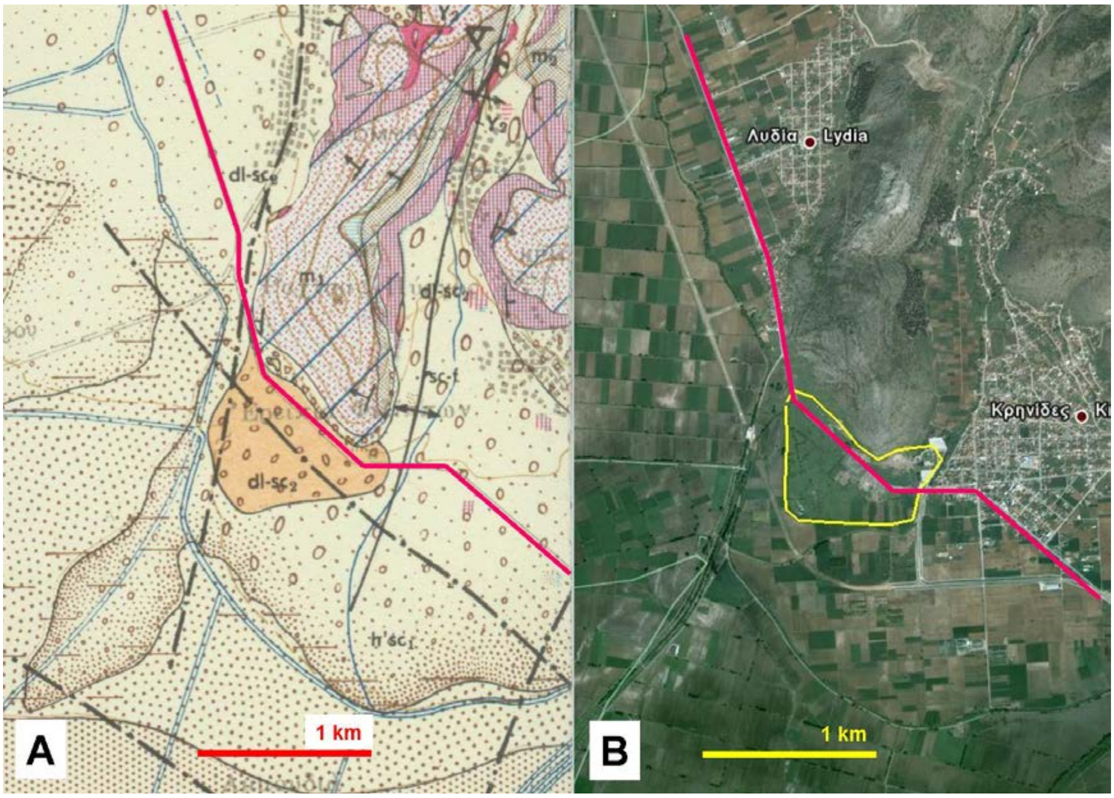


Figure 5: **A.** The "Intermediate Terrace" (dl-sc_2) in the area of ancient Philippi (extract from Melidonis (1969) map), **B.** The ruins of ancient city of Philippi (yellow outline depicts city walls), (from Google Earth). Red line depicts the asphalt road.

Ancient Philippi

The area along the foothills of Philippi Acropolis (*Pyrgos Rachtsa hill*) was also investigated.

A large amount of clastic material cover the area; but these deposits although originating from scree and alluvial debris are strongly intermixed with human debris containing, among others, fragments of pottery, bones and marine shells. These sediments have a significant expansion throughout the area of ancient Philippi city ruins. A simple comparison between the mapped area of "Intermediate Terrace" and the ruins of the ancient city of Philippi indicates an almost perfect matching (Fig. 5 A, B). In this case it is obvious that although these sediments are anthropogenic (they comprise archaeological and not geological strata) they were mistakenly considered as natural sediments characterized as "Intermediate Terrace".

Vromolimnes basin

The area of Vromolimnes includes a small, closed, endorheic intermountain basin situated at 350m asl, between the mountains of Volvi – Vertiskos – Kerdyllia (Fig. 1, 6). Morphologically is separated into two smaller sub-basins, where two small shallow lakes named Lantza and Mavrouda, exist. Until 1950's the area was endorheic and was draining towards the two lakes (Vavliakis and Sotiriadis 1979).

Extensive reclamations during 1950-1960 resulted into the draining of the lakes. A network of deep (up to 20-35m) trenches were dug out, draining the waters from Mavrouda lake towards the Lantza lake and then through Kerasias Rema torrent to Volvi lake (Vavliakis and Sotiriadis 1979).

Among others, one of the peculiar characteristics of the area is the high salinity of the soil and the ground water, in the areas of the two lakes, that causes serious cultivation problems in the reclaimed areas (Psilovikos, Vavliakis and Sotiriadis, 1979). Another characteristic is the presence of an extensive natural vegetation of halophytes (Babalonas et al., 1980).

Several publications exist for the area mainly from the academic staff from the Department of Geology of the Aristotle University of Thessaloniki: Psilovikos (1977), Psilovikos, Vavliakis & Sotiriadis (1979), Sotiriadis, Psilovikos & Vavliakis (1979), Soulios & Dimopoulos (1984).

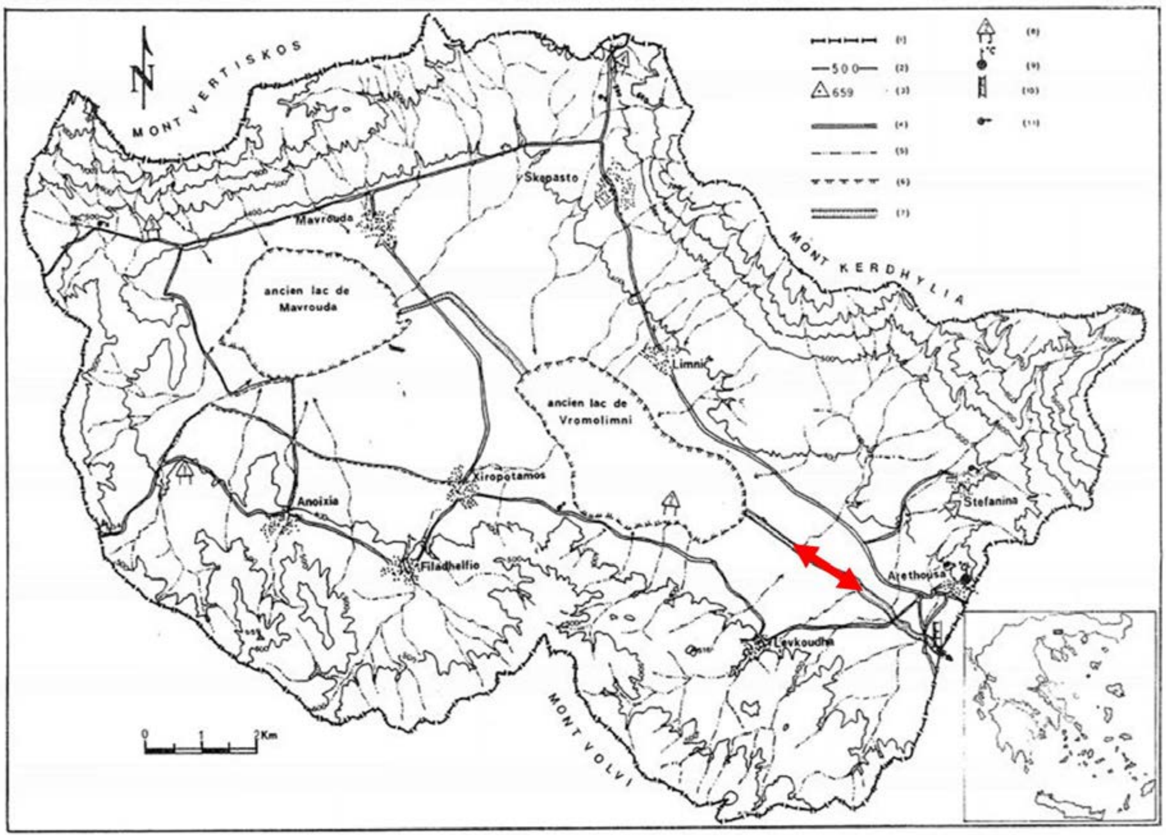


Figure 6: Drainage network of Vromolimnes area, double arrow depicts the deep drainage trench of Lantza (after Soulios & Dimopoulos, 1984).

The study of Psilovikos, Vavliakis & Sotiriadis, (1979) is the first to present the stratigraphy of the sedimentary sequence of the basin (Fig. 7) that is divided into:

- *Lower system of redbeds*
- *Upper system of clayey sands-sandstones*

Τὸ ἀνώτερον σύστημα τῶν ἀργιλλοψαμμιτῶν κατέχει τὴν κεντρικὴν περιοχὴν τῆς λεκάνης μὲ πάχος ὑπερβαῖνον τὰ 70 m εἰς τὰς περιοχὰς τῶν τέως λιμνῶν Μαυρούδας καὶ Λάντζας. Πρόκειται περὶ ἐναλλαγῶν, λιμναίων, θαλασσίων λιμνοθαλασσίων καὶ ποταμοχειμαρρίων ἰζημάτων εἰς στρώματα μὲ φακοειδῆ καὶ σφηνοειδῆ πλευρικὴν ἀνάπτυξιν (σχ. 4).

Σχ. 4. Σχηματικὴ συνθετικὴ τομὴ κατὰ μῆκος τοῦ μεγάλου ἄξονος τῆς λεκάνης τῶν Βρωμολιμνῶν. 1. Ὑπόβαθρον, 2. Ἐρυθροστρώματα (Κατώτερον σύστημα), 3. Ἀργιλοψαμμῖται (Ἀνώτερον σύστημα).

Ἰλὺς καὶ ἄργιλος πλαστική, τυρφώδης εἰς τὰ βαθύτερα καὶ πρασίνη εἰς τὴν ἐπιφάνειαν, μάργα ἀσβεστοῦχος πρασινοκιτρίνη καὶ ἄμμος λεπτόκοκκος ἀνοικτότεφρος - κιτρίνη ἐντὸς τῆς ὁποίας εὑρέθησαν θανατοκοινωνίαι Unio, ἀποτελοῦν ὑλικὰ τὰ ὁποῖα ἀπετέθησαν εἰς περιβάλλον λιμναῖον - λιμνοθαλάσσιον ἢ θαλάσσιον.

The upper system of clayey sands-sandstones occupies the central part of the basin with thickness exceeding 70m in the areas of the former lakes Mavrouda and Lantza. They comprise alternations of lacustrine, marine lagoonal and fluvial sediments forming lens shaped layers with lateral edging up (fig. 4).

FIGURE

Fig.4. Schematic synthetic cross section along big axis of Vromolimnes basin. 1. basement, 2. redbeds (Lower system), 3. clayey sands-sandstones (Upper system).

Silt and plastic clay, more peaty downwards and greenish at the surface, greenish-yellow calcareous marl and light yellow fine sand containing Unio thanatocenosis, represent materials deposited into lacustrine-lagoonal or marine environment.

Figure 7: Stratigraphic data of Vromolimnes (after Psilovikos et al., 1979, page. 367).

A simplified synthetic stratigraphic section of the Vromolimnes area is presented at page 367 of this paper (Psilovikos et al., 1979); as well as the discovery of marine, lagoonal and lacustrine bivalves (lamellibranchiata) into the *Upper system of clayey sands-sandstones*, is referred (Fig. 8).

Γενικῶς τὰ ὑλικὰ τοῦ ἀνωτέρου συστήματος εἶναι χαλαρὰ καὶ ἐντὸς αὐτῶν εὑρέθησαν τὰ ἀκόλουθα ἐλασματοβράγχια :

Donax verustrus	θαλάσσιον
Spondylus gaederopus	θαλάσσιον
Cardium edule	θαλάσσιον - λιμνοθαλάσσιον
Unio	γλυκέων ὑδάτων (λιμναῖον)

Εἰς τὴν περιοχὴν τῆς τέως λίμνης Λάντζας χαρακτηριστικὴ εἶναι ἡ παρουσία ἁλοφύτων (ΜΠΑΜΠΑΛΩΝΑΣ κ. ἄ., ὑπὸ δημοσίευσιν) ἐνῶ ἐμετρήθη καὶ ἁλμυρότης ὑψηλοῦ βαθμοῦ αὐξανομένη μετὰ τοῦ βάθους (Υ.Ε.Β. - Συμεωνάκης), ὅπως φαίνεται εἰς τὸν ἀκόλουθον πίνακα :

Generally the materials of the Upper system are unconsolidated and inside them the following lamellibranchiata were found:

Donax verustrus	*marine*
Spondylus gaederopus	*marine*
Cardium edule	*marine – lagoonal*
Unio	*fresh water (lacustrine)*

In the area of the former lake Lantza it is charachteristic the presence of halophytes (BABALONAS et al., in press) while high values of salinity were measured increasing with depth (YEB – Symeonakis), as shown on the following table:

Figure 8: The discovered mollusc fauna (after Psilovikos et al., 1979, page. 367).

Based on the high salinity of soil and ground water, on the presence of halophytes, but mainly on the finding of marine molluscs (determinations by E. Georgiades – Dikeoulia Athens University), a marine entrance in the area and a subsequent palaeogeography were proposed (after Psilovikos et al., 1979, page 369) that can briefly summarized as follows:

- During Lower Pleistocene the sea enters into the area of Vromolimnes forming an estuary or a lagoonal environment that is affected by the fluctuating climatic conditions. As a result successive layers and lenses of lacustrine, marine, lagoonal and fluvial sediments were deposited.
- During Upper Pleistocene the area was uplifted, communication with the sea was interrupted, and a close basin was formed.

Figure 9: 3D visualization of Vromolimnes basin with Strymon-Serres and Mygdonia basins in the vicinity (Google Earth).

Elaborating information from the literature

If we compare the area of Vromolimnes basin with the neighboring basins of Strymon-Serres and Mygdonia (Fig. 9) a paradox rise: In a small closed, endorheic, intramontane basin, situated at 350m asl, a marine entrance during Pleistocene is proposed, while at the two other larger basins situated at lower altitudes (Strymon-Serres 5m asl; Mygdonia 30m asl) no marine entrance during Pleistocene have been traced, although these basins are in almost direct contact with the sea.

Discussing all the above we can focus on the following:

- Halophytes are growing up in areas with high salinity (Babalonas et al., 1980).
- High salinity of an area does not necessarily indicate that the area was once upon a time connected to / or affected by the sea.
- In non carstic, closed, endorheic, intramontane basins located at low or mean latitudes high salinity is expected. In these areas surficial runoff concentrate in the deepest part forming a seasonal lake. Climatic conditions and evaporation can result to complete drying up of the seasonal lake (playa). The rain water slowly washes very small amounts of salts from the rocks of the area, that are finally transported and deposited after evaporation in the seasonal lake. This procedure can diachronically accumulate large amounts of salts and increase considerably the salinity of the area (Hammer, 1986; Bridge and Demicco 2008).

The basin of Vromolimnes fits exactly the above model; a non carstic, closed, endorheic, intramontane basin consisting of impermeable hard crystalline rocks (mica schists, gneiss, amphibolites), surficially drained to the small lakes of Lantza and Mavrouda.

The published mollusc fauna (Fig. 8) includes 4 bivalves with the following characters:

- *Donax venustus*: Marine bivalve, soft bottom dweller, lives into sandy bottoms, edible.
- *Spondylus gaederopus*: Marine bivalve, unequivalve with considerably thick shell, rocky bottom dweller, and lives cemented with one valve on rocky substrates, edible, greatly used by prehistoric man as raw material for artifacts and ornaments (rings, pendants, bracelets, etc.) (Syrides, 1992).
- *Cardium edule*: Marine – Lagoonal, soft bottom dweller, lives into sandy bottoms at small depth ~0.5m, very common and in large numbers, as food litter, in prehistoric settlements. The old name *Cardium edule* is replaced by *Cerastoderma glaucum.* (Syrides, 1992).
- *Unio*: Fresh water bivalve, epifaunal dweller of sandy bottoms in lakes and rivers, edible. Common food remnant in prehistoric settlements situated near lakes and rivers. Interior of the shell is pearly and in many cases was used for artifacts. (Syrides, 1992)

Remarks:

The above fauna is extremely poor in genera and species; only 4 are present. Ecologically the fauna is completely heterogenic; it includes genera and species living in different environments (marine, lagoonal, lacustrine) and habitats (sandy bottom, rocky substrate). It is practically unrealistic to suppose that this entire fauna coexists naturally in the same geologic layer. Consequently, serious questions about the natural origin of this fauna rise. Further it has to be noted that the fauna includes only edible molluscs that are commonly found in prehistoric settlements.

It was clarified (Psilovikos & Vavliakis, personal discussions on 1998), that these mollusc shells were collected from the upper part of the sections of the deep trench of Latza (Fig. 6); "*the shells were not many, they were all found in the same dark gray bed*".

Field Work

Field reconnaissance of the deep trench was carried out, during the spring of 2009, in a length of 1.500m where the deepest sections are exposed. Although the sides of the sections are now covered by vegetation, in many places clean parts allow observation of the stratigraphy.

The dug out debris of the trench were piled along both sides of the trench and long mounds were formed, increasing height of the trench. The mounds are continuously washed by rain water while in many places recent quarrying leaves fresh sections (Fig. 10 A, B). Intensive prospecting along the excavated sections of the trench did not reveal any fossiliferous layer and no fossil molluscs were found. Investigation was focused also on the excavated debris since if a fossiliferous layer existed, then the mixed debris should contain scattered fossils.

Rain washed debris offers a good chance for a quick and representative prospecting for the contained materials. No shell or shell fragments of any mollusc (except land snails) were found but on the contrary few scattered pottery fragments were spotted, one of them into a large lump of dark gray-blackish loamy sediment (Fig. 10 C, D, E). As mentioned before the mollusc shell fauna reported in Psilovikos et al. (1979), originate from the upper part of the trench sections (=younger beds) so combining this with the finds of pottery shards it is possible that all these originate from a younger layer which actually hosts the relicts of human activity (occupation layer). A realistic hypothesis is that in this area a human occupation existed (prehistoric settlement?) that was practically destroyed after the extensive excavations for the deep trench of Lantza.

The quest for fossiliferous layers was expanded to the rest of Vromolimnes area but no fossil molluscs were found.

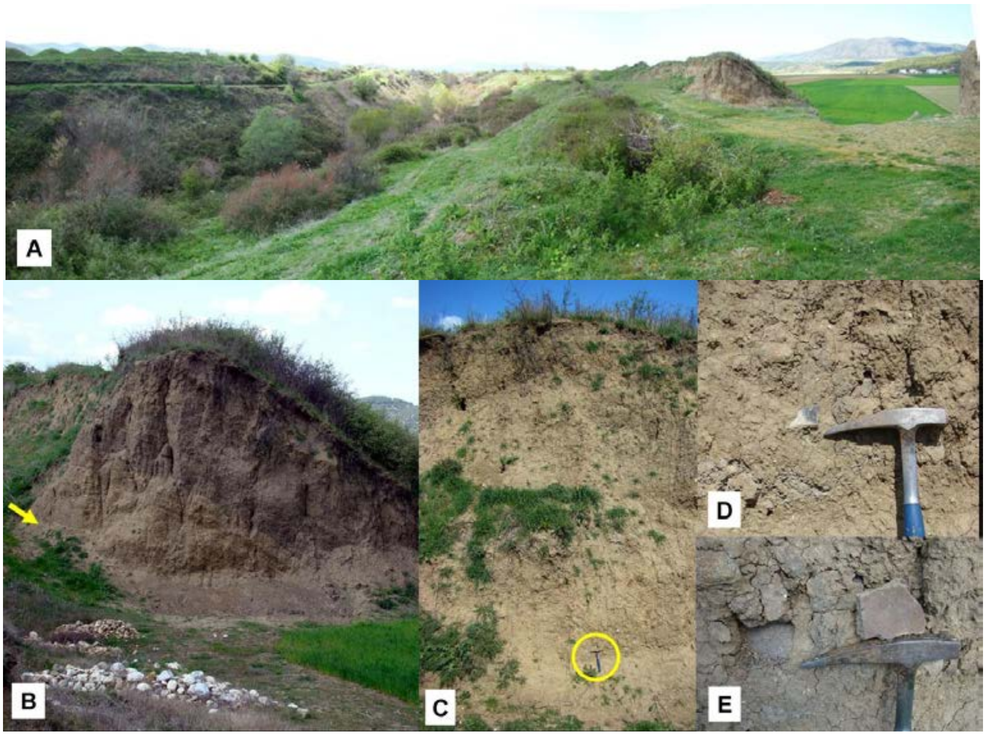


Figure 10: **A.** The drainage trench of Lantza (view westwards). **B.** Mound from the dug out debris (quarried). **C-E.** Scattered pottery fragments in the mound debris.

Human leftovers of marine molluscs into recent sediments

Human intervention in the natural environment began thousands years ago, since prehistoric times. Human influence is minimal, in the early times but diachronically increases and gradually the man changes the environment. Human activity can change the morphology of an area, and is also reflected by the various remnants left by man. As it is reported in this work it is clear that the influence of the human activity on the recent sediments is a factor that was underestimated in older geological studies.

Human occupation in an area leaves many remnants that are accumulated and included/embedded into the "occupation layers". These layers are the byproduct of human living into an area; they consist of disturbed soil and sediments of the area moved by the man. All the remnants of human activity like: food litter (bones, shells, seeds…), pottery shards, stone tools, bone tools, wood, charcoal, building material (stones, mud bricks, clay) are included in small or large amounts into these layers. Thickness and lateral expansion of these layers varies. In many cases, thickness is considerable resulting to the forming of small or large artificial hills (typical examples are the Prehistoric toumbas / mounds / magoules), reflecting the long time of human occupation. But in many other cases these layers are thin, restricted in expansion and poor in human litter; in these cases, it is difficult to be recognized and distinguished from the neighboring natural sediments.

In any case it is self-evident that materials, e.g. marine shells, included in these sediments do not necessarily reflect any physical process and must not be used as paleoenvironmental indicators, otherwise erroneous interpretations can result.

Synthesis of the edible mollusc faunas that are found in areas (settlements and layers) of prehistoric human occupation, are in direct linkage with proximity and plentitude of the source areas (Syrides 1992, 2005). In areas near or close to the sea marine shellfish prevails, while faraway from the sea and close to rivers and lakes fresh water mollusc shells are abundant. Exceptions of this rule are shells collected for artifacts and ornaments (eg. *Spondylus, Glycymeris*) that are transported in great distances, even hundreds of km, away from the sea (Syrides, 1992).

The edible mollusc faunas of prehistoric sites are originating from nearby sources. Although these remnants could be found mixed into middens, the various shells reflect the different habitats and areas of collection. Along sandy coasts the soft bottoms dwelling genera are prevailing: *Venus, Donax, Solen – Ensis, Callista, Tellina, Tapes, Pinna, Murex bradaris, Cerithium,* etc. While at rocky coasts and substratums genera like *Arca, Spondylus, Ostrea, Mytilus, Patela, Murex trunculus,* etc. Appear (Syrides, 1992). Among various prehistoric settlements situated near the sea, shells of the bivalve *Cerastoderma glaucum* (= *Cardium edule*) are a very common food remnant (Syrides, 1992). This is a marine species but with considerable adaptation to brackish or low salinity waters. It lives in dense populations into shallow (~0.5m) silty- sandy bottoms of sheltered shallow bays, lagoons, close to river deltas. Due to its abundance it was gathered and consumed in huge numbers by prehistoric man; as a result in many places *Cerastoderma* shells are the main constituent of shellfish food litter. For example in two prehistoric settlements close to Thessaloniki VASILIKA-II and THERMI B, *Cerastoderma glaucum* represents 95% and 82% of shell litter respectively (Syrides, 1992). More precisely in VASILIKA-II *Cerastoderma glaucum* includes 1.360 shells from 1.434 in total, and in THERMI B includes 6.647 shells from 8.319 in total. In some cases shell middens are so thick that "Shell Layers" were formed.

Anthropogenic or natural origin? Criteria for distinction

What a geologist should take care in the field in order to determine the origin of the mollusc shells that have just found into younger, unconsolidated, surficial sediments and avoid any misleading? Some simple criteria for this are included in TABLE I.

A natural fossiliferous layer usually contains numerous shells of a rich, in genera and species, mollusc fauna as well as abundant microfossils. The fauna includes shells of various sizes reflecting ontogeny (embryonic-juvenile-immature-mature shells) of the majority of the species. Synthesis of the fauna is homogenous indicating specific environment (eg. marine or freshwater) and habitat (eg. silty or gravelly bottom). Along the exposure of a fossiliferous layer fossil mollusc shells are regularly included, while structure and bedding reveal the same environment with that fauna indicates.

An anthropogenic layer contains shells of marine molluscs that are mainly food litter. Since these molluscs are man gathered, the fauna is expected to consist of edible genera and species having a specific or larger shell size due to selective collection.

It is usual that man gathers shells from different areas and environments; as a result their disposed remnants form mixed heterogenous faunas. Finally the shells are embedded into the anthropogenic layers together with pottery shards, bones, charcoal, etc. These layers (occupation layers) consist of a mixture of human byproducts and debris having a chaotic or incompatible with natural processes internal structure.

Greece and the broader Aegean region, is an area with intense prehistoric occupation. The extended long jigsaw coastline of Aegean resulted to a close contact of the prehistoric man with the sea as food source. This is reflected to the large amounts of shellfish litter found in many settlements. One of the most common marine shells found in prehistoric sites situated close to the sea is *Cerastoderma glaucum*. It has a hard solid ribbed shell, durable through the time even if it is exposed on the surface. It can be easily recognized, even from small fragments, due to the characteristic ribbed external decoration. Personal experience of the author suggest that in many cases the shells and fragments of *Cerastoderma glaucum* found on the top soil or into soft surficial sediments are associated to human activity.

<u>Hint</u>: in the case of suspicion about the origin of the marine mollusc shells, you had just found, look for a simple and easy recognizable first criterion: <u>Pottery shards</u>

TABLE I. Criteria to distinguish natural and anthropogenic strata containing molluscs.

Characteristics	Natural strata	Anthropogenic strata
Synthesis of fauna	Homogenic - indicating the same habitat	Heterogenic – mixed, coexisting of species from totally different environments and habitats
Number of genera & species	Large	Small, specific species
Are all molluscs edible?	NO	YES
Shell size	All sizes (small to large) reflecting ontogeny	Mainly large size (hand gathered)
Presence of genera & species with very small shell	YES	NO
Presence of microfossils in the sediment	YES, numerous, same environment with the other molluscs	NO, and if found they are few, accidental presence characterizing totally different environments
Bedding and sedimentary characters of the sediments that contain the molluscs	Bedding and characters reflecting the same environment with the molluscs	Chaotic or massive bedding containing various heterogenic materials, in case of vestigial bedding structure and texture are completely different from the natural one
Presence of anthropogenic materials: pottery, bone, charcoal, burned molluscs, etc.	NO	YES numerous

Conclusions – Results

In Philippi basin the presence of marine mollusc shell fragments was confirmed in two places: at Kokkinochoma village, and at the foothills of Philippi Acropolis. In both cases they did not reflect any natural process, but comprise older human food litter of edible molluscs. The "Intermediate Pleistocene Terrace" in Melidoni's map is not of natural origin, but consists of anthropogenic debris covering the large area of ancient Philippi city ruins.

In Vromolimnes basin the proposed, 30-years old, theory of sea entrance during Pleistocene is not confirmed. The past theory was based in the presence of marine molluscs, the high salinity of soil and ground water, and on the presence of halophytes.

After extensive field work no fossiliferous layers were located and no marine mollusc shells were found, that could support a marine entrance. The published "marine" mollusc fauna is a completely heterogenic fauna including only 4 species that is not possible to coexist in nature. There are strong indications that these molluscs originate from human-occupation layers, after the discovery of scattered pottery shards into the dug out debris of Lantza's trench. The extensive excavations of Lantza trench obviously destroyed any relic of such layers. High salinity of soil & ground water (used as a strong argument for marine entrance)

can be clearly explained as a diachronic naturally evolved phenomenon due to the endorheic drainage pattern of the basin. Evolution of halophytes in the area resulted after high salinity.
For a long time and in many cases human influence / intervention in nature was totally ignored or underestimated by researchers. As a result erroneous opinions were proposed and considerable mistakes were done.
In any case of discovering fossil molluscs into recent surficial unconsolidated sediments, before using them as palaeoenvironmental indicators, special care should be taken to carefully check their origin. Simple criteria are proposed for this (Table I)

Epilogue

The question of marine presence into the basin of Vromolimnes follows the author since 1985, as a Ph D candidate supervised by by Prof. Antonis Psilovikos. During the endless discussions and opinion exchange with Antonis and Prof. Leftheris Vavliakis for various research subjects, among others, the first uncertainty about the marine presence in Vromolimnes was expressed. The years after the discussion on this remained inactive. The last decade this discussion slowly reactivated; new opinions about a new common methodic scientific approach after the recent knowledge and improvements on the study of palaeoenvironmental, paleontological & archaeogeological subjects were expressed. It became acceptable by the colleagues that a re-investigation and a possible re consideration of their previous opinions should be undertaken in a common joined research. But life makes her own decisions; Antonis and Leftheris passed away on November 13th 2006 and December 7th 2006 respectively.
This article is dedicated to their memory; a minute acknowledgement for their contribution on the geological and physicogeographical study of Macedonia and Thrace

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