Boeotian landscapes. A GIS-based study for the reconstruction and interpretation of the archaeological datasets of ancient Boeotia.
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Appendix III

Fluctuating landscapes: the case of the Copais basin

The morphology of Boeotia is characterised by a series of valleys originating from tectonic depressions generically oriented NW-SE, surrounded by two types of carbonate relief: massifs of limestone and dolomitic limestone of Lias-Trias, which reach considerable heights (Parnassos, Helicon) concentrated mainly to the S-SW, and lower reliefs that hardly reach 1000m height, characterised by alternation and sovrapposition of limestone, sandstone and chert of Jurassic and Triassic, marl, sandstone and pliocene conglomeration, and pleistocenic sediments, whose materials, through erosion processes, form the sedimentary deposits of the valleys: pleistocene-holocene fluviolacustrine sediments.
Karstic landscapes are frequent in the region, with several open or closed *polje* (called by the Slovenian word, i.e. basins without superficial drainage). The classical karstic landscape is characterised by a poor superficial hydrography and by a well developed subterranean hydrography. This has always conditioned the life of human communities, both as far as water availability in general, and as far as soil fertility and concrete possibilities for cultivation of the land.

In this article I will describe the water behaviour of the Copais basin and present the results of the digital reconstruction of the water level fluctuations, as well as the effects the differences in water behaviour would have had on past communities gravitating to the lake. With this aim, I will illustrate the contribution of historical geography as well as of computer modelling, of historical and epigraphical sources as well as of palaeoenvironmental studies, of 'historical hydro-engineering' work, as well as of modern hydrogeological studies.

THE KARST

Generally speaking, the constitutive elements of the karstic[1] landscape are forms created by the dissolution of rock in natural water. In such an environment erosive processes dominate due to the dissolution of mainly calcareous rocks. Limestone is calcium carbonate ($CaCO_3$), impure to a greater or lesser degree. Carbonate is soluble in water rich in carbon dioxide (CO_2). Carbonate rocks are not very permeable, but fissurate; water runs through breaks in the rock and opens paths of subterranean circulation. Differences in the process of dissolution, due to different factors related to rocks, water and climate, cause large variability in the karstic landforms, both above and below ground. Among the major surface landforms are the poljes.
Poljes can be defined as closed features of large area (often kilometres – the Slavic word *polje* means 'open fields'). The polje, in its typical form, appears as a large depression flat and horizontal, surrounded by relatively steep slopes and with the angle between the two surfaces generally abrupt. It is usually characterised by the

[1] From Slavic *karst* = rock.

presence of openings of subterranean natural channels –*katavothrai* in greek- at the edge. In the 'active' polje, the deepest ground becomes flooded seasonally, when the *katavothrai* cannot drain all the water collected in the basin. In the wet season some *katavothrai* can even produce an inversion in the hydrologic cycle and become springs (*katavothra*-springs). This phenomenon often leads to the formation of a 'karst pond'. The climate and the extension of the hydric basin, the water-feeding from water-bearing stratum, the number and capacity of the *katavothrai*, the layer of fluviolacustrine impermeable sediments in the lower part of the basin, could all lead to the formation of a perennial lake, subject to seasonal and annual fluctuations, often of great extent. The presence of water with periodical flooding which erode and drag the incoherent sediments, limits the permanent laying of detrital deposits at the foot of the slopes, even though we have a considerable presence of alluvial cones or cones of detritus.
The slopes around the basin are marked by the presence of caves, which are the typical morphology resulting from karstic erosion.

In order to understand the karstic phenomena in a region, we must understand its hydrogeological characteristics.
In particular, in considering the geological formations prevalent in Boeotia and their hydrogeological characters, we can isolate three principal aquifers in the region:
1) calcareous and calcareous dolomite aquifer, formed by limestone and dolomitic limestone complex with a medium or high fissure and karstic permeability, characterised by a relatively deep and powerful subterranean hydraulic circulation. The flow of the springs of this aquifer is about 100 to 1,000 litres per second;
2) gravel-silt-sand aquifer, formed by deposits of fluviolacustrine detritus complex with a variable porous permeability, characterised by a not very deep subterranean hydraulic circulation, located primarily in the cones of dejection or in the lacustrine delta. The flow of the springs is only few litres per second, unless they are also fed by the water-bearing strata of the calcareous complex;
3) sandstone-marl, limestone-marl, clayey-schistose aquifer (limestone-marl sandstone-marl-clayey complex) with a medium-low or absent fissure and porous permeability, characterised by a poor subterranean hydraulic circulation. The flow of the springs is few litres per minute.

Two poljes in particular can be considered good examples for illustrating the Boeotian karstic landscape, and play an important role in the history of the region: the Copais basin, which can be considered the largest polje of Greece (and the Balkan area) and one of the major poljes in the Mediterranean area; the Domvraina valley, to the SE of the Copais basin, which is a large closed polje at the foot of Mt. Helicon, to which gravitated the ancient city of Thisbe[2].

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[2] For Thisbe *polje* and ancient attempts of drainage see Knauss 1992. The Domvraina *polje* is illustrated in chapter II.3.10.

THE COPAIS[3]

In the Copais basin, the history of the landscape can be seen as strongly marked by the presence of the large marshy lake until its total drainage at the end of the 19th century. The large marshy lake was subjected to continuous, and often strong, level fluctuations, within a hydric basin having an extension of ca. 1900 sq. km. The dry land extension therefore fluctuated accordingly. The settlement history of the area can be seen as influenced and affected by the relationship between communities gravitating towards the basin and the water element, their perception of the environment and their life in it. Factors of different natures would have influenced, directly and indirectly, the life of human communities gravitating towards the Copais through time. Also, human impact, mainly through attempts to at least partially drain the basin (in different periods of history, e.g. Mycenaean and Hellenistic/Roman times) to gain land for agriculture, would have influenced the evolution of the eco-dynamics in different ways and at different levels in the diverse historical periods. The reconstruction of the lake/marsh behaviour (the source of a parallel economy as well as of disease) would help to better interpret and evaluate the available archaeological record (for management purposes also), and would throw light on the relationship between human settlement and communities and the wet environment, as well as the human eco-dynamics in the area in the various periods.

The present study takes into account the geomorphological and palaeoenvironmental studies carried out in the area, as well as the known historical data, and implements a dynamic digital reconstruction of the lake fluctuations, in order to better evaluate and analyse the available archaeological evidence.

Geomorphological and palaeoenvironmental studies

The Copais basin can be described as a tectonic depression of ca. 350 sq. km. It is part of a very large karstic circulation system which, along with the Copais itself, encompasses the lakes of Yliki and Paralimni[4], to the E of the basin, up to the Euboean gulf. Drained completely a century ago, and now cultivated, the Copais is a plain which was in the past occupied by a marshy lake probably never deeper than 3-4m, and invested by strong seasonal and annual fluctuations, which influenced the actual conditions as well as the perception of the marshy lake limits[5].

The basin was completely drained at the end of the 19th century. Drainage works, conducted by a French company, started in 1883, and then continued from 1889 by an English company[6]. Essentially, in order to improve the drainage of the water of the basin, they created a new opening: water from the Kephisos was diverted into a gallery in the Karditsa bay, to Lake Likeri, then Paralimni, then the sea. Water from the Melas was partially canalised for irrigation and partially drained into the *Megali Katavothra* in the NE bay (Pritchett 1969: 89ff; H. Kalcyk-B. Heinrich 1989: 56).

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[3] The landscape of the Copais is illustrated separately in this appendix, while other lake or *polje* areas are included in individual *chorai* chapters. This is due to the fact that the Copais area (including the basin surroundings) includes more *chorai* and micro-regions and involves more micro-regional dynamics.

[4] For the hydrological behaviour of Yliki and Paralimni lakes, see chapter II.1.

[5] Philippson 1951: 466 remarks that in the SW it is uncertain where the lake finishes and according to the line one accepts the basin can be either 300 or 350 sq. km.

[6] The history of the drainage is summed up concisely by Iakovidis 2001. See also Knauss et al. Kopais 1. The lake was ca. 200 to 220 sq. km.; 190 sq. km. of it was drained by the Copais company (Philippson 1951: 470 from their documents).

Attempts at draining the basin are known also from antiquity, from Prehistoric times onwards (see below).

The hydric basin covers ca. 1900 sq. km. The major superficial water feeding is from the Kephisos and Melas rivers from the W, and a series of small rivers that enter the plain from S, among which the Probatia/Herkyna, Phalaros/Pontsa and Lophis can be mentioned (see fig.4). These rivers surely contributed in the past, before the drainage of the basin, to create marshy areas on the southern and western borders of Copais, and probably increased the seasonal fluctuation of the lake. Philippson notes in particular that these rivers frequently ended in marshes (Philippson 1951: 473 – Herkyna[7], Pontsa[8], and other streams[9]).
The water courses, in particular the two main rivers (Kephisos and Melas), emptied themselves into the plain, before being canalised by the ancient and (mainly) modern drainage works, and the natural outlet had been ensured through time by more than 20 *katavothrai*, located along the NE edge of the basin (from the village of Pyrgos to the Onchestos pass), which alimented the subterranean water circulation system towards lake Yliki and the sea (Philippson 1951: 476). The natural outlets of the two rivers can be still recognised today in the NE bay, in the area between modern Kastron (ancient Copai) and the *Megale Katavothra* (at Agios Ioannis) (Knauss 1987; Kalcyk & Heinrich 1989). Philippson (1951: 476-478) describes the types and characters of the Copais *katavothrai* and the dynamic of the natural drainage of the basin: they are all *Wand Katavothren*, caves or fractures formed by water action in the abrupt limestone rock. The water that flows into the *katavothrai* appeared partially as *kephalaria* (= karstic springs) at some points outside the basin, such as at Larymna and Skroponeri or beneath the sea. There are also springs in the Copais basin[10]. While at present one of the key elements of the drainage[11], in the past the Kephisos river did not work as a 'regulating factor' of the lake's fluctuations.
On the basis of our knowledge of the deposits present in the plain and in the surrounding areas and on the sedimentation processes, it can be hypothesised that the directions of water outflows, both superficial and underground, were, at least in the last 20,000-30,000 years, in some ways similar to the modern ones, even if having differences related to the karst hydrology and to the definition of the principal valleys. Morphology confirms this scheme, as also pointed out by Philippson, while examining the relationships between the Copais basin and the Theban plain and areas

[7] The Herkyna, the river of Levadeia, S of the Hyppia plain turned and ended (together with the water of the Kalamaki spring) in a marshy zone that extended to the W of the Copais lake water, by the modern villages of Ag.Dimitrios for ca. 5 km. up to the foot of Laphystion near Rachi (Philippson 1951: 473. For the marshy area near Rachi see below and fig.4 and chapter II.3.1). This marshy area formed a dangerous area between the plain of Kephisos and the plain to the S edge of the basin, through which the main road ran. This marsh probably played host to the battles of 85 BC - Mitridates *versus* Silla - and 1311 - Frankish cavalry *versus* Catalan soldiers (Philippson 1951: 473).
[8] The Pontsa river forms a delta in the middle of which lies today the village of Mamoura/Alalkomenai (Philippson 1951: 473. See chapter II.3.1 for details).
[9] After the Petra pass starts a line of marshes that are formed by the streams. This line runs along the foothills of the hills under Ypsilantis village.
[10] Philippson describes different natural elements involved in the Copais system and their relations with human presence (Philippson 1951: 476-8).
[11] Today the Kephisos is channeled and takes all the water from springs, streams and rivers flowing into Copais. Only a small marshy area is preserved by Rachi (Philippson 1951: 474, see footnote n.8 and chapter II.3.1).

to the E (Philippson 1951: 468[12]). On the other hand, the hydrologic balance must have changed quite considerably in the same chronological span, according to the different climatic phases (which intersected that period).
The annual mean rainfall today varies within a range of 463mm recorded at Tanagra and 470mm recorded at Salonika (Sheil-Steward 2007), with a pluviometric gradient of ca. 40 mm for every 100 m elevation. The rainfall average, according to the Mediterranean climatic zone**,** presents a maximum in November/December and a minimum in July, with rain concentrated in the October-March period (75% of the total). Rainfall is characterised by a high variability, in particular during the dry season, with peaks of three months without rain, frequent in a sub-semiarid climatic area like the Mediterranean.
Kalcyk and Heinrich (1989) report a hydrologic inflow to the basin of 600,000,000 m³ during the winter and 150,000,000 m³ during the summer. Even if the authors do not state it, it is possible that these numbers concern the effective inflow of the basin having subtracted the evapotranspiration, calculated by means of analysis of precipitation and potential evapotranspiration data (Thornthwaite formula[13]). It seems evident that the hydrologic surplus, which corresponds to the effective inflow to the basin, is concentrated in the October-March period, while from April to September rain does not provide any substantial contribution to the inflow to the basin, and stronger evaporation processes also help the drainage of certain areas and the transformation of the lake into a fen. Another contribution in the April-May period comes from the Kephisos river overflowing, due to snow melting, while the Melas, fed by the sources at the NW edge of the basin, near Orchomenos, is characterised by a more regular annual waterflow.

These seasonal differences and the high annual variability, even in the absence of regional or worldwide climatic variation, must have strongly influenced the nature and extension of the wet area (lake or swamp), the extension of the dry area of the basin, and the water availability. Accordingly, many factors must have influenced, directly and indirectly, the lives of the people that inhabited the area in various periods: the availability of dry land[14], the potential use of this (and of the wet areas as well, see below) in the various periods of the year and in the mid and long term.
Another process which must have helped the transformation of the landscape through time is the sedimentation process in the lake-bed, with plugging or preferential drainage effects at an altitude different from that of today. Valleys have been reached slowly, in a continuous process, by the deposits eroded and dragged from the slopes, in this way making the landscape more gentle, and creating possible drainage routes for subterranean water coming from the carbonate aquifer. Such sediments could have also played another role: they could sometimes obstruct the *katavothrai*, thus making

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[12] Philippson 1951: 468-9: a lower pass separates the Karditsa bay from Yliki (see chapter II.3.7). Only a low col separates the Copais basin, on its E side, from the NW edge of the Theban plain, which here is lower than the Copais basin (see chapter II.3.12).
[13] La formula di Thornthwaite (1948) si basa sulla relazione esponenziale esistente tra l'evapotraspirazione potenziale e la temperatura media mensile dell'aria.
[14] For wet and dry areas in the basin before the drainage, Philippson points out (1951: 470) that even today, after drainage, one can find signs that give us a clue: the dry area is now characterised by fields of small size, the turning of paths that are marked by trees, the presence of villages. On the other hand, the past wet areas are marked by the absence of villages, square-cut paths, obviously artificial and regular field divisions.

the water level increase, but then, in wetter seasons or periods of overflowing of the lake, the *katavothrai* could reopen, once under hydrostatic pressure.
Tectonic processes could also have helped modification of the physical characteristics of the basin, producing variations in the height of the impermeable bed of the basin in its relation with the *katavothrai*, as well as variations of the piezometric level of the water-bearing stratum, with direct consequences on the nature and extension of the water spectrum. Looking at the last 20,000-30,000 years, and taking into account the fact that climatic and tectonic factors act at different timescales (much slower in the case of the latter), we could consider the climate as a critical factor in the variations of hydrological phenomena.
Transformations in hydrologic behaviour during time could have been determined also by the closing/opening, either natural (as seen above) or artificial, of all or some of the *katavothrai*, or by the existence of other working subterranean effluents different from those at present. This could have caused great differences as regards the behaviour of the lake's fluctuations and the water level, with a consequent impact, more or less conditioning, on the human settlement. On the other hand, human impact, by means of drainage and water diversion and collection works, mainly for agricultural reasons, must have influenced, even if at different levels in time and space, the natural evolution of the basin[15].

Pollen analysis and the study of the magnetic properties of the sediments from cores from Copais and exposed sections of lacustrine sediments in the basin allow us to create a first reconstruction of the climatic-vegetational evolution of the basin and eventual traces of human impact/intervention from ca. 27,000 years BP up to 3,000/2,500 years BP (Allen 1990; Turner & Greig 1975; Rackham 1983).
Both pollen and magnetic analysis seem to indicate, since ca. 5,000 years BP, a decline of the humid post-glacial phase, with a thinning out of forest coverage in favour of a drier climate, with denudation and erosion of the slopes (Allen 1990: 177, Zangger 1992, Bintliff 2000d and 2002 - see chapter II.1). A drier climate must have also reduced the extent of the lake, probably modifying it into a seasonal swamp, almost completely dry during the summer months when, with the probable exception of the Melas, the inflow from the rivers and streams was reduced almost to zero[16]. Another clue for the presence of a swamp rather than a proper lake, with a strong annual fluctuation, can be seen in the presence of peat levels in the superficial sediments of the basin (peat probably present also in the Mycenaean drainage channels) (Knauss et al. 1984). Most probably, even in full summer in certain periods, large swamps remained in the area around Orchomenos, in the SW area and around Haliartos[17] (fig.4 and fig.5).
Therefore, seasonal and annual variations, and the long term climatic variations even more, must have caused a very significant fluctuation of the 'shoreline', either of a

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[15] We have a clear example on this in the late Medieval period, when watermills closed up the *katavothrai* – see below.

[16] Philippson (1951: 479) notes that the perennial river Melas (which has all its sources within the Copais basin) crossed the dry lake during the summers along the N edge and then to the E to the end of the Topolia bay, before disappearing into the *Megale Katavothra*. During winter, the riverbed was mostly covered by the lake water.

[17] Philippson (1951: 479) reports as always marshy, even in the summers in dry seasons, the large swamp of Tsamali (Orchomenos lake – see below), the corridor corresponding to the modern village of Ag.Dimitrios (see above n.8) to the S of Orchomenos, the area by Haliartos and the corridor S of Topolia/Kastro (ancient Copai). In Philippson's time also there were marshes in these areas.

lake or a marsh/swamp, whose depth was only a few metres, with the consequent covering and uncovering of a wide zone of land.

Historical sources

Ancient texts can provide information both on the extension of the lake at different times, and on the way ancient people perceived the 'lake' environment. Many scholars considering Copais, and marshy landscapes in general, have used historical sources in order to extrapolate information on 'attitudes' to marshes.

Oliver Rackham, discussing the period around the end of the 19th C and the beginning of the 20th C., refers to it as a "helophobic age" (Rackham 1983 and 1990). Indeed, the period was characterised, in Greece, by the drainage of large marsh areas, since then 'given' to cultivation[18]. Beforehand, travellers at the beginning of the 19th C were spectators and describers of a landscape which was much more similar to that in antiquity[19]. Therefore we can imagine, through their accounts and the descriptions of the ancients themselves, how the landscape to which ancient people were used was marked by a much greater presence of watery and wet areas. Here is not the place to discuss in detail the relationship of ancient people with water, but we must note, together with Traina in his extensive book on the subject (Traina 1988), that ancient Greeks were certainly not as 'helophobic' as in recent times. Needs and urges were different then and they had learned how to make the best of the presence of such marshy areas.

Marshes, swamps and fens, as Traina (1988) and Fantasia (1999 after Traina) point out, represent at best the ambivalence which characterises marginal areas (*eschatai*), external to the cultivated space but not at all passive and inertial elements of the rural landscape. In fact, such areas are not simply a pure obstacle to the expansion of cultivation, but in the majority of cases are an ideal place for a parallel economy which can 'exploit' the natural conditions, and which coexists with the agrarian economy, and, to a certain degree, can be considered an expansion of it (see Rougemont 1991: 126-133; Forbes 1996; for marginal areas see Daverio Rocchi 1988).

Wet areas had influence, for instance on the climate: Theophrastus (*CP* V 14.2) reports that in Larissa (Thessaly), when the marsh had become a lake, the atmosphere was thicker and heavier and the region warmer, olive trees reached the city and vineyards never suffered from frost; afterwards, the superficial water was drained away, with the result that the region was colder, olive trees disappeared and vineyards were more frequently subject to frost damage. In V 12.3 Theophrastus says that in Boeotia and Euboea there were fewer occurrence of frost-bitten trees in the years when the Orchomenian lake (i.e. probably the NW bay of the Copais) was higher[20]. In

[18] Apart from Copais – see later in the text – drainage works were carried out in other areas of Greece, before and after the mid 20th century, as reported by Fantasia 1999 n.5: Ematia and Filippi area (Borza 1979: 114), lower valley of Strimonas river (Borza 1989: 60), ancient Larissa area (Helly 1984: 232), Feneus basin in the Peloponnese (Baladié 1980: 104), Taka lake in the Tegea area (Kalcyk-Heinrich 1986: 13ff; Knauss 1988: 36).

[19] Among the travellers who visited the Copais area were Gell, Leake, Forchhammer and Ulrichs. In 1890 James saw the "*big swamp of the Copais*" from Helicon, probably from the road from Mazi to Evaggelistria, just before the drainage work in the Copais started.

[20] The problem for olives at Copais is not winter frost but temperature inversion due to thick fogs from the lake which inhibit warming by sunlight.

fact, the same occurred in modern times, after the drainage of the lake (Philippson and Kirsten 1951: 473), and the same happened in the Fucino basin (Italy) after drainage there (Letta 1972: 13).

The έλη can constitute a valuable resource for economic exploitation, over which to watch[21]. We may think, for instance, of the rarity of plants and spontaneous edible vegetation that grow only in marshy areas and land with stagnant water. Theophrastus (*HP* IX 13.1), for example, refers to the νυμφαία, common at Orchomenos, Marathon and Crete, which Boeotians, who call it μαδωνάις, eat, and to other plants (see Fantasia 1999: n. 47). We should not forget the well known 'flute ribs' (κάλαμος αυλιτικός, *arundo donax*) which used to grow in the NW bay of the Copais basin, between the Kephisos and the Melas, mentioned once again by Theophrastus (*HP* IV 10-11. 9)[22].
Fishing can also be considered an economic value of such areas. A list of fish prices (including both sea and lake fishes) is reported on a stone found in ancient Akraiphia (Vatin 1971). The eels of Copais lake, mentioned by Aristophanes (*Ach.* 880; *Lys.* 36) were famed. Aristophanes also mentions the list of fish prices in Akraiphia market, including not only salt water but also sweet water fishes. This shows that fishing was an important element in the local economy.
Also in terms of the husbandry economy, we have a strong sense of the importance of λίμναι, έλη and equivalents. Poetry, from Homer to Theocritus, depicts marshes and wet meadows as very suitable for large scale animal husbandry (e.g. Hom. *Il.* VI 506; XX.221; *Od.* IV 601)[23]. Pausanias (I 32.7) reports on the marshes of the Marathon plain as good for flocks (βοσκήματα). Theophrastus mentions the plants in marshy regions which allow good pasturage, especially in the NW area of lake Copais, near Orchomenos (Thphr. *HP* IV 10.7: σίδη, φλεώς and IV 8.13)[24]. In this area, even toponyms relate explicitly to husbandry: an area is designated as Ιππία or Βοεδρία, and a river is called Προβατία (Thphr. *HP* IV 11.8-9)[25]. Moreover, Rackham (1990: 103) says that Greeks managed to breed cattle in an apparently unsuitable environment thanks to the presence of these marshy areas[26].

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[21] See epigraphical evidence –even if from Asia Minor – quoted by Fantasia (1999: 67 and footnote n.8): a boundary stone on which is mentioned 'a council of officiers', called συνελερέοντες, the guardians of the marshes.
[22] Theophrastus notes that these particular ribs grow in these areas only if water reached a relatively high level for a period of not less than two years (and he refers to a specific period, after the battle of Chaironeia –338 B.C. This may be an important remark for understanding the hydrological condition of the bay during time).
[23] See the importance of cavalry and the value given to horses in the history of Orchomenos (Farinetti 2003).
[24] See also IG VII 3171 (quoted also by Fossey 1988: 365) mentioning pasturage rights with reference to the grazing of cattle, horses, sheep and goats on Orchomenian territory.
[25] See Lauffer 1974 and Knauss 1987: 2. For the location of these toponyms see Knauss' report in Teiresias 1987, which states: "*It is now possible to identify with more or less certainty the location of several plains named by Theophrastus in HP IV 11.8ff: the area between the Kephisos and the Melas rivers called Pelekania; the Oxeia Kampe, a sharp bend at the point where the Kephissos enters the Minyan canals; north of this, Boedria, where the waters of the Kephisos mingle with the soil just before a deep hole in the marsh (above the ancient dam); and south of the bend, the rich plain called Hyppia (Thphr. HP IV 11.8)*". See the figure in Knauss 1987 and here fig.4.
[26] It is interesting to note that in Hellenistic times the Boeotian towns of Akraiphia, Copai and Orchomenos often used to give licences for free pasturage to the benefactors and creditors of the *polis*: this has to do with the fact that their territory extended to the borders of lake Copais.

On the other hand, there are also unpleasant aspects related to the presence of stagnant water areas. We must take into account, for instance, the threat of malaria, certainly high in such areas. We have evidence for epidemics of malaria in marshy areas of Greece from ancient texts. For Boeotia, we know from Theophrastus (*HP* IV 10-11.9) of an epidemic, occurring after the events at Chaironeia –338 B.C. –, when the water in the NW bay of Copais reached a relatively high level for more than two years. This should most probably be interpreted as a diffusion of malaria (see Fantasia 1999: n.104)[27]. Certainly this was a problem ancient people had to face, and it certainly contributed to their approach and perception of *limnai/eli* areas.

With all this in mind, we should perhaps ask ourselves if, and to what extent, in the Archaic-Classical period the pressure for agricultural land led to interest in areas of this kind, with the aim of clearing areas for sowing or plantation agriculture. Certainly the increasing agriculture gave a stimulus to the agricultural development of this aquitrinous areas (Fantasia 1999), as well as the will of bonifying insalubrious areas. In the Hellenistic period drainage works may have made a more concerted effort to respond to these desires, but in earlier (Archaic and Classical) times human intervention was probably simply intended to consolidate a balance, where the economic exploitation of the marshy areas was, in practice, an adequate counterbalance to the disadvantage of not having those areas available for cultivation.
In any case, the drainage works, whenever they took place, did not radically modify the natural conditions, but were always intended to follow and support natural processes, by cleaning subterranean channels, for instance, or by creating new ones, to help the superficial drainage of karstic basins. Therefore, since the Bronze Age, in the poljes of Central and Southern Greece[28], commonly called *limnai* (see below), human intervention for drainage and for irrigation were strictly connected (Fantasia 1999: 111). Thus, the urge was not simply to get rid of the surplus stagnant water, but to make the best use of it (primarily for irrigation).

What interests us is the question: did the ancients perceive these areas as areas to be reverted to agriculture, or, rather, is it we who attribute to them our own ideas, while Archaic and Classical people were mainly interested in exploiting these areas for the advantages they could provide, as we saw earlier?
One possibility is that ancient Greeks, earlier than the Hellenistic period at least, did not give much importance to, and were not especially interested in, human intervention for drainage, because they simply co-existed with wet places, as natural elements of the landscape, and tried to exploit them for any possible advantage. However, during the Hellenistic period, the desire for drainage (intended as total elimination of superficial stagnant water) grew stronger (Traina 1988), and the realisation of such works was probably perceived as an important moment in the effective realisation of power and sovereignty, rather than an urge due to strong agricultural pressure. Another possibility is that ancient Greeks, even in earlier periods, were conscious of human intervention for drainage processes and the

[27] Theophrastus employs in this passage (*HP* IV 10-11.9) the word λοιμός, which is used also in other ancient texts to refer to malarial epidemics in marshy areas. Analysis of skeletal remains from ancient burial areas could give us an idea of the extent and frequency of these phenomena.
[28] See Mycenaean drainage work in the Copais, in the Argolid and in Arcadia (Knauss 2001).

conquering of land for agriculture, alongside the importance of the wet and marshy places for an integrative economy (Fantasia 1999)[29].
Ancient people probably did not perceive the drainage, as modern people do, as an integral and definitive transformation of the stagnant water into a cultivatable area. Rather, the partial, incomplete, unstable character of ancient drainage works, which we observe in the known cases of drainage (or attempted drainage) in antiquity described in ancient texts[30], cannot assign ancient Greeks to a phase of 'primitivism', as far as the relationship between humanised landscape (i.e. cultivated landscape) and the binomial *limnai/eli* is concerned (see above). Not even the scarce or partial evidence of *limnai* and *eli* and drainage works on them, in ancient texts earlier than the 4th C, would seem to lead us to such a conclusion.
Most of the drainage works indeed took place in the Hellenistic period, as noted earlier, but we also have mentions of and evidence for drainage works in earlier times, some of which are also veiled in mythical tales (most of which were created, as we know, in Archaic and Classical times). In fact, as Fantasia (1999) suggests, also by means of reference to 'bonifying heroes' in myths[31], we know that Classical Greeks were fully conscious of the dynamic processes which had brought the hydrological asset to be as it was in their time, through gradual drainage, and that this may also have been a process caused by human intervention. Furthermore, we should not forget the political and social value given by ancient Greeks to public works related to water for the collective good. Therefore, we should perhaps simply admit, in Léveau's words (1993: 16), that "*l'Antiquité n'a pas connu le drainage total au sens où nous l'envisageons*". We are simply dealing with different perceptions of the relationship between man and fluctuating water that we should take into account when dealing with the understanding of the history and settlement history of such a landscape.

Copais in ancient texts
The lake in ancient sources is mentioned usually as Copais (Κωπαίς), otherwise as Kephisis (Κηφισίς) or Haliartis (Ἁλιαρτίς) or Orchomenia (Ὀρχομενία), all of them used always as adjectives attached to the noun *limni* (λίμνη)[32].
In fact, the Copais is always referred to as a *limni*, i.e. with the same word Greeks used (and still use today) to indicate a proper lake. As noted earlier, however, the lake was probably, most of the time, a large marsh. On the other hand, its great extent, and its character of a vast depression with a bed characterised by very *low* differences in depth, contributed to the idea that people who were living there, as well as visiting it,

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[29] Fantasia 1999 uses fragments from Philarcus to support his thesis: a spontaneous reduction of the marshes as a reaction of the φύση to the use/abuse and control of the marsh areas for economic reasons.
[30] See, for instance, Krates' attempted drainage of the Copais in Hellenistic times (Strabo IX 2) or the Taka lake in Arcadia and the *limni* of Ptechai in Euboea.
[31] Boeotian Herakles first of all, and Cadmos. In certain cases, we also have evidence in myth which tells us about the intentional flooding of basins during conflicts. See the mythical account of Theban Herakles, who re-flooded the Copais basin (after the Minyan drainage) obstructing the *katavothrai* in order to destroy the power of Orchomenos (Buck 1979: 59 and Euripides *Heracl.* 48-59, 220; Apollodorus II 4.11; Diodorus Siculus IV 10.4; Pausanias IX 17.1; 25.4; 26.1; 37.2; 38.7; Pherecydes Lerius *FGrH* 4F95; Isocrates XIV 10; Strabo IX 2.40; Pindarus *frg. 29.2*; Polyaenus I 3.5; IG XIV 1293).
[32] See Geiger 1922: 1346 for documentation of the names. For the name of the Copais, Philippson (1951: 466) writes: the lake was named in antiquity after the *polis* Copai. In more recent times it was called Topolia (after the pre-modern name of Kastro village, at the site of ancient Copai). Homer and Pindar name it Kephisis. Pausanias uses both names (Copais and Kephisis).

had. Therefore, the Copais was, for its people, a *limni*, a lake, and it is referred to in this way by ancient authors. In ancient texts we never read the words *limnaiai, limnades*, *eli, telma*, *tenagos* – all words that indicate wet areas, marshes, *lake-ish* areas -associated with the Copais (except in the case of marshy areas surrounding the lake itself, always mentioned in association with the *limni* though).
Conversely, ancient Greeks had the idea that the Copais was not a common lake, but was marked by a strongly fluctuating character, and that they were dealing with a dynamic landscape, where the balance dry-dried/flooded areas was continuously changing, naturally or by human intervention.

Historical Sources
Strabo, for Copais, gives a careful description of the periodical filling and emptying processes of the internal basins (related to the *katavothrai*), a mechanism certainly known to the Greeks (Strabo IX 2.18 (406-7); IX 2.16 (406) and IX 2.40 (415), with Wallace's comment (1979: 66-79); on these passages see also Guillon 1943 and Fantasia 1999 n.31).
Theophrastus (*HP* IV 10-11.9) reports on the fluctuations of the lake, referring in particular to the NW bay of the basin, which he calls 'Orchomenian lake', as well as on the vegetation in the area.
Pausanias says only a few words about lake Copais (Paus. IX 24.1-2; 38.6-8). The description of Pausanias' itinerary from Akraiphia to Copai (Paus. IX 24.1) is too vague to give us the impression that he crossed a substantially dry basin, getting into a boat only to cross the Kephisos river (Fantasia 1999, n.96) – see discussion below.
The description of the battle at Haliartos, 395 BC, given by Plutarch (*Lys.* 28.6-10), gives the impression of an area around Haliartos which was free of water, as well as Plutarch's mention of the detour that Pelopidas had to make when attacking Orchomenos (Plu. *Pel.* 16) (see later and cf. Kahrstedt 1937). The battle of Orchomenos in 86 BC took place, due to the use of numerous cavalry, in a vast plain, between the city and the Melas marshes (Plu. *Sull.* 20): the lake border line was therefore more arretrated than one might have thought (Kahrstedt 1937: 15; Fantasia 1999).
Plutarch (*Moralia* 578a) reports on a famine at Haliartos (379 BC) due to the rising of the lake's water level.

Epigraphical Evidence
There is some epigraphical evidence concerning boundaries in the Copais area, mostly depending on lake water limits (see below – *Fluctuating boundaries*).
A boundary stone was found (Fossey 1988: 501) among the remains of the Herkyna dike, in the middle of the area, free of water, which constitutes the W part of the Copais basin. It carries the word ὅϱος. Fossey (1988: 497-500) believes it marked the boundary between Koroneia and Orchomenos since, as he thinks, the territories of Levadeia and Chaironeia did not reach the lake (see discussion below). Another boundary inscription (ὅϱος) was found carved on a rock at Phtelio point, marking the boundary between the *poleis* of Copai and Akraiphia, dated to the Hellenistic period (not earlier than the end of the 4^{th} C BC) – IG VII 2792. Another inscription was found and interpreted as boundary stone, once again between Copai and Akraiphia,

datable to the 6th – 5th C BC. The text suggested by Roesch reads: [hόρος Α]κραι[φιέον] [κ]αί Κοπ[αίον[33].
Other inscriptions are linked with drainage work or flooding problems: IG VII 2712, (dated to the 40 A.D – see lines 33-37) is an inscription found on the bank protecting part of the Karditsa/Akraiphia bay from flooding; an inscription (dated to the reign of Claudius) published by Robert (1985: 438), concerns drainage work in the Karditsa/Akraiphnion bay. The so-called 'city archive' of Koroneia, including inscriptions from the city and published by Fossey (1981-3), includes a decree on lake water regulation[34] from the Hadrianic period (see chapter II.3.1)[35].

Digital reconstruction and modelling of the lake fluctuations
Digital modelling of flood dynamics in order to understand wetland landscapes has been applied by different scholars within GIS systems. The best known case studies for the Central and Eastern European area are Gillings 1995, Budja and Mlekuz 2001, and Chapman 2000.

As we have seen, in the case of the Copais basin, seasonal and annual variations, as well as the long term climatic variations, must have caused a very significant fluctuation of the 'shoreline'[36], either of a lake or a marshy area, whose depth was only a few meters, with the consequent covering and uncovering of a wide zone of land, especially to the S and to the W (where the lake proper never existed, but there could have been a large marshy zone).
It would therefore be interesting to try to understand how much the lake environment and the fluctuations of the lake could have influenced settlement, the settlement dynamics and the relationships between settlements in the various periods under examination.

Interdisciplinary analysis could help to individuate, for the various historical periods, this 'unpredictable border' between the lake and the land that was periodically available; it could help to individuate the kind of use that could be made of this land (what kind of cultivation, arable land or wetland plants, productive or poor, etc.), to define the evolution of landscape during time, its natural dynamics, the level of human impact, the quality and quantity of the interrelation between the two elements (water and land, land/water and humans), and the organisation and internal relationships within human communities gravitating to the area.

For this purpose, a dynamic digital reconstruction of the lake fluctuations has been implemented, combining the results of the work of the German team, led by engineer J. Knauss, and his team from the University of Munich (Knauss 1987; Halcyk-

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[33] SEG XXX 440; Teiresias, 10 [1980], AE/2; Lauffer *Chiron* 10 (1980: 161-2). The inscription (dated to the 6th C BC) was found in the plain, 500m NW of Phtelio cape and 500m SW of Gla.
[34] The necessity of repair works for a dike.
[35] Other inscriptions from the area are reported in Fantasia 1999 n.100 and, mainly, in Fossey 1991 (on Boeotian inscriptions).
[36] Typical of the marshy lake is the undefined nature of the shoreline, which was actually comprised of a wider or narrower strip rather than by a definite line, lying between the mainland and the lake proper. This seems to be true especially in the case of Copais; a large, shallow, marshy lake marked by strong seasonal fluctuations.

Heinrich 1989), the geomorphological[37] and palaeoenvironmental studies carried out on the area, the examination of aerial photographs[38], and the known archaeological evidence and historical data. Thus, the digital model constitutes a research tool in itself, and, at the same time, the resultant product of the combined use of different research tools.

Three crucial heights have been taken into consideration, following the important results produced by Knauss and the Munich team (Knauss 1987; Halcyk & Heinrich 1989).

97 m a.s.l., maximum high level of the lake known at the time of the modern drainage (Knauss 1987; Kalcyk & Heinrich 1989).

95 m. a.s.l., maximum level of the lake during the winter season in antiquity until the Medieval period (when a series of watermills closed the *katavothrai* and the water level rose[39]). This level is hypothesised by the Munich Kopais-Project group as the maximum level reached in antiquity, on the basis of the discovery, along the 95m contour line (and in any case between the 97m and 95m levels), of 4 archaeological 'sites', dated by them to between the Neolithic and the Byzantine periods. On the basis of this they conclude that: "*It can be said that the lake never rose above the 95 m contour line for long...*" (Kalcyk & Heinrich 1989: 69)[40].

92 m a.s.l., minimum level –seasonal or annual- of the lake/marsh, below which there is complete drainage of the basin.

Two other levels are reported as meaningful: the 93.5m contour line – lake level in the summer season; and the 96m line – exceptional catastrophic level in the winter season, reached during strong winter floods.

One can note that, while the 97m level indicates a level reached in a certain historical period (from the Medieval up to the end of the 19th century, when the *katavothrai* 'closed' due to the presence of watermills), the border of the lake along the 95m contour line is hypothesised as the maximum level for a very long time span (from the Neolithic to the Medieval period), during which we may have had other slight

[37] The main physiographical classes to be taken into consideration are: abrasion platforms, erosion glacis, depositional level grounds, alluvial cones, littoral strings, colluvial detritic strips, and carbonate isolated reliefs. A systematic and detailed geomorphological survey has not been carried out for this work, but a geomorphological interpretation has been provided on the basis of the topographical and geological maps available, the available reports on the geomorphology of the area, the aerial photographs imported into the GIS system, and some visits on the ground to check available information.

[38] Some aerial photographs from crucial areas have been included and georeferenced into the general GIS system, in order to overlay vector layers with the localisation and interpretation of the marks of littoral strings, palaeo-river beds, and other fossil morphologies.

[39] For the mills the Ottomans used the water flowing into the *katavothrai*, which slowly got closed by the mud, causing the rising of the water level (Philippson 1951: 476).

[40] For the sites, see chapters II.3.1 and II.3.4 and the appendix, in particular Xinos prehistoric and Greco-Roman site (nos.1-2 in fig.4) Xinos prehistoric site (*components KO_65* and *KO_66*), Xinos Greco-Roman site (*components KO_67* to *KO_72*), the prehistoric Petra-Triton site (*components KO_73* and *KO_85*), and Old Orchomenos (*components O_38* to *O_43* – no.6 in fig.4).

differences[41] or abrupt changes (for different reasons), and during which a great number of climatic variations are known on a worldwide scale[42]. Perhaps we should somehow be able to determine a chronologically more precise sequence in the lake's fluctuations, or at least we should keep it in mind while modelling our data. A question we could try to answer, for instance, is: could the lake ever have reached the 97m level (the 19th century level) in any of the periods under study, even if only few times during severe winters? Or perhaps due to human intervention, like the closing up of the *katavothrai* in the Ottoman period for the presence of watermills. It is interesting, for instance that, in the complete study published in its book in German, Knauss (Knauss 1987) mentions a 96m level, which would be the '*catastrophic winter See-ausdehnung*' (exceptional catastrophic level in the winter season). In any case, as the maximum known level we must consider the 97m level, since this is the highest level we know of for the lake, and we cannot exclude the possibility that at times during antiquity the water level might have reached it.
Philippson (1951: 477) notes that the snow from Helicon and especially Parnassos would also play a role. He reports that engineers from the Copais company, in charge of the drainage at the end of the 19th century, calculated that water flowing into the basin in the winters was 160mc/s and on extraordinary occasions reached 300mc/s, while during summer it was estimated at 8mc/s. In the summers, as the area was large (ca. 200 sq. km.) most of the water would evaporate, then, from November onwards, the lake would rise again and the *katavothrai* would function[43].

Elevation base values to produce the model have been taken from the 1:50,000 topographical maps (Vagia and Livadeia sheets)[44]. In a first attempt, a model was made, but the data were not accurate enough to allow for satisfactory precision. I therefore scanned, imported into the GIS system and georeferenced a new set of maps (1:5,000) which cover most of the lake. These maps record points with high values every 150m, and allow for more detail. I have also imported into the system the map published by Knauss (1987) with contours marking the 'crucial' elevation values, and checked the model against his. Corrections on the basis of personal visits in the field and interpretation of aerial photographs were made at this point.

Afterwards, I interpolated (inverse distance weighted) the point values from the diverse datasets and obtained a virtual continuous surface of the ground morphology in the area of the lake. Properly classifying (according to the 'critical' high values) the raster data thus obtained, the probable extension of the lake area in different periods

[41] For instance, Roman finds were found by the Boeotia Project (see below in the text) between the 94 and 95 contour lines.
[42] On the other hand, in the literature we always find that the climatic changes that occurred from the Neolithic to the present were very slight, as noted by Philippson (1951: 479), but see also Allen 1990, Zangger 1992, Bintliff 2000d and 2002 and others. Certainly a climatic change would have occurred in the Early Medieval Warm era (900-1200 AD in Frankish times) characterised by extreme dryness (the Copais lake would have been much lower then). In general, the medieval period is drier and therefore the Copais, Yliki and Paralimni lakes water levels would have been lower, as the Frankish bridge at Klimmataria (Yliki lake) and the tower site at Pyrgos (Paralimni lake) would indicate.
[43] One should also note that lake deposits should have raised the base level of the lake over time. From the higher location of some *katavothrai* we also know that the level of the lake used to get higher in winters in earlier periods – probably before Mycenaean times (Philippson 1951: 477).
[44] The topographical maps of the region (1:50,000 and 1:5,000) are issued by the G.Y.S. (*Geographiki Ypiresia Stratou*: the Hellenic Military Geographical Service).

and seasons could be visualised. In such a virtual continuous surface, the computer program allows the automatic drawing of a contour line which joins all the points (cell of the virtual continuous surface) at a specified height. The final result is a probable border line for the lake (a border between flooded and dry areas) – actually several border lines for different seasonal and hydrological conditions.

A model of the water level fluctuations in dry and wet periods, as well as in summer and winter, has been reconstructed. The model of the marshy lake fluctuations, under natural conditions, is organised as follows:

1. Annual model

1a. DRY periods (One or more DRY years). MIN extension of the lake: up to 92m *a.s.l.*. Relation lake/marsh: marsh progressively covers the whole wet surface and in some periods the lake is replaced by marsh. (fig.1 - A)

1b. WET periods (One or more WET years). MAX extension of the lake: up to 96m (or more –97m for instance- in catastrophic years) and of the marsh. Relation lake/marsh: the lake increases and marsh decreases; marsh progressively becomes lake. (fig.1 - D and E)

2. Seasonal model

2a. SUMMER. MIN extension of the lake: up to 93.5m (or even smaller –up to 92m *a.s.l.*- in dry periods or in very dry summers). Relation lake/marsh: large marsh and small lake. (fig.1 - B)

2b. WINTER. MAX extension of the lake: up to 95m (or larger –up to 96m *a.s.l.*- in wet periods or in very wet winters). Relation lake/marsh: more balanced; the lake increases but usually does not reach the 1b situation. (fig.1 - C)

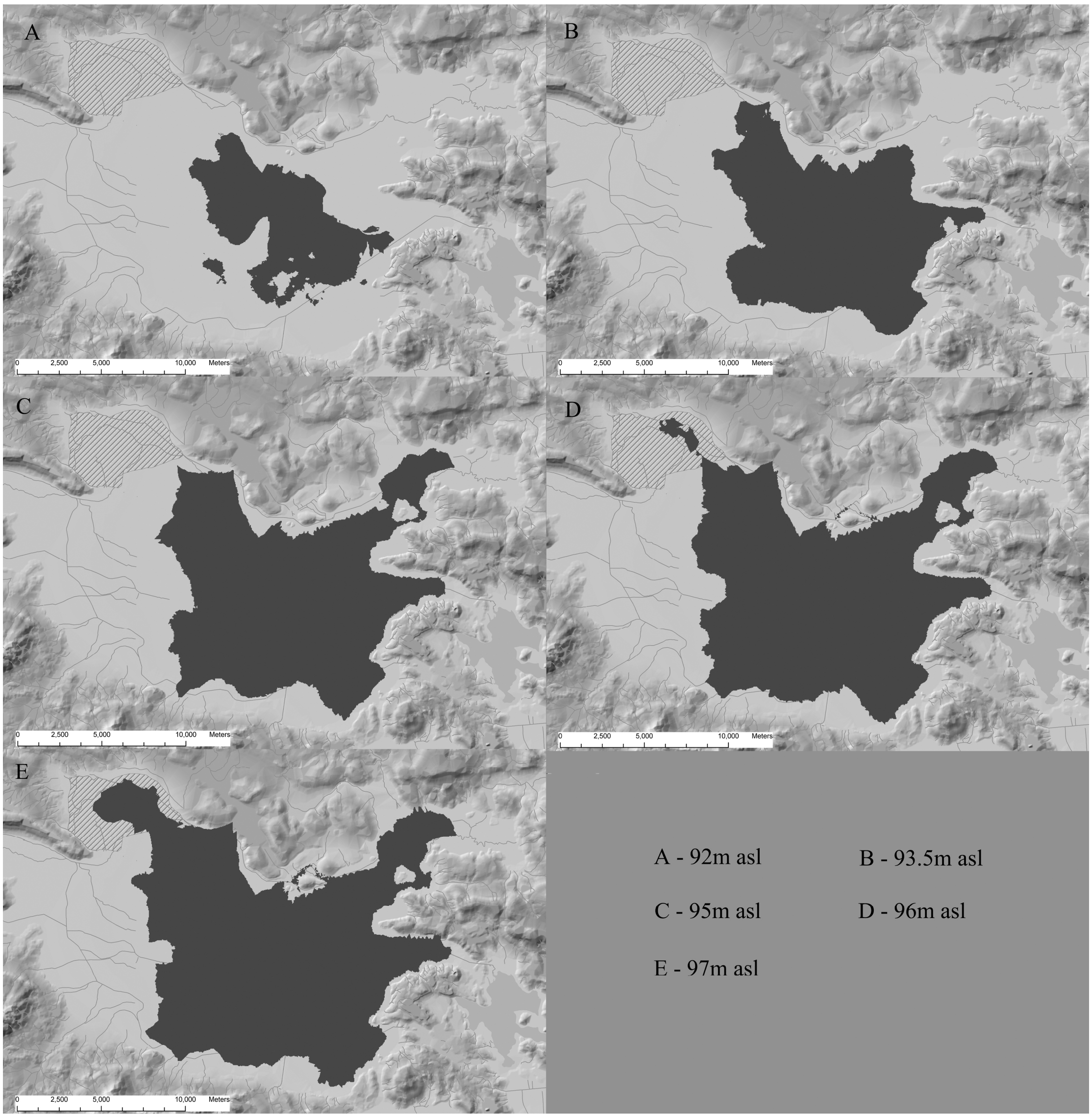

Fig.1 *A digital model of the Copais lake water fluctuations*

The main recognised and reconstructable features related to the various partial attempts at drainage that took place over time[45] were also mapped (fig.2) and inserted into the digital model. *Katavothrai* are also marked on the map.

[45] The most important attempt to drain the lake, and almost completely successful, is certainly the well-known 'Minyan' work carried out in Late Prehistory, probably at some point between the end of the MH period and the LH (see chapter II.3.6 and in particular the site of Gla). There are several studies of the matter: not least the work carried out by the Munich team led by Knauss in order to understand the technical aspects of Late Prehistoric drainage. The main bibliographical references to the topic are: Spyropoulos AAA 1973: 201-210 (for the date of the drainage); Lauffer Kopais I: 131ff; Knauss et al. Kopais 1; Knauss 1995: 83-95. The Mycenaean drainage system of the Copais combined two basic operations: deflecting the courses of the rivers from the basin toward the banks and thence to the *katavothrai* (multipurpose scheme of a great channel and of a secondary channel serving the area of Gla: water supply – flood water drainage – navigation), and constructing polders protected by embankments which prevented their flooding (Knauss et al. Kopais 1; Knauss 1995; Iakovidis 2003: 155). Mythical tales tell us that the complex drainage system went out of use when the Thebans, during a war against Orchomenos in Mycenaean times, flooded the basin closing up the natural *katavothrai* which were used by the artificial drainage work. The myth refers to historical events, probably due to a

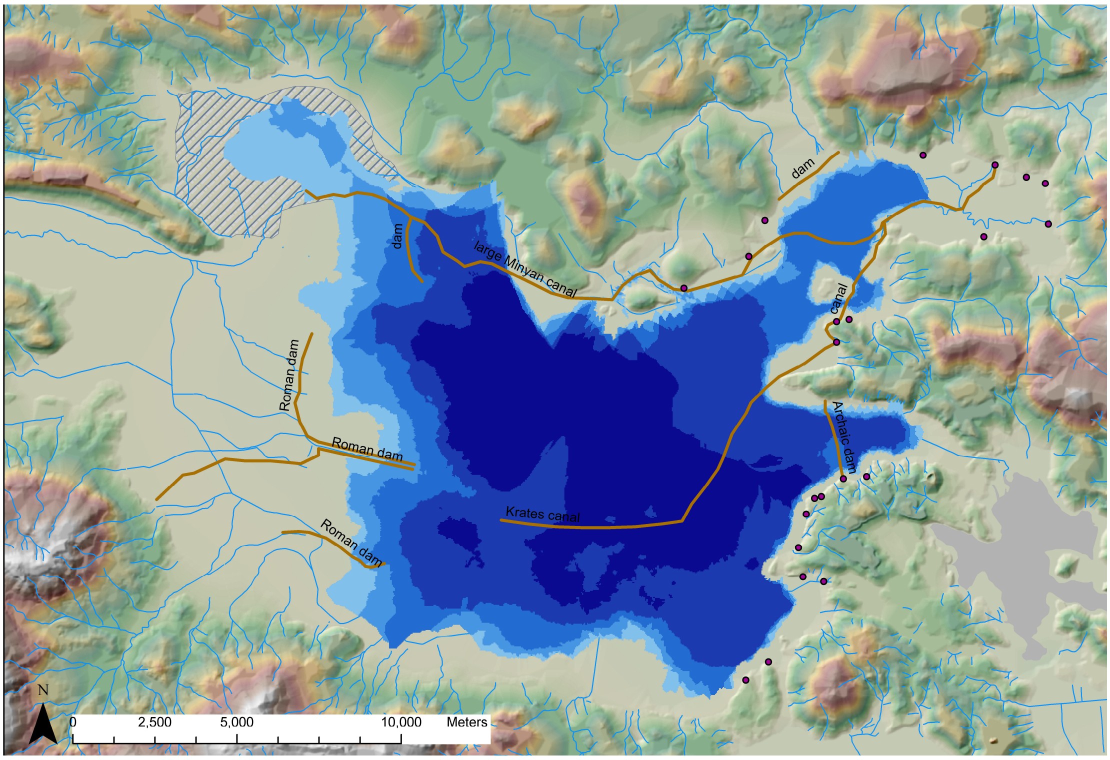

Fig.2 *Map of main recognised features related to the various attempts at drainage of the basin over time (after Knauss et al. Kopais 3)*[46]*. The dots represent the* katavothrai.

The model has an inner hierarchy. The principal component is the seasonal model, which is influenced by the annual model[47]. The suggested lake/marsh relationship is based on the hypothesis that the Copais would in the past have had areas of proper lake and large marshy corridors[48]. Philippson seems to accredit the hypothesis (see above), while Knauss believes that the Copais lake was always only a large marsh. I believe that the suggested model could work anyway, and it could even be enhanced in the case of marsh only. Probably only a systematic campaign of core-sampling would give a more precise picture.

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natural catastrophe, such as an earthquake. Afterwards, general or localised attempts to drain the lake are attested (e.g. Krates' work in the Hellenistic period, or local works such as the Akraiphia dam or the works at the Phalaros/Pontsa and Herkyna outlets – see Knauss et al. Kopais 3 for details).

[46] The map does not include the whole system of channels, dams and polders that totally drained the basin in the Mycenaean period (for details on it see the reconstruction made by Knauss et al. Kopais 1).

[47] Different quantities of water would flow into the lake, according both to periods (climatic changes) and seasons, as noted also by Philippson (1951: 477), up to the limit case of one or more years which could be considered almost free of seasonal variation (in a sub-arid climate, such as the Mediterranean, we could have a year of dramatic drought, with even six months without rain).

[48] Personal visits to the S and W edge of the basin revealed that the 120m contour seems to mark the maximum marshy area linked to the lake's hydrological balance, while river deposits probably characterise the outlet of the perennial streams in the area (Herkyna, Pontsa, and certainly Kephisos). A proper drilling campaign would provide much more information. D.A. Davidson personally gave to J.L. Bintliff, who kindly showed it to me, a digitally drawn map result of his personal work carried out in Boeotia as for evaluation of land suitability for agriculture, with the use of core sampling. In his map river deposits are marked in correspondence of the outlet of Pontsa (probably recognised after a drilling campaign).

In the light of this information, one can imagine how the landscape of the basin in the Greco-Roman period might have been in the different seasons.
As Philippson (1951: 477-8) tells us, the lake was not a open water surface, and modern travellers (before the drainage) report that, from afar, the basin would present an image of a green meadows, and one would get the sense of it actually being a lake only from very close, when appreciating the presence of the reeds. Reeds would mainly cover the deeper part of the lake, and would obstruct water flow. They mainly lay close to the border, giving the impression of a large reed field covering the whole area. In the spring, dry strips of land would appear, which in summer would become large wide corridors, especially from the centre towards the edges. In some years the water lake would have been deep all summer (especially in the centre – see model above, wet periods), while in other years it would have become merely a larger or smaller swamp in the centre (see model above, dry periods), and the dry area would change accordingly. Those temporarily dry areas would be used to plant vegetables, and they naturally had grass, and would be used by shepherds to graze their flocks (in Philippson's time even people from the village of Martinon, in Lokris, beyond the ridges surrounding Copais to the N, would exploit the area for husbandry). The flow of the Melas river would mark the landscape of the N part of the basin in summer seasons, when it crossed the entire basin from W to E along the N edge, to the E end of the Topolia/Kastro bay, before disappearing into the Megali Katavothrai. Several marshy areas would mark the landscape even in summer (see below). Usually, by the end of August the largest area was dry, but the minimum water level in the basin was registered in October. In early autumn, the whole lake looked like a large extended brown area[49], only here and there interrupted by small green marshy patches with reeds and other aquatic plants. In November, the whole area would quickly start to get wet again. The Melas river bed would again be covered by the lake water (Philippson 1951: 479), and in wet winter seasons (or in critical conditions) the water of the lake would join the permanent swamp area in the NW bay, constituting a unique large wet area (see model in fig.1 and see below).
It should be noted here, while describing which kind of landscape ancient people would have seen, that marshy areas were always present and characterised the landscape of the basin, even in the summer. In the NW bay (Tsamali bay) lay a permanent swampy area (Theophrastus' Orchomenos lake[50]) whose marshiness was not directly linked to the lake water fluctuations. As Knauss describes (Knauss et al. Kopais 1 and Kopais 3), the bay is characterised by a hydrological balance and by different behaviour dictated by the water of the Melas and the springs at the foot of Akontion[51] (see chapter II.3.4). Other areas were characterised by the presence of

[49] As Philippson (1951: 479) notes, the bottom of the lake is constituted by white marls, under which in some channel sections he could see yellow sand. The surface layer is a black layer made of swamp deposits, so that the surface of the basin looks dark (towards black) rather than whitish. In some spots the white marls appear on the surface (for instance at the E edge). Immediately after the modern drainage, before they started preparing the land for cultivation, the former lake area looked like a homogeneous brown plain without vegetation. This would probably have been the appearance of the lake before drainage during dry summer times.
[50] Theophrastus, *HP* IV 10.1 might refer to this area, rather than to the entire Copais, when mentioning 'Orchomenos lake'. See also Plinius *HN* XVI 168.
[51] See Geiger 1922: 1348 and others. See Kahrstedt 1937: detour that Pelopidas had to make when attacking Orchomenos, due to the presence of the marsh (Plutarchus *Pel.* 16. For the battle of Koroneia of 394 BC see Pritchett 1969: 89-95). The area of Tsamali should be the area known as Pelekania

permanent marshes, such as the 'corridor' corresponding to the modern village of Agios Dimitrios to the S of Orchomenos, an area by Kalami/Rachi (see above footnote n.8 and chapter II.3.1), the area by Haliartos, and the corridor S of the village of Topolia/Kastro. In Philippson's time also, there were marshes in these areas (Philippson 1951: 479).

Two painters depicted Copais before the drainage (Edward Lear, *View of the mount Parnassus and the Plains of Boeotia* 1862 and Karl Rottman, *The Plain of Cheronea and Lake Copais* 1835), and the paintings are reported in Tsigakou 1981[52]. Reeds and swamp fauna, as well as a series of wet patches, characterise the view, and gives an impression of how the landscape ancient people would have experienced might have been.

Settlement analysis

As seen above, marshes, swamps and fens, represent at the best the ambivalence which characterises marginal areas (*eschatai*), external to the cultivated space but certainly not passive and inert elements of the rural landscape[53]. In fact, such areas are not simply a pure obstacle to the expansion of cultivation, or potential sources of diseases and poor climate, but in the majority of cases are ideal place for a parallel economy (fishing, plants, ribs, husbandry, etc.). Therefore, in addition to the attempts carried out to drain, at least partially, some areas of the basin (see above *passim* and fig.2), one might suppose the existence, sometimes confirmed by the archaeological record available (see below), both of rural sites exploiting the sources of parallel economy from the border of the lake, as well as cult places linked to the water element[54], which would populate and give active life to the marshy landscape.

Positioning the settlements bordering the lake on the DEM (digital elevation model) based on contour lines and spot heights from 1:50,000 topographical paper maps of the region, and visualising the virtual perimeter of the lake, we can appreciate the extension of the community areas and their morphological characteristics, which could not be appreciated without the visualisation of the virtual (supposed 'real') extension of the lake. For the Prehistoric period, some remarks on settlement pattern have been made in the individual chapters concerning the *chorai* gravitating towards the Copais basin, as well as some issues concerning sites found at the border of the lake. We will focus here on some issues related to the Greco-Roman *polis* landscape in the area.

In the case of the Greco-Roman poleis in the area, we could explore how the presence of the lake affects the *polis* landscape behaviour. According to the model, in Greco-Roman times the water level must have been, during winter seasons, at least 1m lower than the level at the end of the 19^{th} C, when the drainage took place. Dry areas (rich in fertile as well as heavy soil, though sometimes marshy[55]) could have been available,

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swamp, which produced reeds for flutes and created some islets (Theophrastus *HP* IV 11.8. It was visited also by Ulrichs 1840: 192). See also Philippson 1951: 476.

[52] Tsigakou 1981, colour plates XIII and XIV.

[53] As Traina (1988) and Fantasia (1999) point out.

[54] See Pappadakis AD 2 (1916): 217ff for a list of cults of Herakles in the Copais.

[55] Even in the presence of seasonal marshes, if the terrain remains dry in the final phase of growing of corn crops, it can be considered potentially good for cultivation.

therefore, to the W and the S, as can be seen in the reconstruction (figs.3-4-5). Thus, we can understand, for instance, where was the cultivable land of the *polis* of Haliartos, otherwise apparently lacking agricultural land. Intensive surface survey has proved this point and revealed sites, in line with Haliartos' acropolis to the E of it, on the border of the lake between the 95 and 97m contour lines (see Bintliff-Snodgrass, in AR 1986-87: 23ff.; cfr. Kahrstedt 1937: 13 on the description of the battle at Haliartos, 395 BC in Plutarchus *Lys.* 28.6-10). As noted by the Boeotia Survey Project (Bintliff-Snodgrass, in AR 1986-87: 23ff.), between the 95 and 94.5m contours the 'background' density of sherds (indication of agricultural occupation) dropped abruptly almost to nothing. It can be seen as proof of Knauss' hypothesis, at least for the periods concerned. Haliartos' acropolis location was defended to its N and NW sides by the water of the lake. Moreover, quite a large zone of cultivable land was available to the city on its E and W side, along the edge of the lake, between the lake itself and the slopes of the hills, as well as beyond the acropolis, on the foothills (visible in the map showing land potential), as has been proved also by intensive surveys.
To mention another example, the small town (*kome*) of Alalkomenai, at the SW edge of the basin, clearly exploits the very small valley in which it is located, but had also available land in the plain (even in winter in dry years, and to a certain extent also in wet years) – fig. 4.

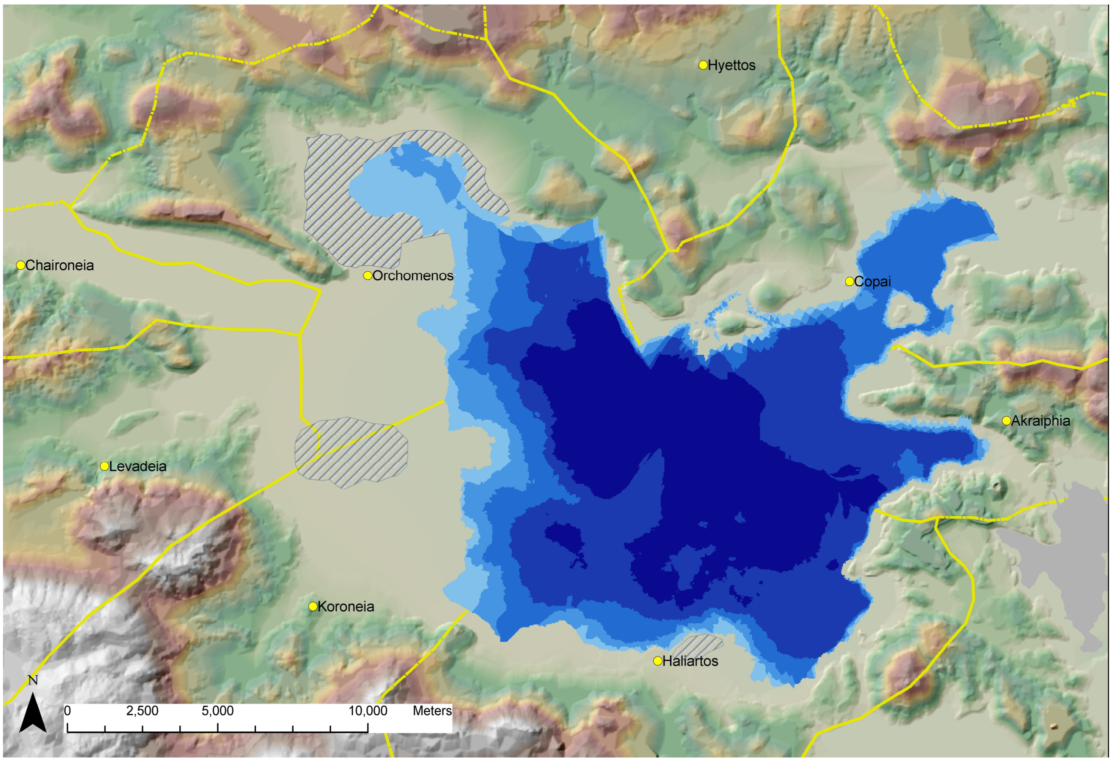

Fig.3 *Map showing the location of the Greco-Roman* poleis *around the Copais basin, the reconstructed borders of their* chorai *and the suggested model of the lake fluctuations. Hashed are the probable wet areas in the past.*

Around Copais, bordering *poleis* (from Orchomenos to the NW to Akraiphia and Copais to the NE, and along the South side to Haliartos and Koroneia) had learned how to coexist and cope with the lake's fluctuations, sometimes taking advantage of it in economic terms, including the fertile and arable land bordering the lake when it was free from flooding in dry seasons (in spring or when the water level was low for consecutive years)[56]. Akraiphia, for instance, built a dam connecting the two hilly edges of the Karditsa bay, so as to protect its land from flooding (see fig.2 and chapter II.3.7 for details). A more general attempt to drain the largest area of the lake was carried out in the Hellenistic period by the hydraulic engineer Krates (335 BC), as known from ancient sources (Strabo IX.2 - see fig.2).

Thus, analysis of the position of the settlements which gravitated towards the lake could be a useful exercise for understanding the relationship of ancient communities with the lake, in terms of landscape archaeology. The digitally reconstructed model of the lake fluctuation can help in evaluating the relationship between *poleis*, perilacustrine activities and the marshy lake[57].

The archaeological record available would indicate, for the Greco-Roman period since G times, mainly the existence of peripheral activities by the edge of the lake, and in particular cult places probably linked to the water element (nos. 7, 14, 20 and uncertain 6 and 9 in table 1 and fig.4) and burial areas which could be associated with settlement and rural sites - nos. 1 to 5, 10, 11, 15, 21 and 22 in table 1 and fig.4). On the other hand, also rural sites exploiting the sources of parallel economy from the border of the lake are archaeologically attested within all the *chorai* gravitating towards the lake (nos. 8, 12, 13, 17 to 19, 23, 24 and probably 6 and 9 in table 1 and fig.4). In the territory of ancient Koroneia, activities in this perilacustrine and marshy segment of the landscape are attested indirectly by burial evidence (nos.1-3-4-21) alongwith the burials, possibly marking rural plots along a road exiting the *chora*, known at the very edge of the basin by a marshy area (at Kalami/Rachi alongwith other signs of habitation activities[58]). By ancient Haliartos, at the S edge of the basin, intensive research[59] discovered a string of A-C rural sites (map fig.4 no.18) and a large LR estate (map fig.4 no.19), which attest the rural exploitation of the edges of the lake in Greco-Roman period. The same kind of landscape use is known for the area of Orchomenos (map fig.4 no.6 – a C and R possible rural activity; no.9 – a C possible rural site; no.8 – a R settlement area) and along the E edge of the basin (map fig.4 nos.12, 13 with uncertain character; no.23– a G to C probable hamlet site; no.24 – a C probable farmstead; no.17 – a LR villa rustica).

Sites are attested, as already pointed out by Knauss and its team (Kopais 3) while conducting researches at the edge of the lake to investigate its historical level(s), outside the 95m asl contour, which is the level hypothesised by the Munich Kopais-Project group as the maximum level reached in antiquity in normal wet conditions (see above and fig.4).

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[56] Travellers in the area in the period before the modern drainage report on cereal cultivation (also rice) and cotton production. See Bursian 1862-1872, I: 195; Frazer 1898, V: 112. Theophrastus informs us of the density of Boeotian wheat (*HP* VIII 4.5) due to thick soil and cold climate (*CP* IV 9.5). The problematic drainage of the soil surely favoured the cultivation of vegetables. In the wet plain of Orchomenos, as well as in Egypt, for instance, good melon can be produced (σίκυοι πέπονες Pseudo-Aristoteles Pr. 20, 32, 926b5). On the fertility of the drained land of the lake basin see Strabo (IX 2.16 (406)). For the whole question see Fantasia 1999 n.85.

[57] Further attempts in this direction have been made in the individual *chorai* chapters.

[58] Signs of a possible rural occupation are also known on the Kalami-Lioma hill, known as a Prehistoric settlement site, immediately above Kalami/Rachi and the marshy area.

[59] Boeotia Survey project (Bintliff-Snodgrass, in AR 1986-87: 23ff.)

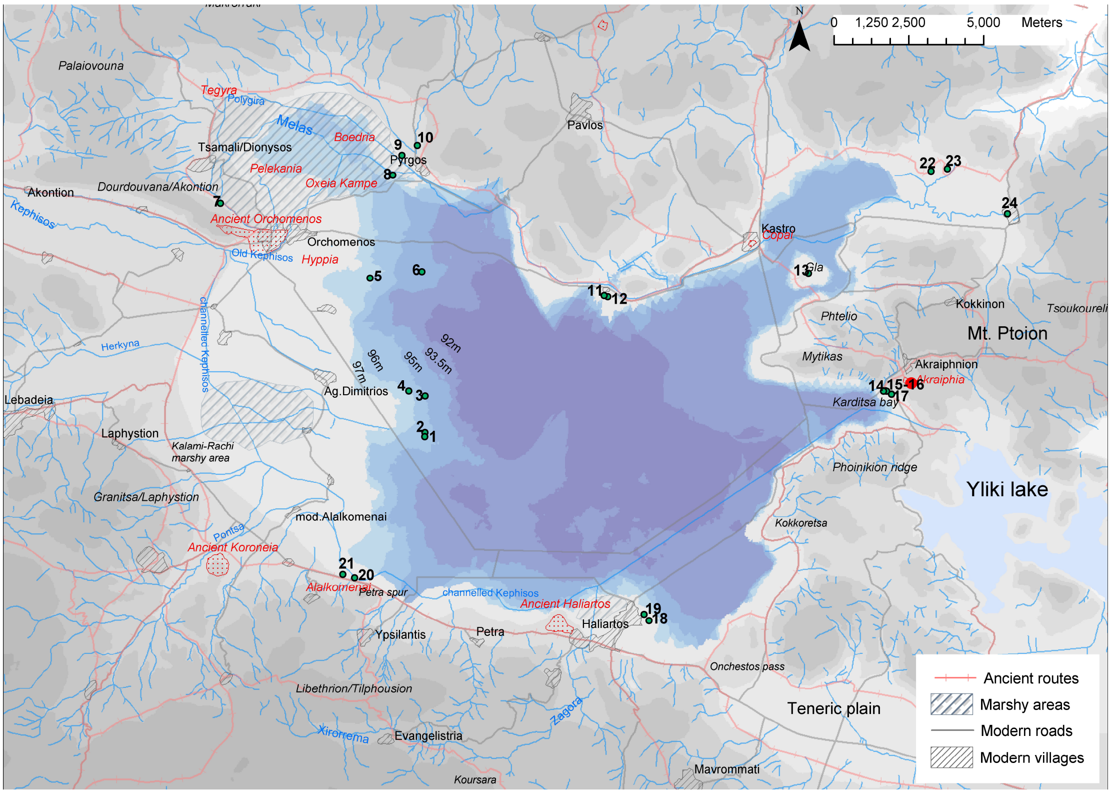

Fig.4. *Greco-Roman sites along the reconstructed lake edge*

Component_ID	Site	Period	Character	Toponym	Evidence	Bibliography
KO_70	1	C - H	burial place	Xinos	a tombstone	Knauss et al. KOPAIS 3: 17ff
KO_69	2	(C?) – H – (R?) – (LR?)	cult place	Xinos	Epigraphical evidence (dedication to Apollo Paiaion), potsherds and architectural fragments	Knauss et al. KOPAIS 3: 17ff
KO_11	3	gr-rom	burial place	Ag.Dimitrios East	grave tumulus with an inscription	IG VII 2931; Knauss et al. KOPAIS 3: 17ff
KO_20	4	R	burial place	Ag.Dimitrios East	necropolis of imperial date	AA 1937 : 19
O_25	5	Greco-Roman?	activity focus?	Orchomenos Magoula SE	*magoula* (tumulus?)	Knauss et al. KOPAIS 3 : plan 2.8
O_42	6	C and R	activity focus	"Old Orchomenos"	cult place? Rural activity focus?	Knauss et al. KOPAIS 1: 225; Knauss et al. KOPAIS 3: 32ff
O_35	7	C - H	cult place	Melas Source	structures and evidence	De Ridder BCH 19,

Component_ID	Site	Period	Character	Toponym	Evidence	Bibliography
					interpreted as cult place (sanctuary of Herakles ? – Pausanias IX 38.7)	1895: 150ff.; Fittschen AReports 1998/9: 56 and fig.64; BCH 123 1999: 730
O_60	8	Greco-Roman (R)	activity focus	Pyrgos-Melas dam	architectural fragments and potsherds over an extended area (settlement?)	Lauffer Kopais I: 161ff; Knauss et al. KOPAIS 3: 68ff
O_66	9	C	activity focus	Pyrgos Magoula	Structural remains and 5th C BC material referring to a cult place (or simply to a rural activity site?)	Lauffer Kopais I: 168
O_58	10	C	burial place	Pyrgos-Trassa	architectural fragments, sherds and tiles, bone fragments and surface walls	Lauffer Kopais I: 159
NC_87	11	C	burial place	Stroviki-Nisi (lower W hill)	C graves	AD1969: 179 (and Lauffer Kopais I: 186)
NC_7	12	C- (H? – R? – LR?)	activity focus	Stroviki-Nisi (E hill)	Signs of C occupation uncertain in character	Lauffer Kopais I: 192-3
NC_73	13	C - H	activity focus?	Gla	unclear evidence	HS&D 1979: G9
AK_55	14	G	cult place	Akraiphnion-Nat.Road junction	Excavated structures and layers	Rescue excavation AD 51 1996 (2001): 275-278; Aravantinos 2004: 86
AK_57	15	R	burial place	Akraiphnion-Nat.Road junction	excavated burials	Rescue excavation Aravantinos 2004: 88
AK_58	16	R	special activity	Akraiphnion-Nat.Road junction	a pottery kiln installation	Rescue excavation Aravantinos 2004: 88
AK_53	17	LR	rural site	Akraiphnion Grava	villa rustica	Rescue excavation AD 49 1994 (1999): 278-281
Boeotia survey site by Haliartos - HAL B4	18	G to H	rural site	Haliartos N	surface potsherds	Boeotia Survey project - Bintliff and Snodgrass AR 1986-87: 23ff.
Boeotia survey	19	LR	rural site	Haliartos N	villa (large LR estate center)	Boeotia Survey project - Bintliff and Snodgrass

Component_ID	Site	Period	Character	Toponym	Evidence	Bibliography
site by Haliartos – Kahrstedt site						AR 1986-87: 23ff.
KO_27	20	C - H	cult place	Solinari Agios Ioannis	Excavated structures which could belong to a temple (to Apollo Tilphosios?)	Excavated by Spyropoulos AAA 1973: 381-385; AD 1973: 271
KO_93	21	G	burial place	Solinari - Nat Road	excavated burials	Rescue excavation AD49 1994: 284-286
NC_37	22	A - C	burial place	Chantza (vicinity)	A and C tombs	Fossey 1988: 287
NC_45	23	G to C	activity focus	Agios Ioannis-Spitia Katavothra	a probable hamlet site	Hope Simpson 1965; HS&D 1979; Fossey 1988: 287; Lauffer Kopais I: 239-40
NC_56	24	(G?) -C	activity focus	Agios Ioannis-Megali Katavothra	a probable farmstead	Lauffer, Gnomon 1952: 483; Hope Simpson 1965; Fossey 1988: 286

Table 1. *Greco-Roman sites along the reconstructed lake edge*

Fluctuating boundaries

Kirsten (1951) points out the problem in defining, in such a 'fluctuating' situation, the borders between the communities around the basin[60] (in a period, like the Classical, when the extension and limit of each territory had an important socio-political value[61]). As has been remarked, the constant tendency of the Greek poleis was to reach a stable border, individuated by reference features, creating a 'linear border' (Daverio Rocchi 1988: 25), or individuating 'no man's land' as separating officially recognised areas. Therefore, the border line was given a political importance as well as a sacral value[62].

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[60] The land that a lake gives to the people seasonally (or even only in certain years) is an element of uncertainty for the community surrounding the lake. In a community based on agriculture, where property is of value (as it was in Classical Greece), as soon as land is free from water, it immediately becomes desirable for exploitation by someone, i.e. even marshy land needs to have an owner. One might suppose that conflict between communities would arise here (for Copais see Kirsten 1951). If land flooding and de-flooding are regular phenomena, then the communities would set rules, and whenever an area of land dried and became available for cultivation, people from the same community would always cultivate it. If rules were not set, and borders not clearly defined, people would have to fight for their land each time.

[61] Snodgrass 1987-9; Piérart 1974: 259ff, and many others.

[62] The border line has a political value and expresses a political boundary. It is perceived as the limit of the portion of land on which the power of the city-state realises its control in a natural and stable way. The border has to be intended in relation to what it includes, i.e. the appropriation of the concept of polis in its physical, social and political dimension (Daverio Rocchi 1988: 25-26).

Kirsten (1951: 670-1) had also noted that, around the Copais, the different gulfs formed by the basin morphology became in practice the defined (at least on three sides) *chorai* of each *polis* (the area available to it and belonging to it). Kirsten suggests that the territory was well defined on all four sides when the water level was high. In this case, the lake would act as a good marker for the definition of the different areas, better defining each *polis chora* (ways of communication, roads, were beyond the hills around the lake, as the presence of sanctuaries, such as the *Tilphossion* or the *Ptoion*, indicates). The territory extended into the basin as much as the relief and the dry area. On the other hand, when the water level was low, from natural reasons or from attempts to drain the lake, the *poleis* would have to define their boundaries in the direction of the lake again. The boundary inscription carved on a rock, marking the border between Copai and Akraiphia, may present proof of the necessity of an intervention of the Boeotian Confederation in Hellenistic times to solve a dispute[63].

We could check whether this reading of the situation in Archaic/Classical/Hellenistic times is valid and works within our model; taking as the high level of the lake Kirsten talks about the 95m level (Knauss 1987), and as the low level of the lake, 92.5m (Knauss 1987). However, we should consider the territories of the individual poleis, and the lake's effect on them, also in the case of a water level at 93.5m ('normal' summer season level, according to Knauss), as well as at 96m (exceptional winter 'catastrophic' level, according to Knauss) and at 97m (the maximum level known), in order to better test Kirsten's remarks. In the light of the reconstructed model of the lake fluctuations, the lake in the W part of the basin was always, even in high water level conditions, lying back in respect to the edge of the basin. Although one should not forget that water is a widely-used border element, one would suggest that, especially in the S and W areas of Copais, the projections of the surrounding relief into the basin are the most significant border element, as Kirsten 1951 correctly remarks (see fig.3 and fig.6).

An open question, for instance, is the location of the border line between the territories of Orchomenos, Chaironeia and Levadeia. As Fossey has already suggested (1988: 500), it is very hard to define actual territorial divisions in a landscape such as the Copais plain and in particular in its W part (the lines marked on the map in fig.3 are only arbitrary, especially as for the border lines within the basin).

Fossey (1988: 501 and 497-500) notes, on the basis of ancient texts[64], that the *chorai* of Levadeia and Chaironeia did not border the lake and therefore locates the limit of the *chorai* very much lying back in relation to the Copais basin. He proves his argument with a boundary stone, found among the remains of the Herkyna dike[65], in the middle of an area which constitutes the Western part of the basin. It carries simply the word ὅρος. Fossey (1988: 497-500) believes it marked, in Early Roman times at least[66], the boundary between Koroneia and Orchomenos since, as he believes, the

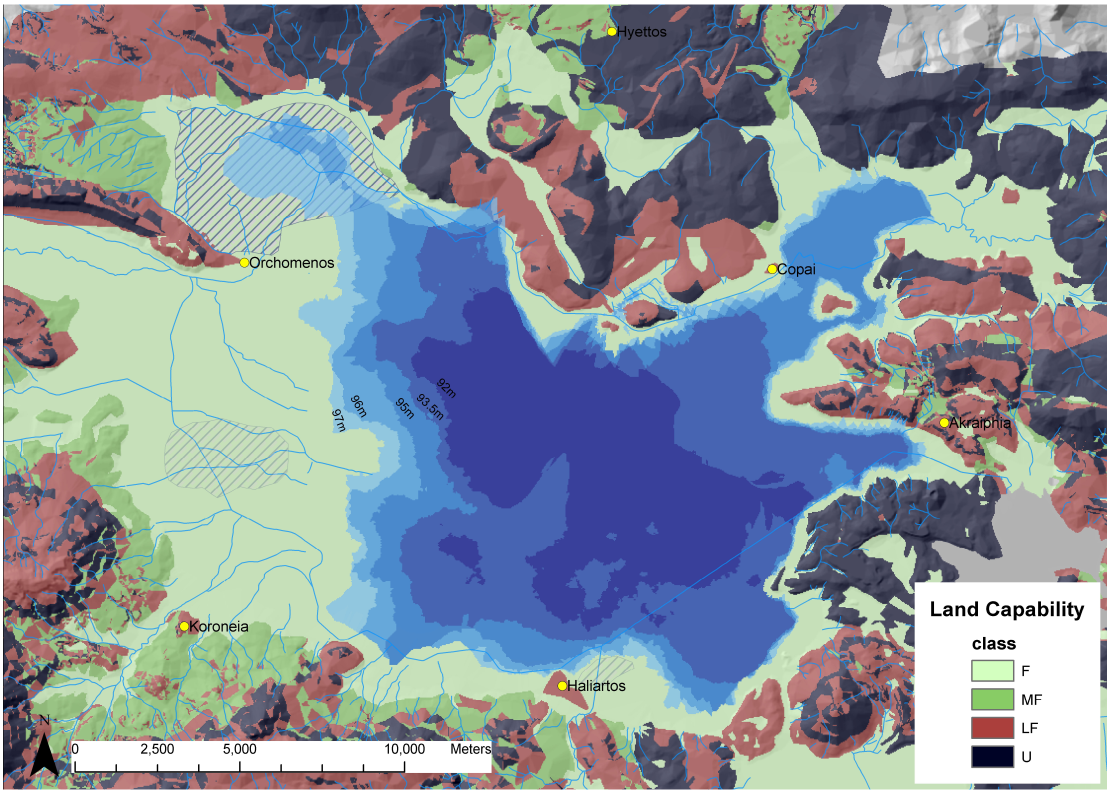
[63] IG VII 2792: 'border between Copai and Akraiphia, defined by the Boeotians'. The inscription was found on Phtelio cape (see fig.4).

[64] Pausanias IX 39.1; IG VII 3170; Theophrastus *HP* IV 11.8; Strabo IX 407.

[65] The inscription [AE1108] was found in Dodekakleidi locality, about 0.5km N of Xinos (Fossey 1988: 501). The Roman dam in which the inscription was found is mapped in fig.2 after Knauss et al. Kopais 2.

[66] The boundary stone is dated to the 2nd-1st C BC (Fossey 1988: 501).

territories of Levadeia and Chaironeia did not reach the lake and therefore Koroneian and Orchomenian *chorai* were neighbouring.
Kirsten also assumes that the territories of Chaironeia and Levadeia did not reach the lake. He states (1951: 670): ‘Because the territory of Orchomenos extended until the highland (until Probatia[67] and Kephisos), which was also the border with Levadeia and Chaironeia, Orchomenos was the richest *polis* of the Copais basin and that’s why it was predestined to be the leader, the leading centre of the Copais area’. I think that this should be reconsidered, since the lake in this Western part of the basin was really lying back (i.e. the water of the lake did not fill in the ‘bays’, unlike Karditsa bay, or the NE bay), forming a real plain (see fig.3 and fig.5). Perhaps the *chorai* of the two *poleis* (Levadeia and Chaironeia) extended as far as the beginning of the plain, with the plain itself belonging mainly to Orchomenos (this, probably, is the location of the city plain, mentioned as Hyppia in ancient texts[68]). A division of the land based on a cost-distance analysis[69] from the *poleis* surrounding the lake would support this hypothesis (fig.6). This might also help to explain the inner location of Chaironeia and Levadeia within their valleys.



[67] The Herkyna river, identified with ancient Probatia (see chapter II.3.2).
[68] The Hyppia plain is known, in association with Orchomenos, from ancient sources (Theophrastus *HP* IV 11.8) as the largest and nicest plain of Boeotia (Plut. *Sull.* 20.4-5), where the infamous Minyan cavalry was trained. See Knauss et al. Kopais 3 fig.6.8 and in this article fig.4.
[69] The cost-distance analysis (performed within the GIS system) takes into account, in calculating the distance between locations, the effort (cost) of moving (walking) through the land. The algorithm used is mainly based on distance and slope (see for instance Stančic et al. 1997, Gillings and Wheatley 2002: 151ff, Howard 2007), taking therefore into account the terrain morphology. A similar attempt of exploring territorial divisions in the area was carried out by Fossey (1988, fig.64), using Thiessen polygons (based on Euclidean straight-line distance not weighted by topography).

Fig.5 *Map showing the location of the Greco-Roman* poleis *around the Copais basin, the classification of land capability for agriculture in the area (F. fertile, MF. mid fertile, LF. low fertile, U. unsuitable)*[70]*, and the suggested model of the lake fluctuations*

We should always consider also the actual hydro-geological conditions of the plain, which could have been marshy most of the time in some areas (see above). This brings up a further open question: in the Archaic period[71], Orchomenian coins carried on the reverse an ear of corn (Babelon 1907: 938 and Hill 1906: 7). Fossey comments (1988: 364) that this is 'somewhat ironical', since the land of Orchomenos doubtfully can ever have been very productive of crops, since the North-Western bay was marshy in Classical times[72]. In the light of Knauss' information and of our attempt at modelling the hydrological situation and the fluctuations of the lake's extents, we could look more carefully at the interpretation of the relationship of the *polis* of Orchomenos with the lake, and the character of its economy. We know that variations of the lake's water level did not influence the area of Tsamali (NW corner – Theophrastus' Orchomenos lake), whose permanent marshiness was due to the water of the Melas and the springs at the foot of Akontion (see above). We may consider, for instance, the presence of a very large plain to the S of the *polis*, which probably belonged mainly to it, and was perhaps also very fertile, rich in thick soil (limus deposits), though probably slightly marshy most of the time (see Philippson, who discusses the area of Agios Dimitrios – see above[73]), taking into account the actual hydro-geological conditions of the plain. Theophrastus informs us of the density of Boeotian wheat (*HP* VIII 4.5) due to thick soil and cold climate (*CP* IV 9.5). Despite all this, before Orchomenos lay a large cultivable area, fertile and quite suitable for cereal cultivation, even if slightly or temporarily marshy, as in the case of the modern village of Mouriki, at the E edge of Yliki lake.

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[70] The classification of land capability for agriculture in the area is based mainly on the geological maps available from I.G.M.E. (*Institouto Geologikon kai Metalleftikon Erevnon*: the Greek Institute of Geology and Mineral Exploration), considerations on erosion and land workability in Greco-Roman times, as well as personal checking on the ground.

[71] First Orchomenian coinage, around 550 B.C.

[72] Fossey refers to Plutarchus *Sull.* 20.4-5 and Theophrastus *HP* IV 10-11.9 who talk about the 'Orchomenian lake', which, however, probably refers to the Tsamali bay (see above).

[73] *Digital reconstruction and modelling of the lake fluctuations* section.

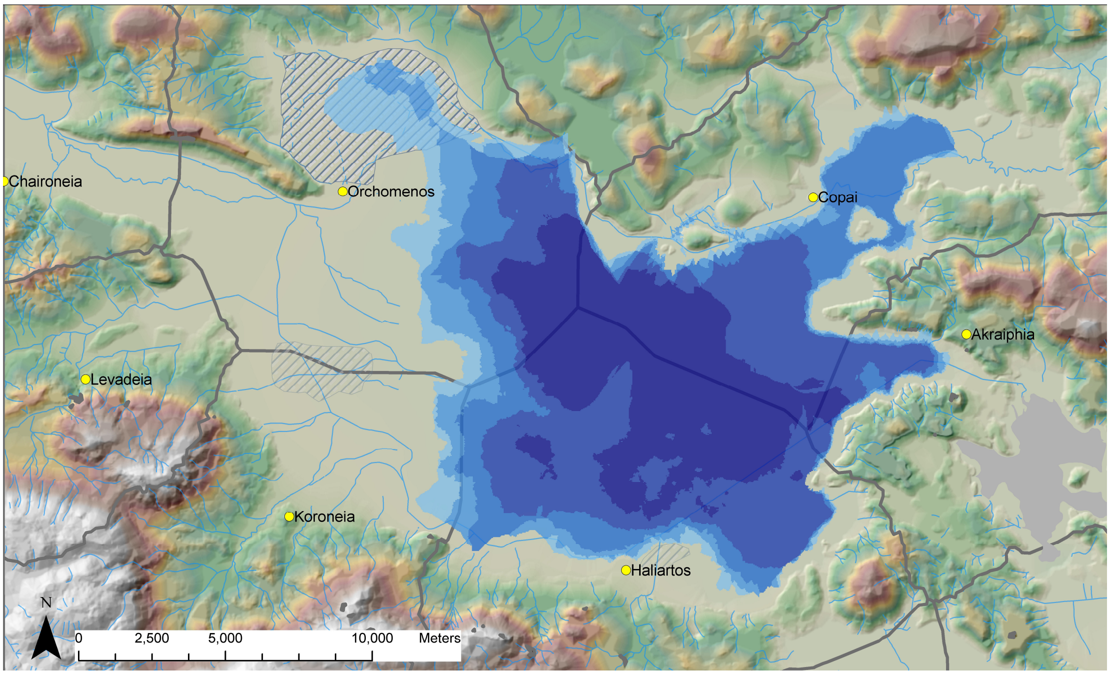

Fig.6 *A division of the land based on the results of a cost-distance analysis from the poleis surrounding the lake.*

Concluding, I hope to have dimonstrated that, in the light of the suggested model, we can reconsider the existing discourse on the borders of the communities surrounding the lakes, their economy, their potential and also their effective historico-political power.