

20 VOLES (RODENTIA, MAMMALIA) AS A PROXY TO DATE THE SITE KYPARISSIA 4 (MEGALOPOLIS BASIN, GREECE)

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20.1 INTRODUCTION

The Palaeolithic record provides us insights into the hominin migration patterns and into the way hominins adapted to the changing climatic conditions, as well as how they evolved both physically and culturally. In order to make such interpretations, the age of a Palaeolithic site is of pivotal importance; however, dating of deposits with Palaeolithic finds is often a great challenge. Absolute dating methods, such as radiocarbon, luminescence (TL as well as OSL), potassium-argon or U/Th dating, are possible options to apply. Nonetheless, besides their assets, they also have specific limitations, and the application of absolute dating methods does not always yield reliable ages. An alternative way to estimate the age of a site is the

so-called relative dating method. A classic example of the relative dating is the application of the biostratigraphical evidence. Biochronological dating is based on the fact that the fossil record changes through time due to the migration, evolution and extinction of species, and the detailed knowledge of these changes can be applied to provide relative age estimations for a site. The Quaternary mammalian fossil record yields detailed biostratigraphical data. The climatic fluctuations that characterize the Quaternary, resulted in major mammalian migration/dispersal events and rapid evolution of specific species/lineages. The Quaternary fossil record shows an increase of crown height in the molars of different taxa (e.g., mammoth, rhinoceros, voles), a phenomenon that is regarded as an adaptation to the incorporation of more abrasive



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foods into the diet. Changes in the rodent fauna constitute the base for the biostratigraphical subdivision of the Quaternary into Villanyian, Biharian and Thoringian.

A relatively rapid evolution can be observed in the dental record of fossil voles (Rodentia, Arvicolidae). Different lineages show successively, but not simultaneously, an increase of crown height in the molars, the formation of crown cementum, the development of rootless molars, changes in enamel structure and in the differentiation of the enamel thickness, and the formation of additional enamel in the upper M3 and the lower m1 that results in an increase of complexity of the occlusal surface of both molars. Voles of the genus *Mimomys* are very abundant in the fossil record. The appearance of *Mimomys* species, which have molars with crown cementum, such as *M. minor* and *M. hajnackensis*, mark the beginning of the Villanyian during the Pliocene (van der Meulen and van Kolfschoten, 1986). The appearance of the genus *Microtus* in the European fossil record is regarded as the marker of the Villanyian/Biharian boundary (Fejfar and Heinrich, 1990). Voles of the genus *Microtus*, characterized by unrooted molars, are well-represented and often a dominant taxon in the micro-mammalian fauna since their Early Pleistocene appearance ca. 2 million years ago (Tesakov, 1998). The evolutionary changes in the water vole lineage resulted in the replacement of *Mimomys savini* (a species with rooted molars) by *Arvicola cantiana* (with unrooted molars), which marks the Biharian/Thoringian transition with an age of ca. 0.5 Ma.

20.2 FOSSIL VOLES FROM THE MEGALOPOLIS BASIN

The occurrence of mammalian fossils in the Pleistocene deposits of the Megalopolis Basin is well-known since the beginning of the 20th century

(Skouphos, 1905), and since then several studies have described the large mammalian remains (e.g., Melentis, 1961, 1965; Sickenberg, 1975; Athanasiou, 2018; Konidaris et al., 2018). In the last decades, several systematic studies of the Megalopolis Basin's small mammals have been conducted (see also Doukas and Papayianni, 2016), particularly focusing on the late Early–Middle Pleistocene Marathousa Member. The Marathousa Member (Choremi Formation) consists mainly of clastic deposits of fluvio-lacustrine origin, intercalated by lignite seams; the latter are distinguished into three main lignite packages, namely Lignite Seams I, II and III (from the lower to the upper one) (Vinken, 1965). Below is a summary of the studies conducted so far on the micromammals originating from these deposits.

20.2.1. THOKNIA

Benda et al. (1987) published the small mammal assemblage collected from the lower lignite bed exposed in the Thoknia lignite mine (Fig. 1a). They identified only two taxa, *Mimomys (Kislangia) rex* and *Pliomys cf. bolkia*, and they state that the presence of *Mimomys rex* and the absence of *Microtus* (even though the assemblage is small) allows for a correlation to the upper part of the Villanyian.

20.2.2. CHOREMIOU SECTION

In order to contribute to the discussion on the stratigraphical position of the Marathousa Member, a team of Greek and Dutch paleontologists sampled at the Choremiou section (Choremi lignite mine; Fig. 1a) four different levels with mammalian remains: CHO 1 and CHO 2 are from Lignite I, CHO 3 is from the base of Lignite II, and CHO 4 is from deposits that were originally

assigned to Lignite III. However, the study of the small mammals from Marathousa 1 (see below) and the recent research in the basin (Karkanas et al., this volume), which shows extensive faulting in the Choremi mine, indicate that the CHO 4 fauna originates from a lower lignite seam.

All four CHO samples yielded vertebrate remains: Reptilia are well represented in CHO 2, CHO 3 and CHO 4, while mammalian remains are most abundant in CHO 3 and CHO 4, with 68 and 94 identifiable specimens, representing ten and seven species, respectively (van Vugt et al., 2000). The Choremiou faunal assemblages include three different voles: *Pliomys* aff. *episcopalis*, *Mimomys* aff. *savini* and *Mimomys* sp. The large vole, *Mimomys* aff. *savini*, with hypsodont molars with crown cementum in the re-entrant angles, is by far the most abundant species. The majority of the larger lower m1 molars show an occlusal pattern that resembles *Mimomys savini*; the pattern of only a few larger lower m1 molars resembles that of the molars from Thoknia assigned to *Mimomys rex* by Benda et al. (1987). Both CHO 2 and CHO 4 yielded in addition a rooted molar with a *Mimomys* pattern and crown cementum in the re-entrant angles, that are too small to be assigned to *Mimomys* aff. *savini*. These two molars are therefore listed as *Mimomys* sp.

Mimomys aff. *savini*, the species that is well represented in the four Choremiou assemblages, does not show any difference in morphology and size among the different levels. This observation suggests that the four faunas do not differ much in age and, as a consequence, it indicates that there is no major stratigraphical hiatus in that particular part of the Choremiou sequence.

Remarkable is the absence of the genus *Microtus* in the Choremiou faunal assemblages. Benda et al. (1987) assumed a late Villanyian age of the Marathousa Member because of the absence of the genus *Microtus* in the Thoknia small mammal

assemblage. However, a taphonomic/ecological explanation seems to be more applicable (van Vugt et al., 2000). The complete absence of terrestrial molluscs in the fauna CHO 2, CHO 3 and CHO 4 combined with the dominance of aquatic taxa in the herpetofauna, indicate specific paleoenvironmental conditions that are unfavorable for the accumulation of terrestrial voles, such as *Microtus*. Hence, the absence of *Microtus* in the Choremiou assemblages does not necessarily contradict the late Early Pleistocene age of the CHO 1 and CHO 2 faunal assemblages, and the early Middle Pleistocene age of the assemblages CHO 3 and CHO 4.

20.2.3. MARATHOUSA 1

A more recent small mammal assemblage has been collected from lacustrine deposits intercalated between Lignite Seams II and III, exposed at the Middle Pleistocene (Lower Palaeolithic) site Marathousa 1 (MAR-1), located in the Marathousa mine (Fig. 1a; Panagopoulou et al., 2018). The small mammal assemblage is diverse and includes *Crocidura* sp., *Arvicola mosbachensis*, *Microtus* sp. (cf. *M. arvalis*), *Apodemus sylvaticus* vel *A. flavicollis* and ?*Alactaga* indet., but it is dominated by the voles *Arvicola* and *Microtus* (Doukas et al., 2018). The molars of the larger water vole do not have roots. This indicates that the faunal assemblage is younger than the Choremiou section assemblages, where *Mimomys*, the predecessor of the genus *Arvicola*, is the predominant arvicolid. The unrooted *Arvicola* molars show a positive 'Mimomys' enamel differentiation with a mean SDQ (Schmelzband-Differenzierung-Quotient; Heinrich, 1982) value of 122, which indicates a late Middle Pleistocene age (ca. 400 ka.; Marine Isotope Stages-MIS 12/11) for the lacustrine deposits, in broad agreement with the radiometric and magnetostratigraphic dating (Blackwell et al., 2018; Jacobs et al., 2018; Turloukis et al., 2018).

Marathousa Lignite Seam III, which is overlying the deposits that yielded the MAR-1 small mammal assemblage, must therefore be of late Middle Pleistocene age or younger.

20.2.4. KYPARISSIA 4

A fourth site in the Megalopolis Basin that yielded fossil micromammals is Kyparissia 4 (KYP-4) in the Kyparissia mine (Fig. 1a, b). KYP-4 was discovered in 2007 and has yielded a rich and diverse assemblage of large mammals (Athanassiou, 2018; Athanassiou et al., 2018). In 2019, KYP-4 was re-

visited during a systematic and targeted field survey in the framework of the Megalopolis Paleoenvironmental Project (MegaPal) and the CROSSROADS ERC project (Harvati, this volume; Karkanas et al., this volume). Two main areas of interest were defined, Area A (the findspot of Athanassiou, 2018) and Area B (to the east of Area A, including a partial *Hippopotamus* skeleton). In addition to the discovery of lithic artifacts (Karkanas et al., this volume) and the enrichment of the large mammal collection both in terms of specimens and taxa (Athanassiou et al., this volume; Konidaris et al., this volume), sampling for molluscs (Boni et al., this volume), ostracods (Papadopoulou et al., this

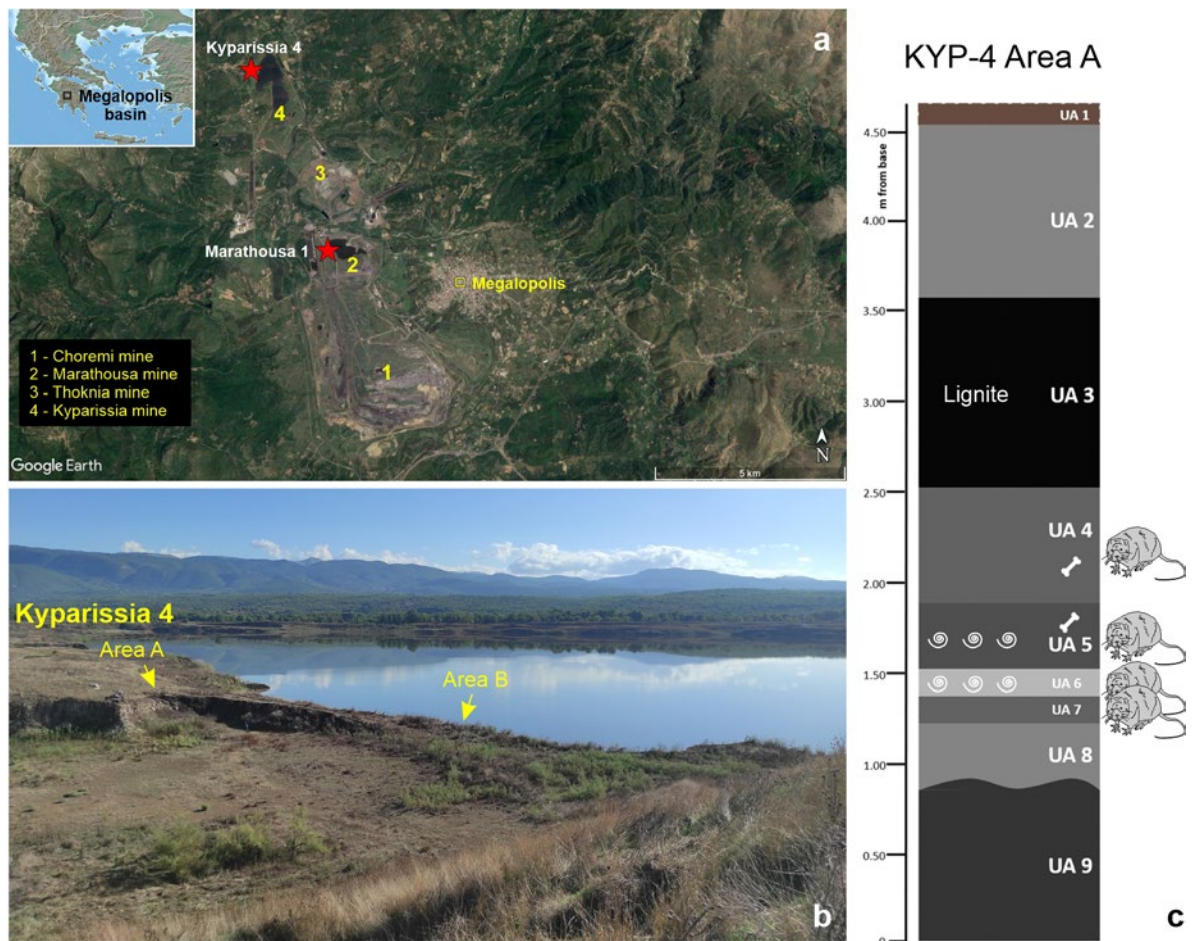


Figure 1: a, Geographic position of the Megalopolis Basin, and of the micromammal-bearing Middle Pleistocene (Lower Palaeolithic) sites Kyparissia 4 and Marathousa 1, in relation to the main lignite mines of the basin (satellite image from Google Earth); b, distant view of Kyparissia 4; c, simplified stratigraphic column of KYP-4 (Area A) showing the stratigraphic units, and the position of the samples that were taken and contain small mammals; water vole drawing redrawn and modified from <https://www.drawingtutorials101.com/>.

volume) and micromammals (this study) was also conducted. The KYP-4 sedimentary sequence is divided into several distinct stratigraphic units, comprising an alternation of dark grey organic rich mud layers with an intercalation of a lignite layer towards its upper part (Fig. 1b). The larger mammal fauna consists so far of the following taxa (Athanasioiu, 2018; Athanasioiu et al., 2018, this volume; Konidaris et al., this volume): *Castor fiber* (beaver), *Macaca sylvanus* (macaque), *Vulpes* sp. (fox), *Palaeoloxodon antiquus* (straight-tusked elephant), *Stephanorhinus* sp. (rhinoceros), *Equus* sp. (horse), *Sus scrofa* (boar), *Hippopotamus antiquus* (hippopotamus), *Dama* sp. (fallow deer), *Cervus elaphus* (red deer), *Praemegaceros verticornis* (giant deer) and *Bison* sp. (bison). The analysis of the first collection of small mammals from KYP-4 forms the primary focus of the present study.

20.3 METHODS

Sediment samples to collect small vertebrate remains were taken from the site KYP-4 during the fieldwork of 2019 and 2020. Twenty-two sediment samples, weighing ~70 kg in total, were collected. The majority of the samples originate from the main lithic/vertebrate-bearing unit UA4 (13 samples; ~40 kg) in Area A, while the rest come from UA5 (5 samples; ~15 kg) and UA6 (2 samples; ~7 kg) of the same area (Fig. 1c), as well as from the mollusc-rich *Hippopotamus*-layer in Area B (2 samples; ~6 kg). Additionally, one arvicolid hemimandible was directly collected from unit UA7 during the fieldwork. Sediment samples were air-dried and then soaked in containers filled with water and ~50 ml of 30% concentration H₂O₂. Subsequently, samples were wet sieved using a 0.5 mm mesh and then left to air-dry. Examination and sorting for vertebrate remains was conducted under a stereoscopic microscope. Complete or partly fragmented recognizable vertebrate remains were

collected. Here, we focus on the more diagnostic and informative dental elements of the collected small mammals, which are identified to the lowest taxonomic level possible.

20.4 RESULTS

The Kyparissia 4 sediment samples from the units UA4, UA5 and UA6 (plus the isolated hemimandible from UA7), and the *Hippopotamus* layer in Area B, yielded in total more than 1000 small vertebrate remains; UA5 is the richest unit with ca. 700 specimens. The highly fragmented remains represent a variety of taxa: fish (Cyprinidae), frogs/toads, snakes, insectivores —shrews (to be identified)— and rodents (Fig. 2a, b). The rodent assemblage, taking into account the small number of dental remains, is very diverse. At least five different taxa could be identified: *Mimomys* sp. (cf. *Mimomys savini*) (large), *Mimomys* sp. (small), *Microtus* sp., *Apodemus* sp. and ?*Mus* cf. *spretus*. The faunal assemblage includes only seven complete molars: one shrew molar, three murid molars and three complete vole molars. Based on the characteristics of the available remains (rooted molars with cement and a *Mimomys* enamel differentiation), it is obvious that at least two taxa of the genus *Mimomys* are represented. The larger one is represented by an upper M3 (Fig. 2c) and a lower m2 (Fig. 2d); the small one is represented by a lower m3 (Fig. 2e). The small mammal assemblage also includes unrooted molars that are assigned, based on the morphological features, to the genus *Microtus*. The occlusal surface of the unrooted *Microtus* lower m1 shows the occurrence of five more or less closed triangles and an *arvalis*-type anterior cap (Fig. 2f). The morphology indicates the presence of a *Microtus* (*Microtus*) species and excludes a species of the subgenus *Microtus* (*Allophaiomys*). Species-level identification of the *Microtus* remains is not justified because of the limited number of identifiable specimens. The di-

mensions of the three murid molars indicate that we are dealing with two different species: a larger one, possibly a representative of the taxon *Apode-*

mus sylvaticus, and a smaller one with the size of *Mus cf. spretus*, a taxon that is well represented in



Figure 2: a, b, Microscope views of small vertebrate remains from Kyparissia 4; c–f, voles from Kyparissia 4, stratigraphic unit UA5: c–d, larger *Mimomys* species (cf. *Mimomys savini*): c, upper M3 sin.; d, lower m2 dext.; e, smaller *Mimomys* species: lower m3 sin.; f, *Microtus (Microtus)* species: lower m1 dext. (c1, d1, e1, and f1 in occlusal view; c2, d2, and e2 in lingual view; f2 in labial view).

the Choremiou 4 small mammal assemblage (van Vugt et al., 2000).

20.5 DISCUSSION – CONCLUSIONS

The occurrence of voles of the genus *Mimomys* (characteristic for Early–early Middle Pleistocene faunas) in the KYP-4 fossil assemblage, indicates that the fauna is clearly older than the one from the middle–late Middle Pleistocene site of Marathousa 1 (Doukas et al., 2018). The KYP-4 small mammal assemblage shows similarities with the Choremiou 3 and 4 mammal faunas. The presence of *Microtus* (*Microtus*) indicates that the fauna post-dates the *Allophaiomys*/*Microtus* transition that takes place roughly around the Early/Middle Pleistocene transition (Brunhes/Matuyama geomagnetic polarity boundary; 780 ka). The combination of voles with rooted molars assigned to the genus *Mimomys* and unrooted *Microtus* (*Microtus*) molars suggests an early Middle Pleistocene age for the KYP-4 small mammal assemblage. This age is in agreement with the available stratigraphic and macromammal biochronological data, and thus altogether, the current evidence indicates that KYP-4 is older than MAR-1 (500–400 ka) and is placed in the lower part of the Middle Pleistocene.

The presence of a medium-sized vole of the genus *Mimomys* is biostratigraphically important. Medium-sized *Mimomys* taxa are well represented in the European Early Pleistocene fossil record, but most of them went extinct before the end of the Early Pleistocene. Only one medium-sized vole, *Mimomys pusillus*, has a larger biostratigraphical range. A limited number of European sites, e.g., Choremiou (van Vugt et al., 2000; Doukas and Papayianni, 2016), Kärlich, Germany (van Kolfschoten and Turner, 1996), Pakefield, UK (Parfitt et al., 2005) and Chiu-Atasova, Russia (Southern Urals; Danukalova et al., 2016) indicate the early Middle Pleistocene (predating MIS 16) occurrence

of a medium-sized *Mimomys* species. The species is rare, and the remains are often assigned to *Mimomys* sp. because of the absence of diagnostic elements.

The KYP-4 small vertebrate record is small. However, if one considers the small amount of sediment that has been processed (in total ca. 70 kg; in comparison, the Choremiou sediment sample was 10 times larger), it is obvious that the deposits that have been sampled are very rich in small vertebrate remains. Remarkable is the fact that the diversity of the encountered small mammal fauna is high and that the sample includes biostratigraphically important taxa. It emphasizes the importance of the Megalopolis Basin, and in particular, the deposits exposed in the Kyparissia lignite mine, for the detailed study of the Eurasian faunal evolution. The results of these studies are of great importance to date the hominin presence in regions such as the eastern Mediterranean.

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