

15<sup>th</sup> Congress of the

RCMNS

Regional Committee on Mediterranean Neogene Stratigraphy

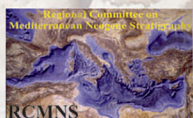
# Exploring a “physical laboratory”: the Mediterranean Basin

2017 SEPTEMBER  
03<sup>rd</sup> - 06<sup>th</sup>

Crowne Plaza Hotel  
**ATHENS, GREECE**



HELLENIC REPUBLIC  
National and Kapodistrian  
University of Athens



Regional Committee on Mediterranean  
Neogene Stratigraphy



Geological Society  
of Greece



Hellenic Committee of  
Palaeontology-Stratigraphy



Hellenic Sedimentological  
Association



Geotechnical Chamber  
of Greece

Book of Abstracts



HELLENIC REPUBLIC  
**National and Kapodistrian**  
**University of Athens**

**Book of Abstracts**  
**of the 15<sup>th</sup> Congress of the RCMNS**

**Athens, Greece 2017**



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Regional Committee on Mediterranean Neogene Stratigraphy  
National and Kapodistrian University of Athens  
Geological Society of Greece  
Hellenic Committee of Palaeontology and Stratigraphy  
Hellenic Sedimentological Association  
Geotechnical Chamber of Greece

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## Welcome Letter

Dear Colleagues and Friends,

On behalf of the Organizing Committee, I would like to thank you for joining us at the 15th RCMNS Congress ***“Exploring a “physical laboratory”: the Mediterranean Basin”*** which is taking place in Athens, Greece, on September 3-6 2017 at Crown Plaza Hotel. This congress is co-organized along with the RCMNS and the National and Kapodistrian University of Athens, helping in a fruitful exchange of opinions and visions among the Greek, the European and the International colleagues.

The main topic of the Congress is the Mediterranean Sea and includes all the cognitive fields connected with geo -sciences/earth sciences, physical processes, human activities as well as the burgeoning environmental changes. The prime target of the Conference is to present and disseminate knowledge, to develop the “know-how” in methodology and presentation of research results in this specific scientific field which will be addressed.

To our eminent speakers and all participants who have come from all over the world, we are greatly honored and pleased to welcome you in Athens. We are indeed honored to have you here with us.

The Greek organizing committee and also the scientific committee have done a fantastic work preparing our congress and I would like to thank them for their energy, competence and professionalism during the organization process.

We have with us today representatives from universities and research organizations. We hope that these three days of congress, allows academics, researchers and professionals to share their ideas and views on the Neogene Geology of Mediterranean.

By the end of the Congress, as usual, we intend to formulate the final conclusions and eventually make some recommendations, which will be a benchmark for the future and will certainly contribute to promote excellent research.

The congress includes three keynote lectures by G. Koufos on “Chronology and Biostratigraphy of the Neogene-Quaternary continental deposits of Greece”, by W. Piller on “In and out – tracing Mediterranean – Atlantic interactions in the Neogene” and by P. Megalovassilis on “A brief history of marine geochemical hydrothermal research in Oceans and Seas of Earth”. The technical programme includes 162 oral and poster presentations organized in 13 sessions: 1) Koufos' Eden: mammals (and not only) at the eastern corner; 2) Towards a new understanding in the Messinian Salinity Crisis; 3) The effect of the Messinian Salinity Crisis on the Mediterranean fish fauna; 4) Tectonics and Geodynamics; 5) Marine Geology and the Aegean Volcanic Arc; 6) Mediterranean Paleoceanography and Geochemistry; 7) Mediterranean Paleoclimatology; 8) Tortonian-Messinian transition on land; 9) A revolution in European Biochronology: 40 years of MN zones; 10) Neogene Mediterranean Paleogeography; 11) Mediterranean and Paratethys; 12) Environmental Geosciences; 13) Cenozoic plant assemblages in the E. Mediterranean region.

Athens, a city famous all over the world for its history and culture, has many places of interest within a relatively small area surrounding the city center (Syntagma Square) in walking distance from the congress venue. The Crown Plaza Hotel is also conveniently situated nearby to the districts of Plaka and Monastiraki (old town) as well as Kolonaki (shopping and museums area and night life district). Acropolis, the New Museum and charming historic quarters with restored 19th century neoclassical homes, picturesque pedestrian streets, shops and restaurants, and ancient monuments from classic and Roman era will offer you unforgettable memories to take home.

I wish you a fruitful Congress and an enjoyable stay in Athens.

On behalf of the Organizing Committee

Professor Hara Drinia

Chair of 15th RCMNS Congress  
National and Kapodistrian University of Athens  
Department of Geology and Geoenvironment

## **The RCMNS Congress over time**

The Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS) has been organised for almost 60 years and so far, it has been successful. The committee is part of the Subcommission on Neogene Stratigraphy (SNS) of IUGS within which it plays an important role. Firstly, due to intensive studies in the Mediterranean region, most of the global GSSPs for the Neogene have been established in this area, pointing at its overall importance. Secondly, from the start, great attention has also been put on the Paratethys for its widely decoupled evolution from the Mediterranean and its correlation with the Mediterranean successions, which both demonstrate our understanding for these different water bodies.

Fourteen successful congresses have been already organized and the fifteenth is now hosted in Athens, the second one since 1979. The current global environmental/ecological status, the constant need for energy resources and the need for a comprehensive understanding of the geological processes, that have started in the past and still affect the peri-Mediterranean regions, make the purposes of this Congress always well-timed.

Emeritus Professor Michael D. Dermitzakis

Honorary Chair of 15th RCMNS Congress  
National and Kapodistrian University of Athens  
Department of Geology and Geoenvironment





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## KEYNOTE LECTURES

### CHRONOLOGY AND BIOSTRATIGRAPHY OF THE NEOGENE-QUATERNARY CONTINENTAL DEPOSITS OF GREECE

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**Objectives:** Since the beginning of the 1970's, the chronology and biostratigraphy of the continental deposits, filling the Neogene/Quaternary basins of Greece, restricted to some old information for Pikermi, Samos, "Saloniki" and Megalopolis. The information were scarce, doubtful and in many cases without or limited stratigraphic background. Extensive field work during the last 50 years, carried out by several local and foreign researchers, led to the discovery of numerous mammal fossiliferous sites and a great amount of fossils have been unearthed and studied. The present work is an effort to bring all recent data together in order to build an updated biostratigraphic table for the Neogene-Quaternary continental deposits of Greece. The table is restricted to this time span as there is one reference about the presence of Paleocene and another one for ?Oligocene in Thrace.

**Methods and Results:** The study of the new and old mammal collections provided several biochronological data, constituting an important basis for the biostratigraphy of the continental deposits. In addition, new dating methods (e.g. magnetostratigraphy, radiochronology) allow obtaining absolute ages for several mammal faunas. Similar researches in the neighboring countries enriched remarkably our knowledge and provided information for better faunal comparisons and biostratigraphic correlations.

The Early and Middle Miocene information are limited as the known mammal fossiliferous sites and faunas are scarce. The oldest Neogene mammal faunas of Greece are those of Gavathas and Lapsarna (Lesvos Island), dated to the early Orleanian, MN 3 with an age >18.5 Ma. Recent studies of the Early Miocene fauna of Aliveri (Evia Island) and the Middle Miocene one of Thymiana (Chios Island), dated to MN 4 and MN 5 respectively, provided useful information for these time intervals. The Late Miocene mammal fossiliferous sites of Greece are numerous and their rich faunas gave accurate biochronological data. Their combination with the results of magnetostratigraphy and radiochronology provided an almost complete biostratigraphy for this time interval. The Pliocene mammal fossiliferous sites are relatively rare and the faunal data poor, thus the biostratigraphy of this period is limited. Several new Early Pleistocene faunas have been discovered and their extensive study provided accurate chronological evidences allowing the biochronology and biostratigraphy of the corresponding deposits. There are numerous Middle-Late Pleistocene fossiliferous sites in Greece but the majority of the mammal collections are fragmentary, including a single or a few fossils with doubtful determinations; moreover several of them originated from caves or fissure fillings with limited stratigraphic significance. Additionally, great number of Late Pleistocene faunas are endemic insular ones having only local biostratigraphic significance.

**Conclusions:** The extensive field work and the numerous publications of the last decades, have greatly promoted the mammal biostratigraphy of the Neogene-Quaternary continental deposits of Greece. Nevertheless additional efforts are necessary to complete this, focusing on the gaps of Early-Middle Miocene and Pliocene.

# A BRIEF HISTORY OF MARINE GEOCHEMICAL HYDROTHERMAL RESEARCH IN OCEANS AND SEAS OF EARTH

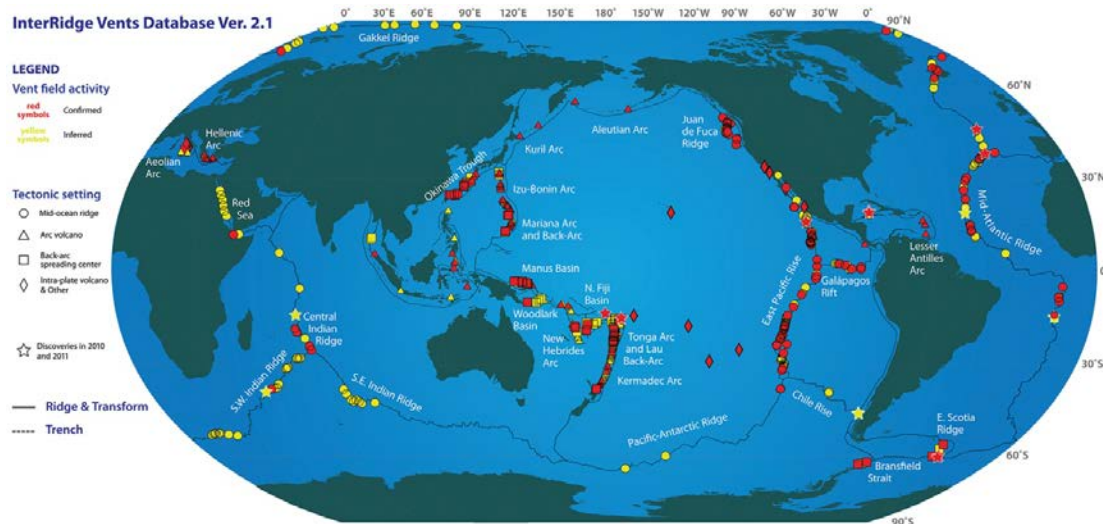
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**Objectives:** Submarine hydrothermal activity although suspected it has been identified almost accidentally in Galapagos Ridge 40 years ago in 1977 due to the discovery of temperature anomalies recorded in the water column attributed to low-temperature vents (Lonsdale, 1977; Corliss et al., 1979), while the first high-temperature black smoker vents were discovered at 21°N on the EPR a few years later (Rise Group, 1980; Spiess et al., 1980; CYAMEX, 1981). Since then, numerous marine scientists from various fields of interests are constantly following the pioneering work made by a few scientists and are adding new discoveries of geochemistry and biogeochemistry about these special marine environments. Hydrothermal activity at mid-ocean ridges is one of the key processes governing the transfer of energy and material in various forms, from the inner part of the planet. In addition, hydrothermal water-rock interactions play a major role and influence remarkably the composition of the oceanic crust and the chemistry of the oceanic water masses. Moreover, hydrothermal vent fields produce exciting ecosystems that support diverse and in some cases unique biological communities which are highly involved in the organic carbon cycle. Hydrothermal venting is a major earth geochemical process and deserved much further attention from all the research community.

**Methods & Results:** The present study presents the history in brief of the original Marine research on submarine hydrothermal systems the last 40 years. Analyse the multidisciplinary findings on these exciting systems on earth seafloor from the geological, geochemical and biogeochemical point of view. Emphasis has been given to the most important scientific achievements in marine hydrothermal research in the last 4 decades in various oceanographic environments and regions such as the Pacific and the Atlantic Ocean, the Indian Ocean and the Mediterranean region together with remote locations in various places on Earth. Conclusions are grouped chronologically in an effort to follow the natural evolution of time passed in accomplishing the geochemical knowledge of earth's marine hydrothermal systems.

**Conclusions:** Deep hydrothermal systems of Earth's Oceans together with shallow hydrothermal venting that occur in many Seas is a major key process redistributing elements between rocks seawater, and atmosphere supporting unique biological species and thus plays a very important role in the further understanding of Earth Geochemistry.



**Fig. 1.** Global distribution of hydrothermal fields (map after *InterRidge Programme 2009*).

## IN AND OUT – TRACING MEDITERRANEAN – ATLANTIC INTERACTIONS IN THE NEOGENE

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**Objectives:** The Mediterranean – Indopacific seaway terminated during the Early Miocene resulting in a major change in paleoceanographic and biogeographic conditions. After this termination the connection to and exchange with oceanic waters was possible only to the west with the Atlantic Ocean. This connection, however, changed repeatedly during the Neogene both in location and intensity of water exchange.

We tested these connections in two directions asking several scientific questions:

- (1) Can global oceanic events be traced inside the Mediterranean, are they coeval and are they also expressed in shallow water settings?
- (2) When and to what extent did Mediterranean Outflow Water (MOW) influence Atlantic waters and how can this influence be proven.

**Methods & Results:** For answering question (1) we studied a shallow water carbonate Oligocene – Miocene sequence in the Central Apennine (Decontra section) with sedimentological, paleontological, geochemical, and geophysical methods. All these methods were used to reconstruct the paleoenvironmental conditions and to establish an integrated stratigraphy. The later was primarily based on biostratigraphic tie points, however, it was possible to orbitally tune high-resolution gamma ray (GR) and magnetic susceptibility data to the 405 kyr eccentricity metronome. The tuning allows, within the established biostratigraphic, sequence stratigraphic, and isotope stratigraphic frameworks, a precise correlation of the Decontra section with pelagic records of the Mediterranean region, as well as the global paleoclimatic record and the global sea level curve. Spectral series analyses of GR data further indicate that the 405 kyr orbital cycle is particularly well preserved during the Monterey Event. Since GR is a direct proxy for authigenic uranium precipitation during increased burial of organic carbon in the Decontra section, it follows the same long-term orbital pacing as observed in the carbon isotope records. The 405 kyr GR beat is thus correlated with the carbon isotope maxima observed during the Monterey Event. Finally, the Mi-events could also be recognized in the  $\delta^{18}\text{O}$  record and coincide with plankton-rich, siliceous, or phosphatic horizons in the section.

For elucidating question (2) we studied upper Miocene to lower Pliocene sediment cores from the Gulf of Cadiz (Spain) drilled during IODP Expedition 339: Mediterranean Outflow. Benthic foraminiferal assemblages show a distinct faunal turnover which indicates a considerable change of the depositional environment at the Miocene/Pliocene boundary. Foraminiferal composition suggests high rates of organic carbon flux and poorly oxygenated sea-floor environment for the basal, late Messinian interval. In contrast, earliest Pliocene assemblages point to periodic advection of warm, better ventilated and likely Mediterranean-sourced waters to the studied site. Specific foraminiferal taxa (*Siphonina tubulosa*, *Globocassidulina subglobosa*, *Planulina ariminensis*) and sedimentological and geochemical records (Zr/Al,  $\delta^{18}\text{O}$ ) suggest a rather sluggish Mediterranean Outflow between ~5.3 and 5.2 Ma. Benthic foraminifera, along with sedimentological and geochemical data thus provide the earliest indications of Mediterranean-Atlantic water exchange following the opening of the Gibraltar Strait. Foraminifera of the so called “elevated epifauna” - *Cibicides lobatulus*, *Planulina ariminensis* and *Cibicides refulgens* - were found at this site, but high abundances of *C. lobatulus* and *C. refulgens* coincide with increases of shelf taxa and grain size, related to episodes of downslope transport. This issue calls into question the applicability of these species as MOW proxies. We had therefore to reassess the role of these three epifaunal species by means of stable isotope analyses ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ). The results warrant for caution when considering *C. lobatulus* and *C. refulgens* as indicators of bottom current strength in unstable slope settings, particularly when co-occurring with allochthonous shelf dwellers. In contrast, *P. ariminensis* shows a signature close to deep-water taxa, corroborating its reliability as indicator of MOW.

**Conclusions:** The case study in the Central Apennines shows, that good water exchange existed from the Atlantic Ocean into the Mediterranean which allows for reconstructing isochronic occurrences of the Monterey Excursions and Mi-Events even in shallow water settings. Various records in the Gulf of Cadiz point to a first slight influence of MOW in the earliest Pliocene with considerable variations in intensity later on. The benthic foraminiferal species *Planulina ariminensis*, a member of the “elevated fauna”, can be considered a valuable proxy for MOW.

# ORAL AND POSTER PRESENTATIONS

## RCMNS 1

### GLOBALROTALIIDS APPLICATION TO THE MIDDLE MIOCENE PARATETHYS-TETHYS CORRELATION

#### **Gonera M.**

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**Objectives:** Globorotaliids prior to the Middle Badenian salinity crisis in Central Paratethys have been analysed: CPN 7 (*Orbulina suturalis* Zone) and CPN 8 (*Uvigerina costai* Zone). There are two taxonomic groups of globorotaliids in the studied material: globoconellids (*Globoconella bykovaе* and *G. minoritesta*) and jenkinsellids (*Jenkinsella mayeri* and *J. transsylvanica*). The succession and coiling preferences of these taxa have been applied to appreciate both stratigraphic succession within Badenian and utility to the global range correlation.

**Methods & Results:** Quantitative analyses of the globorotaliids have been performed in hundreds drill-cores samples from the Polish Paratethys (Upper Silesia Basin of the Carpathian Foredeep). It is five stratigraphically-rank intervals of these foraminifers in the studied material. The investigated Badenian begins with sinistrally coiled *Jenkinsella mayeri* with proportionally coiled *Globoconella bykovaе* interval. It is followed by proportionally coiled *J. transsylvanica* FO and Acme. Still proportionally coiled *Globoconella bykovaе* with small number of proportionally coiled *Jenkinsella transsylvanica* present at the top of the Moravian substage (CPN 7) The jenkinsellids disappear during CPN 7: *J. mayeri* first and *J. transsylvanica* after. The CPN 8 begins with a stratigraphic interval barren of globorotaliids (biozone IIC in the Polish Paratethys). It is followed by three episodic picks appearance of globoconellids amongst globorotaliid-barren deposits (Wielician IID biozone in Poland). The picks are as follow: proportionally coiled *G. bykovaе*, proportionally coiled *G. minoritesta* and then sinistrally coiled *G. bykovaе* just prior the Badenian evaporates.

**Conclusions:** The studied Badenian deposits punctuated by a sequence of the globorotaliid data and combined with the oxygen and carbon isotopic measurements allow to calibrate the deposits with the Serravalian GSSP. Proportionally coiled *J. transsylvanica* FO and Acme represent the Langhian Mi-3a cooling. The Paratethys Moravian/Wielician boundary ought to be positioned at the Mi-3b cooling.

**AUTHIGENIC DOLOMITE CONCRETIONS RELATED TO METHANE-RICH FLUID MIGRATION  
DURING THE LATE NEOGENE IN THE SOUTH-EAST SPAIN BASINS**

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**Objectives:** The present study aims to characterize the nature and origin of the diagenetic fluids that were responsible for the precipitation of authigenic dolomite concretions that occur within the Tortonian, Messinian and Pliocene marls in the SE Spain basins. These concretions are widely distributed in the late Neogene basins of Aledo, Fortuna, Columbares, Lorca, Murcia, Huerca Overa and Vera.

**Methods and Results:** The mineralogy and oxygen and carbon isotopic compositions of authigenic dolomites were used to identify the mineral components and to characterize the diagenetic reactions leading to the precipitation of dolomite. The authigenic carbonate concretions are essentially composed of pure dolomite with a composition from stoichiometry to iron-rich. The oxygen and carbon isotopic compositions of these dolomites exhibit wide ranges ( $-6.5 < \delta^{18}\text{O}\text{‰ VPDB} < +5.6$ ;  $-35.5 < \delta^{13}\text{C}\text{‰ VPDB} < +9.8$ ) indicating that carbonate precipitation occurred within the marly sediments due to circulation of fluids of various composition. There are pseudo-cyclic trends of variations of  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  values of the authigenic dolomites that indicate changes in the characteristics of the diagenetic fluids from early Tortonian to early Pliocene.

**Conclusions:** The low  $\delta^{18}\text{O}$  values indicate that relatively warm fluids were migrating through faults system whereas the high  $\delta^{18}\text{O}$  values characterize restricted evaporitic conditions. The low  $\delta^{13}\text{C}$  values are indicative of anaerobic methane oxidation whereas the high  $\delta^{13}\text{C}$  values are related to methanogenesis, both processes promoting the increase of alkalinity in pore solutions and thus leading to carbonate precipitation. High methane concentrations in the migrating fluids are thought to have created locally gas hydrate reservoirs that were dissociated after the abrupt sealevel fall of the Messinian salinity crisis. Finally, the methane-rich fluid seepage was always active during the Pliocene in the Vera basin, which was the only one in SE Spain reflooded by the Pliocene marine waters.



**THE MASTERS OF ADAPTATION: THE EVOLUTION OF MEDITERRANEAN AND PARATETHYAN GOBY FISHES DURING MIOCENE AS RECONSTRUCTED FROM OTOLITHS**

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Gobies are a diverse group of small fishes, which are highly adaptive and very abundant in shallow marine, brackish to freshwater environments of the world except for the high boreal latitudes. Throughout the Neogene, their otoliths are abundant in the Mediterranean and Paratethyan records. Recently, the increased knowledge of extant otoliths and the study of otoliths in situ in identifiable articulated skeletons have much enhanced our understanding of their evolution in the area. During early Middle Miocene (Langhian) an uninterrupted connectivity between Atlantic, Mediterranean and Paratethyan seas is documented in gobies by a rather uniform faunal composition with a certain degree of diversification that seems to be responsive mainly to climatic differences. With the onset of the Serravallian, the Paratethys became restricted and separated from the Mediterranean during most of the subsequent geological time. The Mediterranean and Paratethyan goby associations diverged from each other. The earlier and more uniform fauna persisted in the Mediterranean. The rapidly changing environment and water salinities that set in in the Paratethys with the Sarmatian (=Serravallian) apparently stimulated a rapid endemic evolution of gobies, which are particularly well adapted to such environments, and which are still richly represented in the present Ponto-Caspian fish fauna. The 'Lago Mare' event during the Messinian salinity crisis in the Mediterranean has revealed a rich otolith-based goby fauna in various Italian localities. Several of the identified taxa seem to be not consistent with the other Mediterranean gobies of the Tortonian before and the Pliocene after the 'Lago Mare' event. They apparently correlate with certain endemic lineages that emerged in the Paratethys during the Sarmatian and that are still present in the Recent Ponto Caspian region. These possibly migrated into the Mediterranean from the Paratethys.

DISPERSAL OF TITANIC TORTOISES THROUGH THE MEDITERRANEAN

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**Aims:** Tortoises form an important part of the Cenozoic fossil record of the circum-Mediterranean area, but they have been rarely the focus of detailed studies. Over the last years research on fossil tortoises around the Mediterranean has intensified, bringing to light new fossil material and allowing the integration of these taxa in phylogenetic analyses. The main focus of this contribution is to discuss previously unrecognized dispersal events involving the titanic tortoises from the Neogene.

**Methods:** A thorough review of the fossil record and analysis of new fossil material, with emphasis on material from Eastern Mediterranean, using standard paleontological techniques, cladistic analyses, and tools for diversity and biogeographic analysis.

**Results:** The phylogenetic analysis of Mediterranean Testudinidae reveals a complex phylogenetic history as neither the small-sized nor the giant tortoises from Europe form monophyletic groups within Testudinidae. Instead, they are placed in different clades within a tortoise phylogeny, suggesting a complex biogeographic history with important dispersal events between Europe, Asia and Africa. Previously suggested dispersals are evaluated, whereas many of the inferred events are discovered for the first time.

**Conclusions:** Giant tortoises of *Titanochelon* clade, known from the entire Neogene on the northern side of the Mediterranean, were recently distinguished from Paleogene European large tortoises (e.g. *Cheirogaster*). Latest phylogenies suggest that these species were more closely related with African clades rather with the European taxa from the Paleogene. This suggests at least one dispersal event from Africa into Europe through the Mediterranean region, prior to the Early Miocene. The evidence supporting this, so far unrecognized, event is presented and the role of the eastern corner of the Mediterranean is evaluated. The arrival of titanochelones in Europe resulted in a faunal turnover and the replacement of "primitive" testudinids by "derived" ones, which dominated Europe till their extinction about 2 million years ago. Giant tortoises are known for their ability to cross long distances through oceanic dispersal to colonize continental and insular environments. As such they represent an ideal opportunity to test dispersal hypotheses inferred from the analysis of the fossil record.

## RCMNS 5

### OLIGOCENE-NEOGENE-QUATERNARY MOLLUSK FAUNA AND PARATETHYS-AEGEAN-MEDITERRANEAN MIGRATIONS

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**Early Oligocene.** The border between Tethyan Realm (including the Thracian-Aegean Gulf) and the Paratethys went along uplands of the Alps, Dinarides, Pontides, and Lesser Caucasus. In their southern flank, in the Sredna Gora and Rhodopian Upland, the Lower Oligocene was represented by coastal beds with a rich Mediterranean warm-water fauna (Karagyuleva, 1964).

**Late Oligocene – Early Miocene.** The Thracian-Aegean region was an area with mainly continental deposition during long time from the late Oligocene to early Miocene. Sedimentological evidences from the roughly terrigenous sediments testify intensive uplift environments in the South Balkanids.

**Middle Miocene.** The marine Middle Miocene sedimentation was very restricted development in the Marmara Region: S. Gillet (1957) illustrated lower Sarmatian (Volhinian) cardinals and Rückert-Ülkümen (1993) found foraminiferal assemblage with Sarmatian endemic species (such as *Elphidium hauerianum*) from the area westward of Istanbul. The upper Sarmatian (Khersonian) Beds with *Mastra caspia*, *M. bulgarica* were described from the same area (Erentoz et al., 1953; Sayar, 1989). The region was a brackish water gulf of the Eastern Paratethys, extending to the Çanakkale region (Taner, 1997).

**Late Miocene.** The Aegean basin became a marine gulf of Mediterranean during Late Torton – Early Messinian transgression. Marine – brackish alternating facies are known in the Alçıtepe formation, outcropped in the northern Aegean, Gelibolu and Çanakkale regions (Şakinç & Yaltrak, 2005, Çağatay et al., 2006, 2007). Later (6.30-6.04 Ma, according to Snel et al., 2006) brackish sediments with the Pontian-like mollusk and ostracod fauna recognizable in the whole Aegean Depression. We believe that the origin of the Choumnikon brackish fauna is related to the oldest Pannonian biota (Popov, Nevesskaya, 2000). At the beginning Pontian (~6.0 Ma, according to Trubichin, 1989; Snel, 2006, Krijgsman et al., 2010) this fauna populated the Eastern Paratethys. Some species of the Late Pontian fauna inhabited the Mediterranean at the “Lago-Mare” stage (5.42 Ma, CIESM, 2007; Esu, 2007).

At the same time in the Anatolian part existed a few brackish basins with endemic non-Paratethyan fauna: Denizli Basin, in the western Anatolia (Oppenheim, 1918; Taner, 1974a, b; Wesselingh et al. 2008) and Yalova Basin, (Yalakdere formation) in the Eastern Marmara region (Emre et al. 1998).

**Pliocene.** Earliest Zanclean transgression reached to the northern Aegean, Dacic, and Taman basins (Maruntianu, Papaianopol, 1995; Semenenko, 1997; Çağatay et al. 2007). Later during the Pliocene continental environments prevailed again in the Thrace – Aegean region.

**Quaternary.** At the early - middle Quaternary time one-way connection is prevailed and the Chaudian *Didacna* of Black sea origin was founded in Çanakkale region (Andrussov, 1896; Taner, 1983), and Caspian *Didacna subpyramidata* Pravosl. was described from the middle Pleistocene of the Iznik lake basin (İslamoğlu, 2009). Late Pleistocene connections took place by recent way and were described in details based on microphytoplanktons (Aksu et al., 1995, Mudie et al., 2002) and mollusks (İslamoğlu et al., 2001; Kazancı et al., 2004). The latest Pleistocene (Neueuxinian), the Marmara basin was affected by only Paratethys, while interrupting the connection with the Mediterranean (İslamoğlu & Tchepalyga, 1998).

CRUNCHING RECORD FROM THE PAST: NEW INSIGHTS ON *MESOPITHECUS*

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**Objectives:** *Mesopithecus* is emblematic Old World colobine monkeys from the Neogene in Eurasia. Its affinities with either Colobini and Presbytini as well as their ecologies were discussed in several studies of which the conclusions sometimes differ. We here explore the feeding ecologies and mode of locomotion of *Mesopithecus* through new data on inner ear structure, inner and outer molar structure, and dental microwear textural analysis (DMTA).

**Material and methods:** The dental microwear textures are correlated with the proportion of challenging foods in the diet and DMTA were ran on molar crushing facets of *Mesopithecus* aff. *Mesopithecus delsoni* from Hadjidimovo (N=12; Bulgaria), and *M. pentelicus* from Kalimantsi (N=17; Bulgaria) and Pikermi (N=24; Greece).

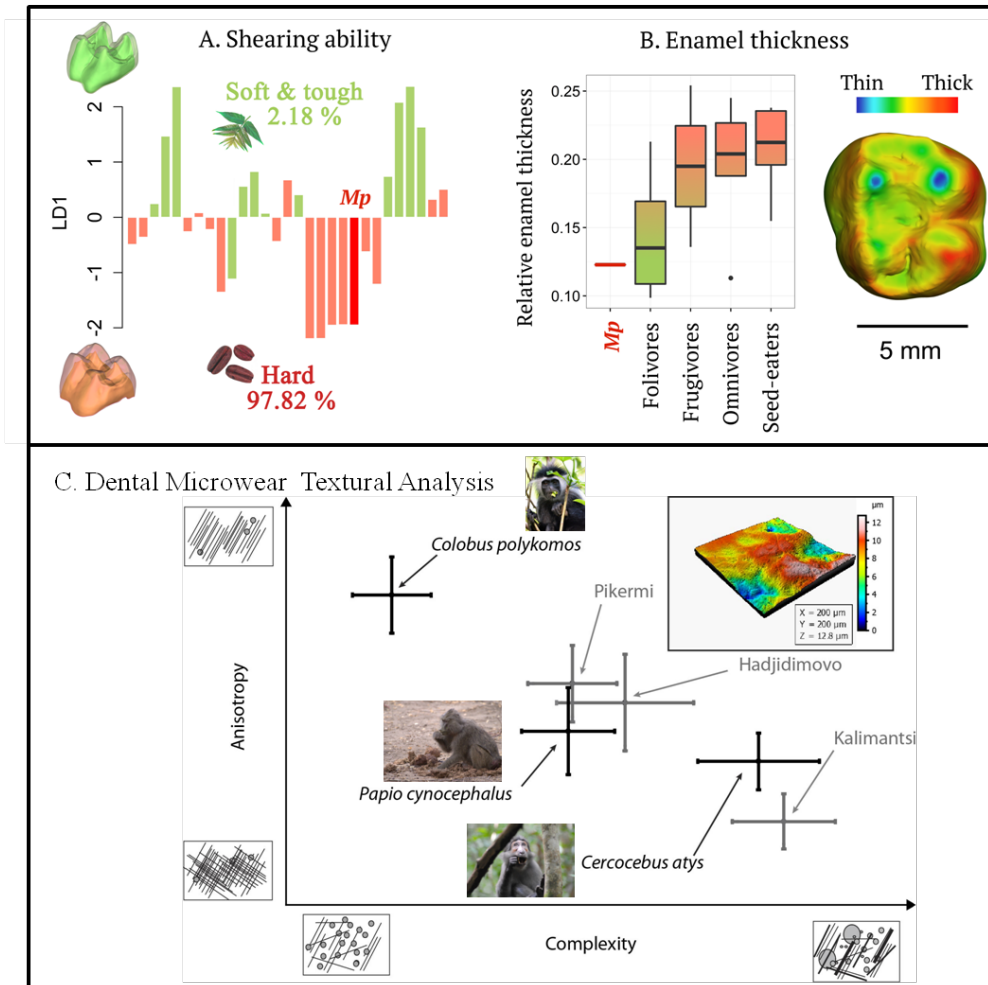
We also investigated dental functional morphology using dental topography on 5 specimens (with unworn M2/) together with relative average enamel thickness computed on a single M2/ of Pikermi. Dental topography evaluates 3D geometrical aspects such as relief or sharpness/bluntness over the whole tooth occlusal surface. Folivorous primates are expected to display sharper dental structures and thinner enamel than primates adapted to consume challenging foods.

Regarding the locomotor behavior, inner ear structure was analyzed on one skull from Hadjidimovo (HD 1626). We expect inner ear structure to reflect the arboreal or terrestrial mode of locomotion of the *Mesopithecus* taxa under consideration. For all of these analyses, different sets of present-day cercopithecines and colobines are included as comparative datasets.

**Results and Discussion:** The morphometric analysis of inner ears does not reveal an adaptive but a phylogenetic signal. Indeed, the first axis of a PCA mostly contributes to discriminate modern cercopithecines from colobines with a significant overlapping. *Mesopithecus* specimens do not plot with the semi-terrestrial *Semnopithecus* but with the arboreal *Colobus*, which plots within the overlapping zone between the two sub-families.

With relatively blunt crests and a low dental relief on M2/, *M. pentelicus* had the ability to crack hard foods such as seeds. However, its relatively thin enamel groups it with other folivorous monkeys (Figure 1A and 1B). This morphology is interpreted as a morphological trade-off between the necessity to avoid tooth fracture against hard food (relatively blunt reliefs) and the need to process a high amount of leafy material (thin enamel to quickly expose enamel cutting edges).

When we considered the DMTA, the 3 samples of *Mesopithecus* significantly differ from the folivorous *Colobus*, and display similarities with *Papio* and *Cercocebus*; the two latter being opportunist and fruit-seed eater, respectively. We can thus tell that *Mesopithecus* was not a strict leaf-eater. The subsequent question to be discussed is the amount of challenging foods in diet. Do challenging foods compose a significant resource all along the year or are fallback foods for a given short period? Implications on regarding evolution and environment will be further discussed.



**Fig. 1.** Linear discriminant analysis of shearing ability from 3D dental topography (A; Score in % correspond to a posteriori inferences), relative enamel thickness (B) and DMTA analysis (C; with a 3D view of the specimen NMNH-FM-K316) of *Mesopithecus* compared to extant Old World monkeys.

**EARLY MIOCENE BIOSTRATIGRAPHY OF THE VALLÈS-PENEDÈS BASIN (CATALONIA, SPAIN):  
PRELIMINARY RESULTS**

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**Introduction and objectives:** The Vallès-Penedès Basin is a classical area for the study Miocene terrestrial faunas of Europe. However, in comparison to the middle and late Miocene part of the record, the early Miocene has deserved little attention. Indeed most of the currently known sites were discovered more than 60 years ago and have not been systematically sampled again. Nevertheless, new major sites, such as els Casots, were discovered during the 1990s, and between 2011 and 2017 the early Miocene outcrops were systematically surveyed resulting in the discovery of more localities. In addition, some of the classical sites were sampled using modern methods, including screen-washing, thus allowing for the recovery of remarkably rich samples of microvertebrates.

**Results:** The early Miocene record of the Vallès-Penedès Basin is more complete than initially thought. The oldest sites date back to the Ramblian (MN3) and are characterized by a diverse glirid fauna dominated by *Pseudodryomys ibericus*, *Simplomys simplicidens* and *Glirudinus undosus*. Cricetids other than the genus *Melissiodon* are absent. The large mammals include the equid *Anchitherium* and some of the oldest gomphoteres of Western Europe, which occur in the Sant Andreu de la Barca site. The cainotherid *Cainotherium* is particularly abundant in the Ramblian sites while cervids (*Procervulus*) and moschids (*Amphitragulus*) are common. The early Aragonian (MN4) is better represented than the Ramblian and it is characterized by the abundance of the cricetids *Democricetodon hispanicus* and *Megacricetodon primitivus*, as well as the eomyids *Ligerimys florancei* and *L. ellipticus*. Occasionally, the cricetid *Eumyarion* is present. Amongst the large mammals rhinocerotids and palaeomerycids (*Ampelomeryx*) are particularly abundant. The tragulid *Dorcatherium* and the suid *Bunolistriodon* are first recorded at this time. The rodent succession is comparable to that of the well-known Calatayud-Montalbán Basin (Aragon, Spain), indicating that a similar biostratigraphical scheme could be applied to both areas. The Ramblian sites are tentatively correlated to local zone A of that basin, whereas the early Aragonian sites are correlated to zone C.

**Conclusions:** The early Miocene mammal record of the Vallès-Penedès Basin includes a good number of sites ranging from the Ramblian (MN3) to the early Aragonian (MN4) that in most cases have delivered both small and large mammals. Preliminary studies of the rodent fauna indicate that the local biozonation of the relatively close Calatayud-Montalbán Basin can be roughly applied to this area. Ongoing magnetostratigraphical studies will provide valuable data to this regard.

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## RCMNS 8

### HOW FAR CAN WE GO? TOWARDS AN EUROPEAN NEOGENE MAMMAL CHRONOLOGICAL SYSTEM

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**Introduction and objectives:** Pierre Mein's MN zones were introduced as an informal biochronological system that could be applied to different areas of Europe and even to Asia and Northern Africa. No diagnosis was proposed for the different zones, and Mein used several features such as selected first appearances or associations of taxa to characterize them. Recent reviews, such as Agustí et al. 2001 or Hilgen et al. 2012, have re-defined the MN units mainly on the basis of selected first appearances in different local sections, thus following more standard biostratigraphical procedures. However, most considered sections are located in the Iberian Peninsula and MN zones are currently used for correlation as far as China. Can this system be applied to so distant regions or a new biostratigraphical scale should be used instead?

**Methods and results:** The age of many of the selected bioevents in recent reviews is well constrained thanks to magnetostratigraphical data, but their geographical range is often restricted to Spain and France. This is particularly evident for the small mammals. For example, different species of the cricetid *Megacricetodon* are diagnostic for the middle Miocene zones, yet these species are not present outside Western Europe. Furthermore, certain small mammal events are clearly diachronic in relatively close regions. Larger mammals in general show broader geographical ranges and are potentially more useful for long-distance correlations. However, current scales (particularly Hilgen et al. 2012) neglect large mammals or only consider them at the genus level. In addition, the first and last appearance of particular large mammal taxa is often not recorded in the available magnetostratigraphical sections, and the reasons for selecting them as diagnostic criteria are sometimes dangerously close to circularity.

**Conclusions:** Current MN scales are only fully applicable to Western Europe. Broadening their geographic range would require the selection of different defining bioevents and probably the design of a whole new system. Large mammals are apparently more suitable for long-distance correlations. The new mammal chronological system should consider the first occurrence of broadly distributed taxa and take into account only well-calibrated events. Local and regional biostratigraphies may aid in constraining the age of particular bioevents when these are not directly recorded in magnetostratigraphical sections. In addition, clear diagnoses and reference sections should be given for the different zones conforming to the standards of stratigraphical procedure.

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ARCTIC CLAY MINERAL COMPOSITION THROUGH ARAON ARCTIC EXPEDITIONS 2016

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**Objectives:** Arctic Ocean has received special attentions not only due to the very sensitive and important region for changes in the global climate but also the potential enormous reservoir of natural gas, stored in the form of hydrates in continental margins. However we don't have much knowledge about the Arctic Ocean. The Korean government succeed first sampling of gas hydrate on the continental slope of the Chukchi Sea through Arctic Expedition ARA07C in 2016. Recent studies reported that some clay minerals such as montmorillonite and nontronite play an important role for the increasing formation rates and crystallizing hydrates at lower activities of methane (such as methane undersaturation) than those at which methane hydrates theoretically form. In this study, we compared the clay mineral composition between the Chukchi Sea (including gas hydrate) and East Siberian Sea (excluding gas hydrate), and interpreted the sediment provenance of whole samples.

**Methods & Results:** The Arctic Expedition ARA07C was undertaken in the Chukchi Sea and East Siberian Sea on the KOPRI (Korean Polar Research Institute) ice breaker Araon in 2016. We used 6 piston core and 3 box core sediments and determined relative clay mineral composition using Biscay's method. Arctic sediments in this study consist of abundant illite (66.6%) with minor chlorite (20.7%) and kaolinite (11.6%) and very scarce smectite (1.6%). Our results well consistent with the previous works. When we use the smectite-illite-kaolinite diagram of Arctic Ocean surface sediments, East Siberian sediments of our data most present in the East Siberian Sea and Chukchi Sea sediments of our data are plotted in the Chukchi Sea and Central Arctic Sea. Clay mineralogy for Chukchi Sea sediments containing gas hydrate shows a little high kaolinite and smectite contents compared with those of East Siberian sediments. Downcore variation in the clay mineralogy for core St\_13 shows difference with depth especially at 120 cm. Below this depth, kaolinite is lower than 10% and smectite is higher than 4%, but kaolinite higher than 10% and smectite lower than 4% higher than 10% lower above this depth. They may suggest that sediment provenance or sedimentary process will be changed with time.

**Conclusions:** Chukchi Sea sediments have a little high kaolinite and smectite contents compared with those of East Siberian sediments. Downcore variation in the clay mineralogy for gas hydrate-bearing core suggests that sediment provenance or sedimentary process will be changed with time.



## RCMNS 10

### ORIGIN AND EVOLUTION OF THE MN BIOCHRONOLOGICAL SYSTEM

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**Aims:** The MN system was presented in 1975 in VIth Congress of the Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS) at Bratislava, as a result of the activities of the "Vertebrate Working Group" from that organization, coordinated by P. Mein. The aim was to elaborate a biozonation based on mammals for the continental realm, similar to the Blow zones of the marine realm. Therefore, a total of 17 "zones" were proposed, ranging from the base of the Miocene to the latest Pliocene.

**Methods and Results:** Each zone was defined according to three criteria: "Formes característiques des lignés evolutives", "Associations" and "Apparition". The geographic range of the system covered the whole Europe, from Portugal to the former Soviet Union, and also including Northern Africa (following the Mediterranean dimension of the working group). Almost at the same time in which the MN system was born, true continental biozones were proposed by Dutch paleontologists in some Iberian basins. A first discussion of the MN system took place in 1975 in the International Symposium on Mammalian Stratigraphy of the European Tertiary, in Munich. In this congress it was decided to refer each MN to a Reference Level. A second main decision was to refer the MN system to a number of mammalian stages, some of them, like the Vallesian and Turolian, already pre-existing. The symposium defined a number of new mammalian stages, which should be characterized in future works: Agenian, Orleanian and Astaracian, covering the early and middle Miocene. In their turn, two super-stages were also proposed: the Aragonian (covering the Orleanian and the Astaracian) and the Catalanian (covering the Vallesian and the Turolian). Actually, none of these new stages were finally formalized, with the notable exception of the Aragonian, defined as a stage by the Dutch team (including M. Freudenthal and R. Daams).

**Conclusions:** While many paleontologists and geologists acknowledged the existence of a common language to which refer their faunas and units, another group of paleontologists avoided the use of the MN system and proposed the establishment of real biozones based on rock-body successions. The latter group mostly included small mammal paleontologists working in the long successions of the Iberian basins. The rock-body followers were able to establish an accurate succession of biozones, with clear boundaries and high degree of resolution. However, they were mostly based on local rodent successions which could be hardly correlated at a regional level. On the other hand, the followers of a wide concept of the MN units outlined the value of the MN system for rough dating and long distance correlations. A turning point in this debate was the irruption of the paleomagnetic analysis in the long successions of a number of basins which led to an attempt of re-definition of the MN's as real biostratigraphic units with well delimited boundaries.

**BETWEEN WESTERN EUROPE AND MINOR ASIA: EOCENE, OLIGOCENE AND MIOCENE  
RODENT FAUNAS FROM THE CENTRAL BALKAN**

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**Aims:** The western and central European Tertiary mammalian faunal history is relatively well known. Also data from Turkey and sites further east in Asia are available. In between, in the central Balkan area, new data on fossil small mammals enable better understanding and correlation between the European small mammal faunas and the ones from Anatolia and Asia, especially during and after the “Grande Coupure”.

**Methods:** Research in the southern part of the central Paratethys since 2003 (Bosnia and Herzegovina, Croatia and Serbia), resulted in several small mammal assemblages in several sedimentary basins from different geological zones and ages<sup>1</sup>.

**Results:** The Eocene and Early Oligocene assemblages from southern Serbia differ sharply from each other. This faunal turnover is seen as a response to the climatic changes during that time, the “Grande Coupure”, such as observed in the terrestrial faunas from western Europe and Asia. In contrast to the European faunas, the Muridae are overall dominant and diatomyids are present in the Early Oligocene faunas.

Also the Early Oligocene and Late Oligocene faunas differ strongly from each other. The Late Oligocene fauna of Banovići<sup>2</sup> is on species level quite unique. The early Miocene assemblages of Snegotin and Sibnica<sup>3, 4</sup> show a mix of species known from Anatolia and Europe. The few Middle Miocene faunal elements of Sinj (CR) and Gračanica (BiH) are as known from Sibnica and Europe.

**Conclusions:** Through time, especially until the Miocene, the rodent assemblages show large turnovers, indicating several phases of immigration and extinctions, combined with local evolution of several rodent taxa. During the Miocene, the assemblages show large similarities to faunas from other areas.

Comparison of Serbian Paleogene rodent associations, with data from the Late Eocene of the Lesser Caucasus (Anatolia) and the European record suggests that the composition of the rodent assemblages observed cannot be explained by a single migration route without introducing hypothetical ecological corridors and/or filters.

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SHALLOW SUBMARINE GAS MANIFESTATIONS IN THE AEGEAN SEA: PRELIMINARY CATALOGUE AND GEOCHEMICAL CHARACTERIZATION

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**Objectives:** The Aegean area, like other regions of intense geodynamic activity, is characterised by extensive geogenic degassing. Gas manifestations widespread on land are also very frequent underwater. The present study aims at producing a first catalogue of these manifestations together with the geochemical characterization of the emitted gases.

**Methods & Results:** Sixty-one samples at 21 different sites have been collected by diving up to 15 m depth, mainly along the south Aegean active volcanic arc (SAAVA). The sites displayed very different gas fluxes. Most of them showed a very sluggish gas bubbling while a few had spatially large and strong bubbling. The most intense manifestation has been found at Kos Island along Paradise beach. Here a total output of about 2.7 tons/day from an area of about 250 m<sup>2</sup> has been measured in September 2016.

Samples have been analysed for their chemical (He, Ne, Ar, O<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>, H<sub>2</sub>S, CH<sub>4</sub> and CO<sub>2</sub>) and isotopic (He, Ar, CO<sub>2</sub>-C, CH<sub>4</sub>-C, CH<sub>4</sub>-H) composition by gas chromatography and mass-spectrometry methodologies. The chemical composition of almost all samples was dominated by CO<sub>2</sub>. Only 11 samples had CO<sub>2</sub> contents lower than 50% most of them showing clear signs of CO<sub>2</sub> loss due to dissolution processes. The helium isotopic composition, ranging from 0.74 to 6.73, points to a significant mantle contribution (5-95%) especially along the SAAVA. Also the  $\delta^{13}\text{C-CO}_2$  values (mostly between -5 and 0 ‰) indicate an important mantle contribution although CO<sub>2</sub> deriving from crustal limestones is often prevailing. Isotopic composition of methane indicates mostly an abiogenic hydrothermal origin although some thermogenic contribution cannot be ruled out. Some sample shows clues of (biogenic?) methane oxidation. Only few samples collected in north Aegean Sea show a clear biogenic contribution. Only few samples showed detectable H<sub>2</sub>S.

**Conclusions:** The present study highlighted a widespread submarine degassing activity in the Aegean Sea mainly along the active volcanic systems of the volcanic arc. The gas composition highlights their tight relationships with the volcanic and geothermal systems of the area. Gases from hydrocarbon fields are on the contrary rare. Although the gases emitted are sometimes quantitatively small they should not be disregarded because their impact can be locally important. Furthermore these areas, especially those where nearly pure CO<sub>2</sub> is emitted, could be the sites where the impact on the marine environment of ocean acidification as a consequence of future increased atmospheric CO<sub>2</sub> levels or gas leakage from geologic CO<sub>2</sub> storage sites can be studied.



Underwater gas sampling at Gyalı Island.

**COMPARATIVE STUDY OF THE NEOGENE SEA GATEWAYS**

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**Objectives:** Comparative characteristics of two well-known sea gateways - the Gibraltar and Bering straits - allow a number of interesting conclusions concerning their geological history. Their opening in the Neogene has led to hydrological changes in the basins, appearance of new ways of marine biota migration, and paleogeographical changes. Whereas there is a comprehensive literature on Gibraltar Strait, below emphasis is given to the data on Bering Strait.

The recent Bering Strait connecting the Pacific and Arctic oceans is 96 km long, at least 86 km wide, and about 50 m deep (the Gibraltar Strait has 65 km, 14 to 44 km, and 338 m, respectively). In spite of these comparatively small dimensions, every year the strait transports about 50 million tons of terrigenous matter and 60 million tons of biogenic matter from the Pacific basin into the Chukchi Sea.

**Methods & Results:** Eurasia and North America were joined by the Bering Land Bridge into one supercontinent for about 100 m.y., beginning from the middle Cretaceous.

The latest data imply that Bering Strait's formation began in the latest Miocene. The strait first opening might be a consequence of either regional tectonic processes or eustatic sea-level rise; a combined influence of both factors is also possible. As a result, marine biota of the North Pacific origin migrated to the Arctic basin and farther to North America. This was reflected particularly in occurrences of Pacific mollusks in the Pliocene sections of Iceland and England ("the *Serripes* Zone"). On the other hand, elements of the Arctic and North Atlantic molluscan fauna migrated into the North Pacific (assemblages with *Astarte*) and spread in Alaska, Kamchatka, Sakhalin, and northern Japan. The first appearance of *Astarte* in the North Pacific stratigraphic sections signals the opening of Bering Strait, because the genus otherwise dwelled only in the North Atlantic-Arctic region. Diatoms from the stratigraphically lowest *Astarte*-bearing horizon in Alaska indicate an age range of 5.4-5.5 Ma for the strait's earliest opening.

It is remarkable that the first Bering Strait opening was close in time to the Mediterranean transgression after the Messinian crisis.

However, a number of problems on the Bering Strait's geological history remain unsolved. Among them are: a) the migration ways of Pacific biota from Bering Strait to the North Atlantic areas are not defined precisely; b) reasons for difference in migration rates of biotic assemblages in shelf zones of these basins are not clear; the role of sea currents is not also well understood; c) the reason for the asymmetry of some molluscan species migrations from the Pacific into Arctic through the strait is not known; d) the influence of the migrants on biocoenoses formation of the Arctic and Pacific ecosystems is not adequately estimated.

**Conclusions:** Comparative analysis of data on paleostraits of different regions (the Panama Isthmus, Indonesian seaway, etc.) may promote deciphering many specific features of evolution of past basins and their biotic communities.

THE XIROCHORI BOVID ASSOCIATION (VALLESIAN, AXIOS VALLEY, GREECE) AND THE FAUNAL CONTEXT OF *OURANOPITHECUS* (PRIMATES, HOMINOIDEA) THROUGH TIME

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**Objectives.** Known since the beginning of the 20th century, the Upper Miocene primate bearing deposits of Axios Valley in Northern Greece have been central to perennial and thorough palaeontological research lasting more than 40 years. Among numerous fossil mammal sites Ravin de la Pluie (RPI), and Xirochori (XIR) have yielded remains of the hominoid primate *Ouranopithecus*, a taxon whose presence outside Axios Valley has been safely recorded in the neighboring Nikiti-1 (NKT) site of Chalkidiki peninsula. Although systematic studies of the RPI and NKT faunal assemblages have been completed in a large extent, the poor XIR faunal association is still partly investigated, especially as regards its bovid content. By completing the systematic study of the Bovidae from Xirochori, we provide here an updated faunal list from this site. This gives us also the opportunity to discuss the changes over time of the faunal context associated with *Ouranopithecus*.

**Methods & Results.** For the definition of XIR bovids we use standard morphometric analysis and comparison with taxa of other Axios Valley and neighboring sites. Relative diversity through time and particular diachronic taxa-combinations are also discussed.

The Xirochori bovid association includes a primitive gazelle, referred to as *Gazella* sp., *Ouzocerus* cf. *pentalophosi*, and cf. '*Protoryx*'. Apart from the primate, the bovids are associated in the XIR fauna by the carnivores *Protictitherium crassum*, *Dinocrocuta* sp. and *Adcrocuta eximia*, the proboscidean *Choerolophodon pentelici*, the rhino *Ceratotherium neumayri*, the giraffid *Palaeogiraffa pamiri* and a large hipparionine horse of the "*H. primigenium* morphotype".

**Conclusions.** Xirochori and Ravin de la Pluie have been magnetochronologically dated at 9.6 and 9.3 Ma, respectively, whereas Nikiti-1 is estimated biochronologically at ~9.0-8.7 Ma, thus altogether covering the whole late Vallesian European Land Mammal Stage. The analysis of the faunal spectra through time suggests that *Ouranopithecus* took part of a faunal renovation at the beginning of the late Vallesian and persisted one mild turnover between 9.6 and 9.3 Ma and a more severe one between 9.3 and 8.7 Ma before its apparent local extinction.

**ANANCUS (PROBOSCIDEA, MAMMALIA) FROM CHOMATERI – THE FIRST RECORD OF THE GENUS IN THE LATE MIOCENE OF GREECE**

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**Introduction:** The fossiliferous locality Chomateri (Attica, Greece), near the classical late Miocene site Pikermi, was discovered in 1971 and excavated from 1972 until 1980. The large mammal assemblage from Chomateri is not studied in detail as a whole, so its faunal context and correlation with Pikermi (end of MN 12), as well as with other Turolian localities of Greece and the wider region, are not yet entirely clear. Concerning the proboscideans, in the rich vertebrate collections of Pikermi four taxa are included –*Deinotherium proavum*, *Mammot* sp., *Choerolophodon pentelici*, *Konobelodon atticus*–, whereas in the by far smaller Chomateri collections (Athens, Vienna), the only two known proboscidean specimens (maxilla with DP2–DP4, isolated dp4) belong to another taxon.

**Results:** The dislocation of the half-loph(id)s and the resultant alternate arrangement of the successive loph(id)s (anancoidy), are diagnostic features of *Anancus*, which are present in the dp4/DP4 from Chomateri and allow the attribution to this genus. However, the anancoidy is rather weak and the occlusal morphology simple, both regarded as primitive features within anancines. This could indicate an early evolutionary stage for the Chomateri anancine, in agreement with the Turolian age of the locality. Nonetheless, recent studies reveal the high morphological variability within *Anancus* populations, which might display a mixture of primitive/derived dental characters. Thus, any biochronological conclusion based on isolated specimens should be always taken with caution. The limited comparative material and the problematic taxonomy of the European late Miocene anancines do not permit a safe specific allocation of the Chomateri specimens, and they are attributed for the moment to *Anancus* sp. The presence of this genus in Chomateri consists the first faunal evidence that the locality post-dates Pikermi. This age difference is considered to be relatively small due to their overall faunal similarity and their faunal differences with the Dytiko localities (MN 13, Axios Valley, Greece).

**Conclusions:** Previously known only from the Plio-Pleistocene, this is the first report of *Anancus* in the late Miocene of Greece, marking its earliest occurrence in the Greek fossil record. Based on the current data, the migration of *Anancus* to Southern Europe (e.g., Spain, Southern Balkans) took place during the end of the middle Turolian, at ~7.2–7.1 Ma, a period that roughly coincides with the decline of the “Pikermian” large mammal fauna. Late Miocene anancines were probably inhabitants of mosaic or even more wooded environments. This further reinforces the existing palaeoecological reconstructions of Greece and the wider region, which indicate a gradual transition to a more closed environment towards the end of the Turolian.

EARLY MIOCENE SMALL ANIMAL REMAINS FROM THE LESVOS PETRIFIED FOREST (GREECE)

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**Objectives:** The Lesvos Petrified Forest (western Lesvos, Greece) has been famous for its plant fossils for more than one century. The first animal fossil from the early Miocene subtropical forest was found in the locality Gavathas, in 1999, and was identified as the proboscidean *Prodeinotherium bavaricum* by Koufos et al. (2003). More recently, a second locality with terrestrial animal fossils, named Lapsarna (LRN), has been found near Gavathas. The fauna available from LRN, deriving from lacustrine organic-rich clays under the pyroclastic material that contains the petrified plants, includes remains of gastropods, ectothermic and endothermic vertebrates.

**Methods & Results:** Based on the taxonomic study of fragmented mollusc remains, isolated fish pharyngeal teeth and utricular otoliths (lapilli), fragmented amphibian vertebrae and a tooth bearing element, reptile fragmented dentaries, teeth, osteoderms and vertebrae and isolated micromammalian teeth, the presence of eight freshwater and three terrestrial gastropod species, three freshwater cyprinid species, two amphibian, five reptile and seven micromammalian taxa has been confirmed. In particular, the material allowed the identification of *Bithynia* sp., *Emmericia* sp., ? *Bania* sp., Hydrobiidae indet., ? *Radix* sp., Lymnaeidae indet., *Gyraulus* sp., *Planorbarius* sp., Helicidae indet., *Milax* sp., *Limax* sp., *Palaeoleuciscus* sp., *Barbus* s.l., *Cyprinion* sp., ? *Mioproteus* sp., Anura indet., Crocodylia indet., Lacertidae indet., ? Natricinae indet., Serpentes indet., Squamata indet., Chiroptera indet., Erinaceidae indet., Talpidae indet., Soricidae indet., *Eumyarion* aff. *latior/weinfurteri*, *Democricetodon* sp. and *Glirulus diremptus*. Stratigraphical and radiometric data suggest an age older than 18.4±0.5 Ma (latest early Miocene) for the locality, with which the faunal composition is in good agreement.

**Conclusions:** The present findings represent one of the best-documented early Miocene gastropod and fish faunas of the Aegean/southern Balkans area, as well as the first record of an early Miocene proteid amphibian in the south-eastern European area. Furthermore, the estimated age of the fauna makes Lapsarna one of the oldest small mammal localities in Greece so far known. The study of the new fossils can lead to a basis for the reconstruction of life in the subtropical forests that covered the area during the early Miocene.

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## MIOCENE TO PRESENT DEFORMATION IN THE AEGEAN: EXTENSION VS. TRANSTENSION AND STRIKE SLIP TECTONICS

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**Objectives:** This paper aims to (i) provide an updated map of the fault network, (ii) understand the seafloor's morphology and offshore geological structure and (iii) develop a new interpretation of the post-Miocene kinematics and deformation of the Aegean Sea.

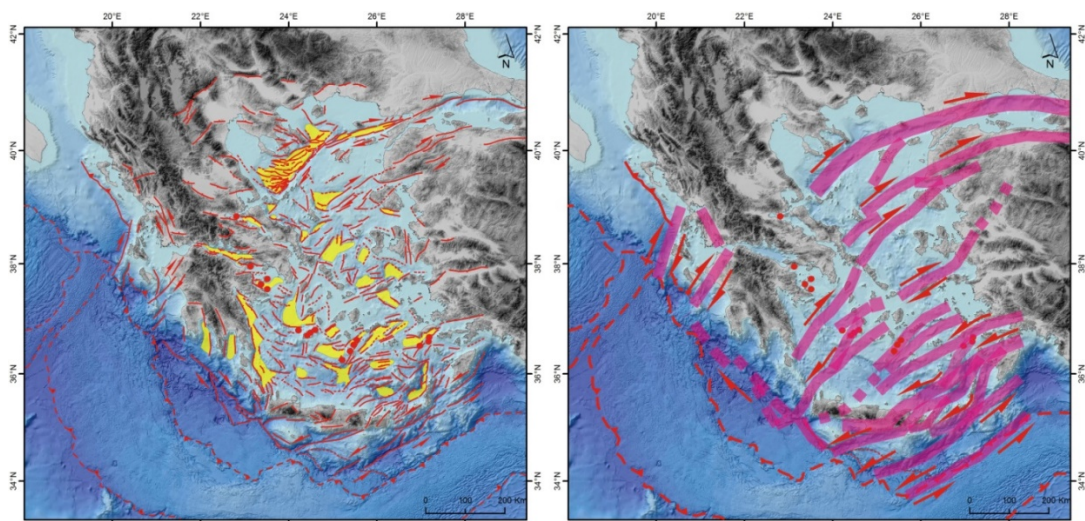
**Methods:** This work is based on the (i) analysis of the new morphological map of the Aegean derived from the integration of GEBCO with swath bathymetry data, (ii) interpretation of recent and vintage seismic profiles, (iii) retracing of the previously mapped faults and (iv) reevaluation of the previously proposed kinematic models.

**Results:** Careful examination of the new bathymetry reveals a complicated geomorphological configuration for the Aegean seafloor: The North Aegean Trough (NAT), developed along the western prolongation of the dextral North Anatolian Fault, is the soundest geomorphological and structural element in the North Aegean Sea. NE-SW elongate, circular or irregular basins, bounded by faulted slopes, ridges, structural highs and shallow plateaus have developed between the NAT and the Cyclades Plateau. Seismic profiling data show that the Plio-Quaternary basins match with the morphological ones, while seismological and kinematic data indicate predominantly dextral oblique to strike slip movement mainly along NE-SW trending faults and conjugate NW-SE ones, leading to transtensional deformation.

Basins and shallow areas in the South Aegean Sea show a phenomenically randomly distribution. They display rhomboid, elliptical, trapezoid or spindle shapes and their dimensions do not exceed a few tens of kilometers. Maximum depths of 2,500 m occur in the southeastern edge of the South Aegean Sea, 2,000 m in the central part, 1,000-1,500 m in the western part and 500-700 m in the basins along the southern margin of Cyclades plateau. The analysis of the seismic stratigraphy highlighted the major unconformity at the end of the Messinian and revealed a two stage post-Miocene evolution with at least one major unconformity and/or change of structural style in Late Pliocene to Early Quaternary, recognized in all(?) basins of the South Aegean Sea. Basin inversion has been observed in many areas too, with faulting, tilting and uplift of the early stage deposits.

**Conclusions:** The morphological and structural configuration of the active basins differ significantly from the ones of the Pliocene basins while the latter are very different from the Late Miocene basins. In general, the wide, arc-parallel basins developed in Miocene as a result of back-arc extension, evolved in Pliocene into a pattern involving localized subsidence and uplift. It was again modified in Quaternary with reorganization and reorientation of the subsiding/uplifting areas and inversion of basins.

We propose that oblique to strike slip tectonics along NE-SW trending fault zones prevailed gradually during Plio-Quaternary in the Aegean Sea and led to the development of localized transtension (basins) and transpression (structural highs). The incipient collision of the Aegean crust with the Libyan promontory south of Crete may have triggered the change from arc-parallel, back-arc extension, prevailing in Miocene, to transtensional/ transpressional deformation in Plio-Quaternary.



**Fig. 1:** Fault network and Plio-Quaternary basins (left). NE-SW strike slip zones deforming the Aegean in Plio-Quaternary (right)



**PALAEO GEOGRAPHY OF THE KARPATIAN/BADENIAN (BURDIGALIAN/LANGHIAN) BOUNDARY ON THE ALPINE-CARPATHIAN JUNCTION: CURRENT STATE AND FUTURE GUIDELINES**

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**Introduction:** The study area is bordered by the Western Carpathians, Eastern Alps, Bohemian Massif and by the Transdanubian Range, so it includes the Carpathian Foredeep, Vienna, Danube and Novohrad-Nógrád basins. In the past the paleogeographic and stratigraphic problems around the Karpatian/Badenian (Burdigalian/Langhian) boundary were extensively studied by multiple authors (Čorić and Rögl, 2004; Piller et al., 2007; Hohenegger et al., 2009; Kováč, 2000; Kvaček et al., 2006; Kováč et al., 2007). These papers point out a significant palaeogeographic reorganization induced by asthenospheric bulging (Lankreijer et al., 1995; Konečný et al., 2002) connected with pronounced volcanism at around ~14-15 Ma (Peckay et al., 2006; Chernyshev et al., 2013). However, these processes did not affect the broad connection between the Mediterranean and Central Paratethys via the Slovenian “Trans-Tethyan Trench Corridor” (Bisticic and Jenko, 1985).

**Objectives:** We would like to question the standard “layer cake” stratigraphy which has been commonly used for the Miocene Central Paratethys, contrary to the standard basin model. We suggest that the Karpatian/Badenian boundary is heterochronous and if this is true, two questions will need to be discussed: What are the spatiotemporal attributes of this boundary? How can this boundary be constrained?

**Methods & Results:** To tackle the stated questions, multiple profiles covering the Karpatian/Badenian boundary within the northern Central Paratethys realm were treated by detailed facies analysis, high resolution biostratigraphy (calcareous nannoplankton, planktic foraminifera) and by comprehensive provenance analysis. Nonetheless this task was complicated by a hiatus which has always been documented at this boundary. We present three different sites (2 wells, 1 outcrop) that may yield the Karpatian/Badenian boundary. The first site, occurs in the Špačince-5 well (Blatné Depression, Danube Basin). Here the Karpatian (NN4) offshore mudstones are separated by a thin coarse-clastic gravity sediment from lower Badenian (NN5) offshore mudstones (Rybár et al., 2016). The Second site is represented by the Nová Vieska-1 well (Želiezovce Depression, Danube Basin) where possible Karpatian deltaic deposits pass into lowermost Badenian (NN5a) shallow marine deposits (Kováč et al., 2017). The third site the “Príbelce outcrop” is located in the Novohrad-Nógrád Basin and consists of offshore Karpatian mudstone (evidenced by electrical resistivity tomography and by seismic tomography), which pass into the lowermost Badenian (NN5a) tidal deposits.

**Conclusions:** All the mentioned occurrences of sediments around the Karpatian/Badenian boundary were connected by a sheared basin system. The Karpatian marine flooding reached from the Carpathian Foredeep, via a wedge-top basin at the edge of Central Western Carpathians (Vienna and Bánovce basins) and continued towards the initially rifted hinterland back-arc basin (Novohrad-Nógrád Basin). Disintegration of this marine gateway during the oblique collision of the Western Carpathians with the Bohemian Massif, gave rise to the Badenian Blatné and Želiezovce depressions of the Danube Basin. The same transgression flooded the Novohrad-Nógrád Basin in the south. This study was supported by grants: APVV-16-0121, APVV-15-0575, APVV-14-0118, APVV-0099-11, VEGA 1/0559/17. Our gratitude goes to the Nafta petroleum company management for allowing access to the well-core repositories.

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THE PROBLEM OF MN13-MN14, OR HOW TO RECOGNIZE THE MIOCENE-PLIOCENE  
BOUNDARY IN THE MAMMALIAN TERRESTRIAL RECORD

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**Introduction & Objectives:** The continental sequence of Sifón de Librilla provides a reliable and detailed biostratigraphic record as it is exceptionally suitable for studying the evolution of small mammals during the late Miocene and early Pliocene. It represents more than 2 Ma of continental record (from 6.9 - 6.7 to 4.6 - 4.5 Ma), ranging from the lowermost MN13 to the base of the MN14 unit. Magnetostratigraphy is currently the most useful and widely available tool for providing independent age estimates of mammal faunas. There are few long stratigraphic sections that yield both micromammal and reliable paleomagnetic data. Fortunately, the Sifón de Librilla section is a very long and continuous sequence in which the magnetostratigraphy has been unambiguously established (Garcés et al. 2001; Agustí et al. 2006). In addition, Garcés et al. (2001) detected that in the Sifón de Librilla section the basal Pliocene transgression occurred just after the valley incision produced by the Messinian Salinity Crisis (MSC), which enables us to make a correlation between the marine and continental biostratigraphic scales. The first level containing small mammals, SIF-413, is immediately above the earliest Pliocene transgression. In this abstract, we analyse the biostratigraphical implications for both detecting the Miocene-Pliocene boundary in the continental record, and differentiating the MN13 and MN14 mammal units.

**Methods & Results:** The micromammal remains were extracted from a large amount of sediment recovered from the level of SIF-413 in the Sifón de Librilla section. All the sediment was screen-washed using superimposed 4.0, 1.0 and 0.5 mm mesh screens. The specimens recuperated are currently kept at the *Institut Català de Paleontologia Miquel Crusafont* (ICP; Sabadell, Barcelona, Spain).

The 157 specimens yielded by the early Pliocene level of SIF-413 are attributed to nine rodent species: *Stephanomys dubari*, *Paraethomys meini*, *Apodemus* cf. *gudrunae*, *Occitanomys alcalai*, *Occitanomys brailloni*, *Debruijnimys* sp., *Apocricetus* aff. *barrierei*, *Ruscinomys* cf. *lasallei*, and *Eliomys truci*. According to the presence of *O. brailloni*, a typical Ruscinian species, this locality has been correlated with the earliest early Ruscinian (base of the MN14 unit).

**Conclusions:** The equivalence between the Mio-Pliocene boundary and the MN13-MN14 limit has been confirmed in this work. Our data indicates that the only element that can mark the beginning of the Pliocene in the continental record of southwestern Europe is *Occitanomys brailloni*. This taxon is the sole species from SIF-413 not found in Miocene levels. Its identification in SIF-413 corroborates its appearance in the earliest Pliocene. Consequently, *Occitanomys brailloni* becomes a key element for marking the Pliocene in the terrestrial record, and for the distinction between MN13 and MN14.

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**THE INVISIBLE WALL: BIOGEOGRAPHY OF THE EARLY MIOCENE OF  
SOUTHEASTERN EUROPE**

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The early Miocene biogeographic history of southeastern Europe and Asia Minor is infinitely complex. Over the last couple of years, much progress has been made in enhancing the terrestrial fossil record of the region in the hope to solve biogeographical issues. In fact, the picture seems only more complex than ever.

When a Turkish-Dutch team discovered the first early Miocene small mammal assemblages in Anatolia, it became evident that these contained murids that would enter into Europe only at the end of the early Miocene. In addition, various endemic genera were found. A simple explanation would be that Anatolia was isolated and that only after the closure of the *Gomphotherium* landbridge and related geographic changes the murids were able to enter Europe. However, the Greek locality of Aliveri would have been on the same landmass. Its fauna has distinct European characteristics, such as the presence of Eomyidae, not found in Anatolia till a much later date. Moreover, some insectivore genera crossed into Europe near the MN2/MN3 transition, showing that intermittent connections for mammals were available. These connections were confirmed when it was discovered that the Anatolian locality of Sabuncubeli contained first records of some large mammal species (*Semigenetta*, *Stromeriella*) in Turkey also found in Wintershof-West, while the new tragulid species clearly reflects affinities with the African forms dated back to MN2. Besides Sabuncubeli, ongoing studies on the old ruminant collections from Keseköy (late MN3) shows the existence of early cervids and moshids (*Procervulus*, *Amphitragulus*) which were very common in MN2-3 localities of Central Europe. In addition, finds from Serbia showed that, as in Aliveri, a mixture could be found of Anatolian and European elements.

Having European elements to the west of the early Miocene Balkan-Anatolian landmass but absent in the eastern part requires some type of ecological barrier. As a rule, dry areas, mountain ranges or broad river deltas spring to mind when we talk about barriers, but such topographical phenomena are somewhat hard to imagine as a division of the landmass. Barriers can, however also be biotic. In the case of the insectivore migrations into Europe, it is notable that only those taxa with no counterpart in the European faunas made the crossing. Although the eomyids did not have a direct counterpart in Anatolia, their niche may have already been occupied. The murid genus *Eumyarion* shows a remarkable radiation in the early Miocene Anatolian faunas, including various small species that, like eomyids, have bunodont and lophodont molars. Moreover, the genus enters Europe close to the extirpation of the eomyids in the west, and when it does, only the larger species are involved in the migration.

Palaeobiogeography can largely be explained by a combination of palaeoenvironmental conditions and the availability of migration corridors. In addition, however, ecosystems may be resilient to invasion as long as a niche is sufficiently covered by a native species. In those cases in which we seem to hit an invisible wall between two biogeographical units, the answer may lie in the constitution of the two ecosystems.

## RCMNS 21

### **MN – UNITS IN DATABASING**

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Forty years after its introduction, the MN system is still blooming. And this is understandable, as it makes for an easy reference to indicate a time frame, particularly in discussions with colleagues working in other areas. In essence, the biochronology based on the sequence of reference localities is a crude system and there have been various attempts to refine it by defining unit boundaries based on first and last occurrences of key taxa leading ultimately to actually assigning ages to these boundaries. And this, in turn, led to discussions to the diachronicity of these boundaries across Europe. Still, even the most severe critics of the system will admit that as a crude time reference it works. And for the average worker, that is all that counts.

Entering a biochronological system into the restricted environment of a database provides some problems. Using thesauri, it is possible to link different stratigraphical systems, but even then choices have to be made regarding the correlations and the ages. Moreover, such thesauri are an unobtainable investment for most non-funded databases. Diachronological systems, however, cannot be that easily accommodated, but there is, of course, the possibility of using a separate field.

In the NOW database, the concept of MN zones follows that of Agustí (2001), including the age boundaries that publication indicated for southwestern Europe. This is a choice the user needs to be aware of. Linking the MN zones directly to an age is an important feature for the many non-specialist users of the database. Ironically, however, these is the very group that is not familiar with the restrictions of the MN system. Even so, a database is a tool and anyone using it, should be aware of both its possibilities and its limitations.

The best solution to the problem seems to be not to use the MN unit as a primary age indication unless there are no alternatives. Many localities in the NOW database are primarily link to age by a palaeomagnetic chron, which provides by far the most accurate dating. If not available, regional biostratigraphic schemes should be used, as they provide a more accurate indication of an age than MN units. If no such zonation is available, we have to resort to MN units in all their imperfection. In any case, the MN zonation should be entered in the field 'Chronostratigraphic age'. It is, after all, an age indication that we all recognize and whereas discussions on the MN system will probably continue for a long time, one thing is clear: it works.

PRESENCE OF A LARGE-SIZED HIPPARION IN THE VILLAFRANCHIAN LOCALITY OF SÉSKLO  
(THESSALY, GREECE)

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**Objectives:** The locality of Sésklo, discovered in 1971 in a clay quarry within a fluviolacustrine basin, has yielded a rich and quite diverse mammalian fauna, dated to the lower part of the European Land Mammal Zone MN17 (Early Pleistocene) (Athanassiou, 1996). In terms of number of individuals the fauna is dominated by a horse referred to the species *Equus stenorhis* Cocchi, 1867 (Athanassiou, 2001). However, some specimens among the equid material excavated in the locality during the early 1970s are characterised by distinct morphology, as well as by different fossilisation: they are heavily mineralised and dark coloured, deriving quite probably from a clayey layer rich in volcanic material, which is stratigraphically situated in the lower part of the sedimentary sequence of the basin.

**Methods & Results:** The available material consists of long-bone parts, as well as autopodial elements, which were studied morphologically and biometrically. Despite their large size, which is similar to that of *Equus* from the upper sequence of the same locality, the studied specimens (particularly the proximal phalanges and the astragali) have a clear hipparionine morphology. A juvenile mandible excavated in 2005 exhibits a caballine enamel pattern (*sensu* Eisenmann *et al.*, 1988), which differs from the stenonid one seen in the Sésklo *Equus*.

**Conclusions:** As a whole the Sésklo *Hipparion* sample is consistent with the advanced morphology of the large-sized Pliocene hipparions of Eurasia, usually referred to as *Plesiohipparion*, and their large body size as well. Currently there is no evidence of hipparion and horse stratigraphic association in Sésklo, the former presumably occurring in deeper layers. The Sésklo Basin is one of the very few European localities that record the faunal transition from the *Hipparion*-dominated Neogene faunas to the *Equus*-dominated Quaternary ones.

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**LIVING (ROSE-BENGAL STAINED) FORAMINIFERAL ASSEMBLAGES (SOFT AND HARD-SHELLED TAXA) IN TWO SUBMARINE CANYONS (POLCEVERA AND BISAGNO) OF THE LIGURIAN BASIN (ITALY)**

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**Aim:** This study is part of the RITMARE Project: BioLig - Biodiversity, ecosystem functioning and pelagic-benthic coupling in Ligurian submarine canyons. Among meiofauna benthic foraminifers are an important and unicellular component of deep-sea detritus feeders representing more than 50% of the total biomass (Gooday et al., 1992). In this study the distribution pattern and microhabitats of Rose-bengal stained living benthic foraminifers (soft and hard-shelled taxa) from two environmental setting in Gulf of Genoa are investigated: the Polcevera and Bisagno canyons and the adjacent open slope (Ligurian Sea). Submarine canyons are reported to be sites of enhanced productivity on continental margins and very dynamic environments strongly controlled by the continental input. Relationships between sedimentary processes and distribution of benthic microhabitats are examined along the depth gradient (water depth interval from 200 to 2000 m) in both canyons and slope settings.

**Methods & Results:** In this study living (Rose-bengal stained) foraminiferal assemblages (soft and hard-shelled taxa) from ten sites were analysed by. The samples were collected by mean of box corer along the axes of the Polcevera and Bisagno canyons and, at different water depth, on the adjacent slope. We compared two different methodologies of analyses of the foraminiferal content, (wet versus dry) obtaining data that although consistent in terms of density evidenced some difference in the taxonomic composition. The preliminary data results highlighted that the unilocular soft-bodies foraminifera are poorly represented. They are present only at deepest stations of Polcevera canyon with morphotypes belonging to genera *Nodellum* and *Hospitella*. The *Nodellum* morphotype is typical of bathyal oligotrophic setting while *Hospitella* is a soft-walled foraminiferal taxon that in other oceanic bathyal environment shows a "squatter" behaviour inhabiting the empty shells of planktonic foraminifera. Contrarily, the data related to hard-shelled taxa showed a well diversified assemblages both in slope and canyon areas. Their distribution seems to be controlled by the quantity and quality of organic matter fluxes.

**Conclusions:** For their morphological features, the canyon systems receive high amount of organic matter and enhanced detrital accumulation (hyperpycnal flows) by channeling and trapping coastally-derived. These sedimentary mechanisms together with the organic carbon supply lead to the arrangement of a new habitat for faunal distribution. This environmental context lead to an environmental instability that is reflected on the meiobenthic community in terms of faunal density, diversity, species composition and spreading inside the sediment.

PIKERMIAN MAMMAL EVENT, POST-PIKERMIAN MAMMAL TURNOVER AND APPEARANCE OF  
*GRAECOPITHECUS*

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**Objectives:** The Middle Turolian mammal age is known in Southeast Europe as a time of bloom of the so called "Pikermian" fauna with dominance of hipparions and a number of bovids. Different opinions were expressed about the Balkans environment of that's time. Recent investigations approve the opinion that the climate and landscape were similar to the semi-opened savannah (Spassov et al., in press: *Paleontographica A*, 2017; Böhme et al., 2017). Till now the Middle Turolian boundaries are not clearly defined. The recently conducted investigations in some fossil sites in Bulgaria and Greece (Gorna Sushitsa, Azmaka, Pyrgos Vasilissis, Chomateri) allow for clarification in this respect.

**Method & Results:** It can be said, based on new data, that the Middle Turolian was restricted in a quite short time span. We could conclude, also, that this time period coincide with the so called "Pikermian event" (see: Kostopoulos, 2009) and thus we can specify more accurately the boundaries of this mammal event. The lower boundary of the middle Turolian could be placed after the paleomagnetic data immediately above the mammal locality GS2 (Gorna Sushitsa site, Bulgaria: 7.44 Ma), where more archaic, than at Pikermi, stages of *Adcrocuta eximia* and *Paramachaerodus orientalis* were determined. Above this locality in G. Sushitsa are located the lowest stratigraphic levels, in which C4 vegetation is determined in Europe, which is found also recently in slightly younger levels in Pikermi (Böhme et al., 2017). The Middle Turolian finished at the Tortonian/Messinian boundary (or slightly below this boundary) with a faunal turnover, marked by the invasion of a number of new mammals from the east (*Anancus* including, which first appearance in Europe could be in Azmaka: Spassov et al., 2012), just at the end of the Tortonian (Böhme et al., 2017).

**Conclusions:** The beginning of the mentioned turnover could mark the beginning of the late Turolian . The noted turnover is related to a significant aridification of the landscape. This is the environment in which appears the potentially first hominin *Graecopithecus freibergi* (Fuss et al., 2017; Böhme et al., 2017). In fact the specific savannah environments which probably stimulate the apes/hominin split and the evolution of the hominin condition, arose on the Eastern Mediterranean. Solounias et al. (1999) point out that the origin of the recent African savannah fauna must be related to the late Miocene Pikermian biome. We can assume that this also applies to one degree or another to the first hominins, which appearance is probably related, after the latest hypothesis, to the early Messinian environments of the Eastern Mediterranean and whose further evolution might be related to migration to the south (Spassov, Geraads, 2009) in the newly developed suitable African environments.



PETRIFIED WOODS OF GALATEAN VOLCANIC PROVENCE (NORTH OF ANKARA) FROM  
MIOCENE AND THEIR PALEOCLIMATOLOGICAL IMPORTANCE

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**Objectives:** Galatean Volcanic Provençe (GVP) (Galatean Volcanic Massive or Köroğlu Volcanics) are one of the five important volcanic areas from Miocene of Turkey. The objective of the presentation is (1) to identify the petrified trees from early to late Miocene of GVP, (2) to evaluate the past vegetation and climate.

**Methods & Results:** During fieldworks petrified woods were collected from Ankara (Kızılcahamam, Beypazarı, Güdül, Çamlıdere, and Nallıhan), Bolu (Seben, Kıbrısçık) and Çankırı (Çerkeş and Orta). Three thin sections (transversal, tangential and radial) were taken from each sample collected from 11 sites. The first results showed that a clear vegetational difference was determined between Seben – Beypazarı and Güdül-Çamlıdere. While willow, poplar, palm, evergreen oaks, sweet gum, elm, maple, pine, cedar and juniper trees were identified around Seben-Beypazarı located in west GVP, and swamp cypress, redwood and bald cypress were identified in central GVP. Maple, elm and pine trees were identified from Yıprak village site, belonging to the Late Miocene. The samples around Seben-Baypazarı belonging to Early Miocene and other palaeobotanical findings overlap with each other and indicate a clear riparian vegetation (stream and coastal) and Mediterranean climate like today. It can be mentioned that a swamp vegetation prevailed in Çamlıdere and its surrounding. The trees belonging to Late Miocene in Yıprak village are rather similar to the plants belonging to Early Miocene on the genus basis.

Maple is one of the most common genera during Early to Late Miocene in Anatolia. Ecological conditions of trees from two sites (Beypazarı-Inözü Valley: INL and Beypazarı-Kıraluç: KIR) were determined based on radial and tangential diameters, and frequencies of vessels. Yaman's formula called "xeromorphy ratio" was used for this work. Diameters and numbers of vessels of 8 maple samples were measured, and xeromorphy ratios were calculated. This ratios were also calculated for all native maple taxa (Yaltırık, 1971) at present in Turkey. The results showed that the current woods revealed 10.5-18.2 in semi dry lands (Maraş, Mersin, İzmir, Erzurum and Van), and 2.5-6.7 in wet lands (Artvin, Rize, Giresun, Kazdağları and İstanbul). In early Miocene woods they are 14.3-29.8 in Beypazarı-Inözü Valley and 1.5-6.8 in Beypazarı-Kıraluç. This result revealed that the growing sites in early Miocene had different characteristics as dry and wet for the maple trees. Based on high amount of xeromorphy ratios, we can conclude that the climate was warm and similar to the today's Mediterranean climate in early Miocene of GVP, as well. The trees having very low xeromorphy values were probably from the wet lands having high amount of water. This result on climate also supports the findings obtained from vegetation structure and paleopalynology.

**Conclusions:** In the Early Miocene, ecological wood anatomy of maple trees and plant communities revealed the presence of a subtropical and Mediterranean climate in GVP.

**ENVIRONMENT AND STRATIGRAPHY OF THE CLASSICAL PIKERMI SITES AND POST-PIKERMIAN LOCALITIES AND THE FIRST, LATE MIOCENE, SAHARA DESERTIFICATION**

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**Objectives:** To investigate the terrestrial environmental and biotic changes around the Tortonian-Messinian transition in the eastern Mediterranean at high-resolution we have studying the classical Pikermian outcrops in Southern Attica (Mesogea Basin). We reconstruct environmental conditions using sedimentology, grain-texture analysis, end-member modelling of grain-size distributions, geochemistry of soluble salts and provenance analysis of U-Pb ages of detrital zircons. We further provide age constraints on fossils and document environmental changes on the basis of combined bio-magnetostratigraphy, cyclostratigraphy and astrochronology. Furthermore, we analyse vegetation using phytoliths, palynology, and micro-charcoal to elucidate landscapes during this critical time.

**Methods & Results:** We sub-divide upper Miocene sediments in Southern Attica into the terrestrial to alluvial Pikermi and the palustrine to lacustrine Rafina Formations. For the Pikermi Formation, a saline aeolian dust deposit of North African (Sahara) provenance, we obtain an age of 7.37-7.11 Ma, which is coeval with a dramatic cooling in the Mediterranean region at the Tortonian-Messinian transition. Aeolian sediments overlying the Rafina Formation (7.11-6.9 Ma) indicate continuation of dust deposition well into the early Messinian. Furthermore, palaeobotanic proxies demonstrate C4-grass dominated and fire-prone wooded grassland-to-woodland habitats of a savannah biome for the Pikermi Formation. Our results reveal formerly unrecognized Mediterranean environmental changes during the Tortonian-Messinian transition and demonstrate for the first time the importance of aeolian sedimentation and C4 ecosystems for the Mediterranean Miocene.

**Conclusion:** The Tortonian-Messinian transition in the Mediterranean appears to represent a period of significant environmental and climatic changes. During the latest Tortonian aeolian dust starts to accumulate on northern Mediterranean shores and C4 grass ecosystems progressively penetrate the Eastern Mediterranean and both constitute the environment of the mammal fauna of Pikermi. The classical Pikermi fauna is terminated at the beginning of the Messinian by a significant faunal turnover (post-Pikermi turnover), accompanied by massive increase of Saharan dust and salt accumulation with profound effects on soil salinity and nutrition. Contemporary, water-stress levels increased and wildfire frequency decreased, which can be interpreted as increasing aridification.

We hypothesize that the ~700 kyr cooling episode (7.4-6.7 Ma), combined with the long-term eccentricity minimum between 7.3 and 7.2 Ma, acted as a final trigger for substantial north African aridization, which resulted in the initial formation of a large Saharan and Arabian desert belt. Furthermore, mineral dust in Attica was rich in soluble evaporites (halite, gypsum) in the earliest Messinian and especially during two pronounced insolation seasonality minima at 7.18 and 7.157 Ma, which suggests an orbitally driven progressive Sahara desertification.

Furthermore, our results reveal precise age control for important large mammalian localities from the Pikermi and Rafina Formations, in particular for those excavated by Gaudry (1855), Woodward & Skoufos (1901), Abel & Skoufos (1912), Symeonidis & Bachmayer (1972–1978 and 1979–1980), as well as the small-mammal-bearing levels sampled by De Bruijn (1974).

**PIKERMIAN AND POST-PIKERMIAN VEGETATION AT THE TORTONIAN-MESSINIAN  
TRANSITION IN THE EASTERN MEDITERRANEAN**

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**Objectives:** Despite its importance for the understanding of the Late Miocene mammalian assemblages in South-Eastern Europe, little is known about the Pikermian and post-Pikermian floral composition due to a sparse palaeobotanical record. The time period from 7.4 to 6.9 Ma spans the Tortonian-Messinian transition and is crucial for our understanding of terrestrial ecosystem and biotic evolution in the Eastern Mediterranean.

**Methods and results:** Phytolith research, combined with palynology, enabled us to gain first insights at diverse vegetation with C4-grasses, shrubs and herbaceous plants, changing our conception of a biome dominated by woody plants to an open savannah-like landscape.

**Conclusions:** This presentation reviews published and unpublished palaeobotanical data (phytoliths, pollen, charcoal) from the Balkan Peninsula (Bulgaria, Greece) and Anatolia, against the background of rapid palaeoenvironmental and palaeoclimatological changes in the Eastern Mediterranean at the Tortonian-Messinian transition.

**THE DIET OF *GRAECOPITHECUS FREYBERGI*: PHYTOLITHS AND DENTOGNATHIC EVIDENCE**

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**Objectives:** Reconstructing the diet of human ancestors is a complex but significant scientific challenge, because it may provide another way to understand our own biology. Here we report on our preliminary results about possible dietary adaptations and nutritional condition of the earliest potential hominin *Graecopithecus freybergi*, which lived in dry C4-grass rich savannah about 7.2 Ma ago in the Balkan Peninsula.

**Methods & Results:** Previous investigations of microwear patterns characterized this species as a hard-object feeder. Our new analysis proceeds by examining mastication-related internal and external dentognathic features using  $\mu$ -CT analysis. We also explore potentially available food resources using palaeobotanic data as phytoliths and pollen. Furthermore, based on geologic mapping and hydrogeologic data, we survey for drinking water availability for *Graecopithecus*.

**Conclusions:** Results will be discussed in the framework of hominid metabolism and have potential implications towards better understanding of subsistence strategies of hominins in savannah environments.

**REFINEMENTS IN BIOCHRONOLOGY IN ASIA AND NORTH AMERICA**

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**Objectives:** Despite the many and varied approaches to dating rocks, the fundamental basis of assessing the age of sedimentary deposits remains comparison of fossil content to the succession of faunas within that local biogeographic province. Given the great span of time for the Neogene Period, and a growing record of assemblages, it has become imperative that high precision relative dating be achieved. This includes independent biochronological dating with refined temporal resolution in separate theaters of evolution.

**Methods & Results:** The biochronological systems for North America and Europe are quite similar in their origin and established practice. Both are based on directional change in faunal content due to evolution, appearances, and disappearances. The immensity of time elapsed correlates with long-term faunal change, but at finer time scales faunal differences result from ecological and biogeographic variables, and sampling bias. In North America, the fortunate occurrences of rocks amenable to radiometric or magnetostratigraphic dating has led to improved temporal control and redefinition of the biochronologic system. The European MN system is undergoing similar adjustments that make its subdivisions understood in terms of the interplay of age and local biogeography. The biochronological system for China and much of adjacent Asia is convergent on chronostratigraphy insofar as the rock-time units (Regional Land Mammal Stage/Ages, Qiu et al. 2013) are increasingly based on observed biostratigraphy with boundary definitions. Application of magnetostratigraphy in cases where long stratigraphic successions embrace superposed stage/ages increases temporal control and provides age estimates for biochron boundaries. For China's Yushe Basin, a nearly complete sequence provides age estimates for four successive stage/ages (Opdyke et al. 2013). The exceptionally long succession for the Potwar Plateau Siwaliks of the Indian subcontinent provides a magnetostratigraphic time frame without need of distinguishing biochrons because the temporal ordering of assemblages is largely unambiguous, with relative dating tied to stratigraphic sections. One question for the Siwaliks is: to what extent do first and last occurrences reflect local or biogeographically regional events?

**Conclusions:** Putting the succession of biochrons of a biogeographic region into a stratigraphic framework with bases defined by biotic events gives them a chronostratigraphic or stage/age basis. Fortuitous application of radiometric dates and magnetostratigraphy supplies temporal resolution toward comparisons of successions. Future study will increasingly reveal differences in faunal histories of adjacent biogeographical regions, and place dispersalist interpretations on a firm basis.

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## ACTIVE SUBMARINE HYDROTHERMAL SYSTEMS AND THEIR INFLUENCE IN THE MARINE GEOCHEMISTRY OF MEDITERRANEAN SEA IN RELATION TO DEEP OCEANIC VENTING

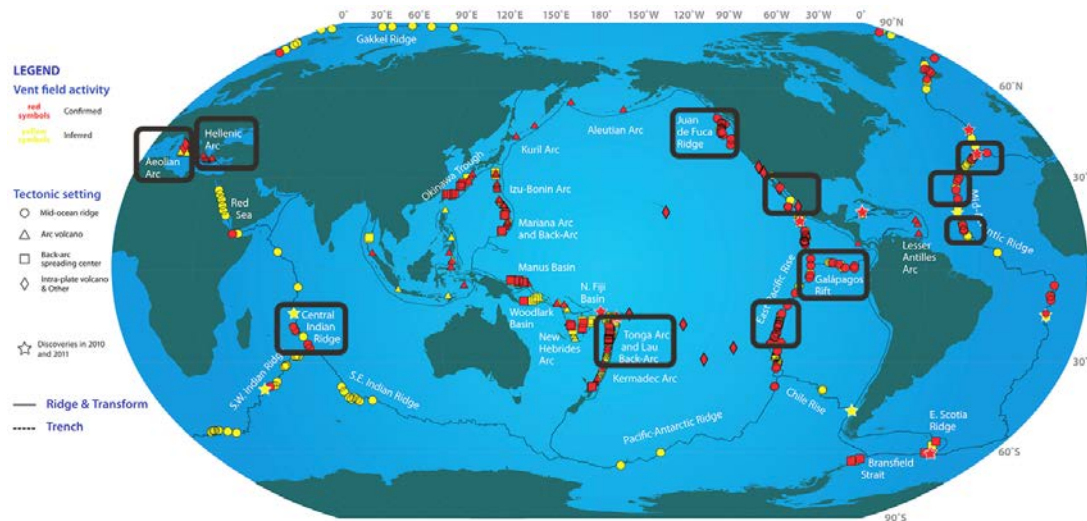
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**Objectives** More than 300 deep-sea hydrothermal vent sites of high-temperature hydrothermal venting have been discovered and investigated around the world in the past 40 years in locations of the Atlantic, Pacific and Indian Oceans. It is well documented that the hydrothermal venting has drastically altered the regional geochemistry around these sites. Hydrothermalism is common also in the Mediterranean Sea due to the collision of the African and European plates. However, most of the known hydrothermal sites in the region, have been found in shallow coastal waters, below 200 m depth. At these localities, the venting fluids contain various gases such as CO<sub>2</sub>, SO<sub>2</sub>, H<sub>2</sub>S, CH<sub>4</sub> and H<sub>2</sub> and heavy metals, due to acid leaching of the underlying rocks, while there is also a distinct diversity of fauna around the vent sites. In the present study, we examine the geochemical inputs in various forms (particulate, dissolved, gaseous) at hydrothermal vents of the Mediterranean Sea in an effort to estimate the potential regional hydrothermal impact on the Mediterranean marine environment geochemistry. Furthermore, we correlate and compare these data sets with relative data from the Oceans aiming to examine the similarities and differences of these geochemical inputs between the Oceans and the Mediterranean Sea.

**Methods & Results:** The present study combines and correlates data from original research and existing data from the scientific literature on submarine hydrothermal vents influencing local and regional geochemistry of Mediterranean Sea. The data sets include also areas of submarine volcanoes, as recent discoveries have proved the formation of hydrothermal venting sites within these areas. Elemental concentrations refer to both dissolved and particulate phase in various depths while the correlation with sediment geochemistry also has been attempted in some locations. Analytical results obtained with a variety of modern methods widely approved and used (AAS, GF-AAS, XRF, ICP-MS and ICP-AES, OES) while concentrations are given in both mg/l or µg/l and mM or µM when needed. Review results are being compared with deep-sea hydrothermal systems of Atlantic, Pacific and the Indian Ocean and are being summarised for correlation purposes.

**Conclusions:** We suggest that shallow-water hydrothermal venting existing in the Mediterranean Sea together with submarine volcanic activity discovered, not only influence local marine geochemistry in dissolved, suspended particulate and sediment phase chemistry but also that there are strong indications that alteration occurs in a much greater regional scale. Comparing with deep hydrothermal systems of Atlantic, Pacific and Indian Oceans there are many common geochemical processes and analogous elemental inputs in the marine environment while some differentiations are being attributed mainly in the different physicochemical parameters, the contribution of rainwater in water-rock interactions, and the, unlike oceanographic conditions and the type of rock substrate.



**Fig. 1** Global distribution of hydrothermal fields and locations of the main active submarine hydrothermal vent data (black squares), incorporated in the present study (map after *Interridge Programme*).

**ELEMENTAL FLUXES FROM SUBMARINE HYDROTHERMAL VENTS INFLUENCE THE MARINE  
GEOCHEMISTRY OFF KOS ISLAND, EAST MEDITERRANEAN**

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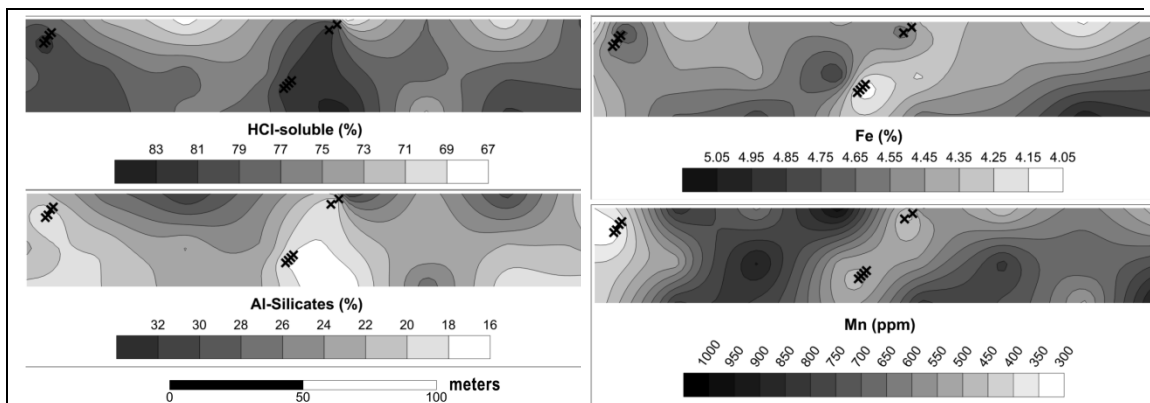
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**Objectives:**

Active submarine hydrothermal venting occurs in various marine environments such as the spreading centres in mid-ocean ridges, in oceanic volcanic and back-arcs arcs in seas and oceans of the earth. Hydrothermal submarine fluids contain certain gases, as well as heavy metals, metalloids and nutrients in various forms (dissolved ions and particulate matter), while they operate for many thousands even million years of activity. They also pose a great influence on biological communities on the venting sites due to nutrients release and favoured by distinct fauna. The present study explores the hydrothermal geochemical sources around Kos Island, East Mediterranean in an effort to analyse not only the influence of the proximity of venting sites but also to estimate the potential impact and possible greater imprint of hydrothermally derived heavy metals off Kos in the Aegean Sea.

**Methods & Results:** Marine geochemical research carried out in Kos Island (Bros Thermi) in the southernmost part of the Hellenic Volcanic Arc where extensive submarine hydrothermal activity occurs in shallow depths < 20m. In the deeper areas off Kos, no hydrothermal areas have been discovered. Sampling was carried out by scuba diving and sediments and hydrothermal fluids obtained on vent sites. Vent fluids were collected with fluid collectors assembled in the field and tested thoroughly prior sampling consisting of two double plastic bags connected via a Y-shaped selectable plastic connector and a plastic funnel. The content of suspended particulate matter (SPM) in hydrothermal waters was determined after filtration with the addition of extra high purity 2M HCl-1M HNO<sub>3</sub> mixture and in the final stage a mixture 0.5MHCl-0.1MHNO<sub>3</sub>. Samples were analysed for Fe, Mn, Cu, Pb, Cd, Sr, Fe, Al, Ca, Si, Ba, and Li, applying Atomic Absorption Spectrometry with Graphite furnace technique (GFFAS). Fine fraction of the local sediments associated with hydrothermally derived elements was separated by laboratory methods and chemical digestion was applied with 6N HCl which dissolves the hydrothermal fraction. Results show that concentrations of Fe, Mn, Zn and Pb exceed those of some deep-sea hydrothermal vents. Besides, heavy metals being incorporated in metal-bearing (e.g. Fe-bearing) particulate matter are enriched relative to seawater ambient chemistry and greatly influence the local sediment geochemistry. Part of metals in particulate form can withstand further oxidation in situ and mixed with seawater implying a potential influence in a much greater area (Fig. 1). On the other hand, nutrients such as P show elevated concentrations compared with Methana and the Lau Basin submarine hydrothermal areas.

**Discussion & Conclusions:** The shallow-water Bros Thermi hydrothermal field is characterized by very high concentrations of heavy metal elements such as Fe, Mn, Zn and Pb, and also by elevated concentrations of such as P. Metals is strongly associated with particulate matter which can be further dispersed, in mixing with seawater, in much greater distance off Kos in the Aegean Sea. Thus, the geochemistry of Kos vents has a potential to influence a much greater area like deep-sea venting activity is causing and proved by analogous researches.



**Fig. 1** Hydrothermal SPM influence on seabed, Bros Thermi Kos Island Eastern Mediterranean

## DEFORMATION ALONG THE AMORGOS SHEAR ZONE, SOUTH AEGEAN SEA

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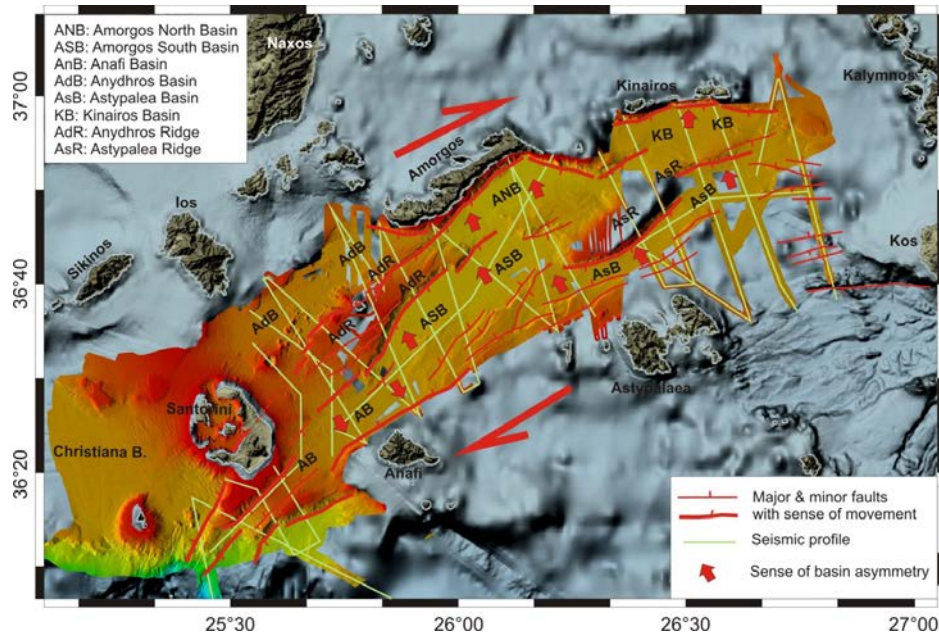
**Objectives:** The purpose of this study is to reveal information about the complex structure of the so-called “Amorgos Basin” through the description of the main geomorphological features and the understanding of the structural architecture, in order to develop a new model for the kinematics and the deformation of the newly proposed Amorgos Shear Zone in Plio-Quaternary.

**Methods:** Seismic and bathymetric data unravel information about the basic kinematic processes and the deformation mechanisms that led to the current geotectonic structure of the area. This work is based on the: (i) processing and analysis of roughly 5,000 km<sup>2</sup> of swath bathymetry data between Santorini, Amorgos, Kalymnos, Astypalea and Anafi Islands and the (ii) processing and interpretation of >700 km of seismic profiles.

**Results:** The new bathymetry suggests that “Amorgos Basin” is not a single basin, but a group of well-developed basins, distributed in a NE-SW trending, consisting of the Anafi (AnB, 600m), Amorgos South (ASN, 700m), Amorgos North (ANB, 750m), Astypalea (AsB, 600m) and Kinairos (KB, 600m) Basins. They are spindle shaped basins, surrounded by steep, faulted scarps, separated by Anydhros (AdR) and Astypalea (AsR) Ridges. Anydhros Ridge splits towards NE into two branches: the northern one separates Anydhros Basin (AdB) from ANB, while the southern one separates ANB from ASB.

The interpretation of the acquired seismic profiles shows that the sedimentary infill of the basins displays very similar seismic character, with well-defined unconformities occurring at comparable stratigraphic levels, indicating thus major tectonic events affecting the entire area. Uplifted sediments from the lowermost parts of the sedimentary sequence, suggest basins inversion. The AsR is built by uplifted and tilted stratified deposits which dip northwards. They continue below ANB and KB forming the lower part of their infill, and are comparable to the lower deposits of ASB and AsB. Similarly, the southeastern part of Anydhros Ridge is built by uplifted stratified deposits, equivalent to the lower basin infill of ASB and AnB. Mainly, NE-SW trending, SE dipping faults control the development of the basins, with maximum subsidence close to the main faults indicating rapid subsidence. The few WSW-ESE to WNW-ESE trending faults are step-overs between the NE-SW ones.

**Conclusions:** Based on the evidence above, we conclude that the area surrounded by the islands of Santorini, Anydhros, Amorgos, Kalymnos, Astypalea and Anafi was a single, symmetric basin during Pliocene, bounded by faults towards NW and SE. In Late Pliocene or Early Pleistocene, a major change in the style of deformation led to the fracturing of the former basin, uplift, tilting and basin inversion along the newly formed faults and creation of five asymmetric basins separated by uplifted ridges. The fault network, the structure and the style of deformation presented here suggest transtensional deformation in NE-SW direction, accommodated by NE-SW trending, oblique faults and E-W directed normal fault oversteps. In conclusion, the study area constitutes a dextral, oblique to horizontal shear zone, the Amorgos Shear Zone.



**Fig. 1.** Swath bathymetry of the dextral Amorgos Shear Zone with main geomorphological elements, fault network and basins asymmetry.



MORPHOLOGY AND PHYLOGENETIC POSITION OF *GRAECOPITHECUS FREYBERGI*

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**Aims:** The hominid *Graecopithecus freybergi* from Pyrgos Vassilissis (Greece) and cf. *Graecopithecus* sp. from Azmaka (Bulgaria) are currently dated to the early Messinian at ~7.2 Ma (Böhme et al. 2017). Mainly based on its external preservation and the previously vague dating, *Graecopithecus* is often referred as nomen dubium, or is used synonymously for the significantly older northern Greek hominid *Ouranopithecus*. To address this issue, we investigated the dentognathic morphology of *Graecopithecus*, using new  $\mu$ CT and 3D visualizations of the two known specimens.

**Results & Conclusion:** The previously unknown dental root and pulp canal morphology confirms the presumed taxonomic distinction (Koufos & de Bonis 2005) from *Ouranopithecus* and shows features that point to a phylogenetic affinity with hominins. *G. freybergi* uniquely shares p4 partial root fusion and a possible canine root reduction with this tribe and therefore, provides potential evidence of the oldest hominin (Fuss et al. 2017).

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**SEISMOTECTONICS IN THE GULF OF TRIESTE (NORTHERN ADRIATIC SEA) BY MEANS OF TOMOGRAPHIC ANALYSIS FROM MULTICHANNEL SEISMIC REFLECTION DATA**

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**Data and Aims** - During the last decade, OGS carried out three geophysical surveys in the Gulf of Trieste (GT), collecting 600 km of Multichannel Seismic (MCS) Reflection profiles. A focused geophysical analysis, encompassing tomography and depth seismic imaging, is crucial for the reconstruction of the seismotectonic behaviour of the gulf.

**Geological Setting** - The GT is the foredeep of the northern External Dinarides and the eastern Alps. Its evolution started from a Mesozoic rifting that generated NE-SW normal faults allowing the aggradation of the Mesozoic-Paleogene Friuli-Dinaric Carbonate Platform. From the Upper Cretaceous to the Oligocene, the Dinaric compression generated NW-SE oriented thrust faults, whose most external elements are located in the GT. Since the Oligocene, the Alpine compression, related to the ongoing northward motion of the Adriatic plate, reactivated the NW-SE oriented faults with a transpressive kinematics. The GT represents the foot-wall of the Dinaric Karst Thrust, extending along the coast of the Karst highland and displacing the Carbonates with an important vertical throw. The Carbonates in the gulf are covered by the Eocene turbiditic Flysch, whose top is depicted by an unconformity related to the Messinian erosional phase, that in the eastern part of the gulf was active also during the Pliocene, as proved by the thin package of Quaternary marine and continental deposits covering the surface.

**Methods** - Traveltimes tomography provides an adequate elastic velocity model in depth, allowing resolution of vertical as well as lateral velocity gradients and a reliable reconstruction of the geological structures. The input consists in the reflected and refracted traveltimes picked on the prestack seismic data. In the present work, we picked two main reflectors, the top surfaces of Flysch and Carbonates. The adopted tomographic software defines the seismic velocity field and the surface geometries through an iterative algorithm that minimizes the difference between the modelled and measured traveltimes. The code inverts in sequence the velocity field, and updates the reflector structure until their variations with respect to the previous step become sufficiently small. In order to further refine the obtained velocity model, we employed an iterative imaging technique involving pre-stack depth migration, residual move-out analysis and grid tomography. The process goes on until the residuals become sufficiently small, which happens when the model exhibits a flat sequence of events. This means that the velocity field is estimated with sufficient accuracy, allowing to obtain an optimally focused depth image.

**Results and Conclusion** - A pre-stack depth migration obtained on a profile normally oriented to the Karst coastline, reveals the top of carbonate platform at a maximum depth of around 1.6 km below the seabed. Other important structural elements affecting the sedimentary units of the GT are also well imaged as a carbonate anticline buried under some meters of Quaternary sediments and extending into the gulf from the Istrian coast. The obtained geological information is then used to construct a 3D geological and structural model of the GT and to enhance the understanding of the neotectonic evolution of the area.

**LATE-SARMATIAN S.I. – MAEOTIAN LITTORAL-DELTAIC ENVIRONMENTS OF THE DACIAN BASIN ALONG THE SLĂNICUL DE BUZAU SECTION: FACIES ANALYSIS AND PALAEOGEOGRAPHY**

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The Late Sarmatian s.l. – Maeotian interval (Late Miocene) in the Eastern Paratethys is characterized by a Chersonian sea level drop followed by a Maeotian flooding event that triggered replacement of faunistic complexes and paleoenvironmental restructuring. The Dacian Basin, as a key region between Eastern and Central Paratethys, was especially sensitive to the sea level fluctuations. However, crucial parameters for understanding and dating the Sarmatian s.l. – Maeotian boundary, faunistic changes and salinity are still debatable.

To address to these questions, we studied the Slănicul de Buzau section in the Dacian Basin (Romania), which exhibits relatively distal littoral-deltaic environments. The aim of the study is to reconstruct the paleoenvironments in the Late Sarmatian (Chersonian) and Maeotian, based on detailed sedimentary facies analysis, in combination with analysis of the ostracod and mollusk faunas, and paleomagnetic dating.

Nine facies associations were recognized in the section. These represent littoral environments (FA1 – Offshore; FA2 – Offshore transition; FA3 - Shoreface), a back barrier system, including lagoons (FA4 – Barrier islands; FA5 – Back barrier lagoon), deltaic environments (FA6 – Prodelta; FA7 – Delta front; FA8 – Distributary channels) and lowland environments (FA9 – Coastal floodplain/lowland). A synthesis of the detailed facies analyses and ostracod and mollusk faunas suggests that:

1. The upper part of the Sarmatian s.l. (Chersonian) demonstrates freshwater lowland environments with widely distributed red paleosols periodically subject to brackish water incursions.
2. The Maeotian starts with a marked transgression and relatively higher brackish water environments that further transform into low brackish back barrier systems with well-expressed shoreface, barrier and lagoon facies associations.
3. The second part of the Maeotian is characterized by fresh water deltaic and littoral environments.
4. The uppermost Maeotian mainly comprises brackish water distal littoral environments with local influence of fluvial processes.

Our depositional model demonstrates features of slow, continuous base-level rise, which is expressed as repetitive, abrupt replacements of relatively shallow water facies associations by deeper water ones, numerous ravinement surfaces and retreat of the shoreface and back barrier bodies. However, there was also observed one significant regressional trend in the middle part of the Maeotian interval, which is characterized by progradation of deltaic deposits with incised channel bodies and fresh water environments. These base-level changes were likely caused by interplay between basin subsidence, sediment input and Paratethys base-level.

FORAMINIFERAL MONITORING OF THE NEW SUBMARINE HYDROTHERMAL SYSTEM OFF THE WESTERN PONTINE ISLANDS (CENTRAL TYRRHENIAN SEA)

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**Aims:** The recent discovery of a giant complex depression (the Zannone Giant Pockmark, ZGP) with active fluid emission in shallow-waters (<150 m wd), off the Pontine Archipelago (Tyrrhenian Sea, Italy), represents an opportunity to study hydrothermal fluid vent (mainly regarding the CO<sub>2</sub> emission) impact on meio- and microbenthic communities and to evaluate the effects of ocean acidification (Ingrassia et al., 2015). Di Bella et al. (2016) highlighted transitional conditions between the vent related sediments and the typical carbonate sedimentation present in this archipelago. The aim of this research is to provide new information, two years after the discovering of this hydrothermal field, in order to monitoring fluid emissions and biota.

**Methods & Results:** New sampling survey conducted on February 2017 allow us to collect new samples on which, besides foraminiferal assemblages, pigments (chlorophyll-a) are studied. Living and dead foraminiferal assemblages were considered in the first 10 cm of the subsurface. The Chl-a was assessed on triplicate by spectrophotometry. Sediment samples (~1.5-2 g dry weight) were extracted in 4 ml of 90% acetone, at 4 °C in darkness for 24 h. Chl-a is a labile pigment used as indicator of the quality of the organic matter, where high Chl-a concentrations suggest local and actual high primary production conditions in the euphotic zone.

Until now the geochemical results highlighted values of <sup>3</sup>He/<sup>4</sup>He and CO<sub>2</sub> enrichment similar to those recorded at Stromboli and Panarea islands (Martorelli et al., 2016). The comparison of the micropaleontological analyses derived from similar environmental sites with those conducted in this research shows similar structural changes (loss of biodiversity, decrease of foraminiferal density), but very different composition. In fact, very unique foraminiferal assemblage consisting of living agglutinated species (*Spiculosphon oceana*, *Jaculella acuta*, *Deuterammia rotaliformis*) is found, representing an update of the foraminiferal distribution for the Mediterranean Sea. In addition, the relevant carbonate dissolution process are testified by changes on the dead foraminiferal assemblages. As regard pigment data, highest Chl-a concentrations were found West of the ZGP, whereas the lowest concentrations were found in the southern sector out of the ZGP, suggesting a possible influence of the hydrothermal activity.

**Conclusions:** The recognised foraminiferal assemblages provide a useful proxy to localise and monitoring vent activity on the seafloor. In fact, their distribution is strongly controlled by composition and concentration of fluid emission. The response of meiobenthic communities resulted in loss of biodiversity, and decrease of foraminiferal density which are strictly controlled by vent activity, such as the zonation in the distribution of Chl-a.

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**HOW WARM WAS MEDITERRANEAN REGION DURING THE MESSINIAN SALINITY CRISIS?**

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**Introduction:** Between 5.97-5.33 Ma kilometres-thick evaporite units were deposited in the Mediterranean basin during an event known as the Messinian salinity crisis (MSC). It is generally accepted that the MSC was a dry period, with higher evaporation than precipitation and runoff. However, how warm or dry the climate was during the MSC is difficult to assess because a modern analogue is missing.

**Methods and Results:** Here we reconstructed the mean annual temperatures (MATs) on continental realm and the sea surface temperatures (SSTs) for Mediterranean Sea between 5.55 and 5.33 Ma, using the TEX<sub>86</sub> proxy based on branched and isoprenoidal glycerol dialkyl glycerol tetraether (GDGT) respectively. These excellently preserved organic biomarkers were extracted from the reference section of Eraclea Minoa section (from Sicily) deposited during the 'Upper Gypsum', stage 3 of the MSC. The MAT's calculated for the 'Upper Gypsum' Eraclea Minoa indicate values of 19 to 22 °C, slightly higher than the present day temperatures of 15 to 20 °C on Sicily. Furthermore, we compared the TEX<sub>86</sub> derived SSTs with the alkenone based,  $U_{37}^k$  proxy derived SST estimates from the same samples. For the samples where the branched and isoprenoid tetraether (BIT) index was lower than the 0.4 threshold limit we could calculate TEX<sub>86</sub> derived SST's as high as 32 °C. These values are slightly higher than the  $U_{37}^k$  derived SST of 20 to 28 °C (the maximum of the available calibration range for  $U_{37}^k$  proxy). These elevated temperature values are up to 10 °C higher than the once recorded in the past 10 kyr in the Mediterranean Sea using  $U_{37}^k$  proxy (Cacho et al., 2002) and even up to 18 °C higher than those estimated for the last glacial period. Values up to 27 °C were recorded during the latest Pleistocene (Herbert et al., 2015) and between 13 and 8 Ma in the Mediterranean region (Tzanova et al., 2015). For the interval between the 8 and 6.4 Ma the  $U_{37}^k$  derived SSTs vary between 19 and 27 °C, close our calculation for Eraclea Minoa section (20 to 28 °C). However, these calculated SST values should be considered with caution because of the known calibration biases given by, for example, unknown species of algal alkenone producer or the GDGT distribution in stratified water basins.

**Conclusions:** Regardless the pitfalls that may arise in using the so-obtained absolute values, the two SST estimation methods hint towards much warmer Mediterranean Sea water during the latest phase of the MSC. These warmer values are recorded at times when enriched  $\delta D$  measured on alkenones and  $\delta D$  of long chain *n*-alkanes indicate both more arid and/or warmer conditions than today for the 'Upper Gypsum' Eraclea Minoa, between 5.55 and 5.33 Ma (Vasiliev et al., under review). We therefore conclude that the climate during the stage 3 of MSC, at the paleogeographic position of Sicily, was drier and warmer than present-day conditions.

**BASIC THEORETICAL INSIGHTS REGARDING THE PAST FUNCTIONING OF THE  
MEDITERRANEAN SEA**

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In this contribution I set out to demonstrate how simple physics provides useful basic insight regarding the past functioning of the Mediterranean Sea. Three different aspects will be investigated.

A classical calculation, featured in many textbooks on physical oceanography, concerns the relationship between in- and outflow through the Strait of Gibraltar and the salinity excess of the Mediterranean Sea over the Atlantic Ocean. In this, the anti-estuarine nature of strait exchange is explained from the fact that the Mediterranean water has greater density. However, in the classical calculation the effect of temperature on density is ignored. Here, the computation is extended by considering not only net evaporation and salinity, but also atmospheric heat exchange and temperature. A relatively small heat flow into the Sea proves sufficient to reverse the exchange, even in the presence of net evaporation acting in the opposite direction.

Of all factors proposed to influence the paleoceanography of the Mediterranean basin it appears that two stand out: (i) the efficiency of the connection(s) to the Atlantic Ocean and (ii) the atmospheric forcing changing on Milankovitch time scales. A simple two-box model is able to capture the interplay between these forcings. For the case of net evaporation changing with precession, the model shows that basin salinity varies in-phase with the forcing when exchange is of a present-day magnitude. However, when the exchange is reduced to values thought to characterise the Messinian salinity crisis, the basin salinity clearly lags the forcing. One implication of this is that, for instance, gypsum is formed at a time when the climate is already wetter again.

The in-phase relation between basin salinity and forcing, found for present-day exchange values, has bearing on the third and last aspect we will study: our on-going efforts to capture the overturning circulation of the Mediterranean Sea with box models. It will be shown that different arrangements of the boxes lead to significantly different results in terms of the relative timing of the forcing and the model representation of deep-water formation. From this follows the important insight that (proxy-)data as to how deep-water formation and forcing were in reality related (e.g., the sapropel record), may provide clues regarding the functioning of the basin.

LARGE PALEOENVIRONMENTAL CHANGES DURING THE LATE MIOCENE AFFECTING THE  
BLACK SEA BASIN (TAMAN PENINSULA, RUSSIA)

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**Introduction:** The Black Sea basin, as a part of the former Eastern Paratethys, represents an ideal target region to study continental response to the changes in the hydrological conditions over Eurasia.

**Methods and Results:** To understand the environmental changes governed by intermittent Black Sea connection to the open ocean during the late Miocene into the transition to early Pliocene, we present here the reconstructed mean annual air temperature (MAAT) based on the relative distribution of branched glycerol dialkyl glycerol tetraether lipids derived from soil bacteria (Weijers et al., 2007). We further quantify the so-called branched and isoprenoid tetraether (BIT) (Hopmans et al., 2004), index used to monitor the changes in the source of the organic matter into our Miocene-Pliocene rocks (Hopmans et al., 2004). Additionally, we extend the knowledge on the hydrological changes further back in time on the entire integrated stratigraphy dated record of the Zheleznyi Rog reference section (Vasiliev et al., 2011).

**Conclusions:** Our MAAT, BIT and additional pH data indicate that the dryer event between 5.8 and 5.6 Ma, inferred from earlier acquired  $\delta D_{\text{alkaneone}}$  data (Vasiliev et al., 2013), coincides with a significant cooling in the continental realm north of the Black Sea. During that time, the Taman region was dry and cold and was receiving fresh water from colder, steppe environment draining the alkaline soils from northern (Black Sea) latitudes. This cooling was the probable cause responsible for the significant, more than 45‰, drop in the  $\delta D_{n\text{-alkanes}}$  recorded from the onset of the Pontian stage to the Kimmerian. Climate at the end of Pontian (in Zheleznyi Rog) was cooler and dryer than before, synchronized with the TG 20-22 or TG 12-14. Additionally, there is an older dry event, at the Khersonian-Meotian transition expressed in very high  $\delta D_{\text{alkaneone}}$  values. This dry event is correlated to the older, dry event recorded in the DSDP 42B 380 between 934 – 830 mbsf (Vasiliev et al., 2015). This suggests that the sedimentary succession from the DSDP 42B was deposited at the transition Khersonian-Meotian transition, implying that the sedimentary succession from the DSDP 42B 380, at depth greater than 934 mbsf, is Khersonian and/or older.

**MIOCENE CLIMATE STATUS IN THE MOESIAN PLATFORM (ROMANIA- BULGARIA) BASED ON BIOMARKERS, SEDIMENTOLOGY AND TECTONICS**

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Miocene epoch marks a period of important changes in the Eurasian domain. During this period the Moesian microplate (southern Romania and northern Bulgaria) underwent a complicated flexural behavior due to the mobility of the nearby tectonic units. The different behavior induced varying sediment charges, lithology patterns and distribution. Considering this the northern part of the study area (the Carpathian foredeep) is characterized by siliciclastic sequences (dominantly deep facieses), while the opposite part is characterized by carbonate precipitation in shallow waters (dominantly proximal facieses). Since Miocene the Dacian basin (which overlain the Moesian Platform) and the Black Sea basin have been highly sensitive to the hydrological cycle variations. In order to determine the dynamic of the basin and the climate variations during the Miocene, we have sampled both northern and southern margins of the basin. The aim of the study is to discriminate between the tectonic and the eustatic influence over the sedimentation rate. To accomplish this we have chosen a multidisciplinary approach including sedimentology, tectonics and organic geochemistry. The sedimentary succession is disrupted by a number unconformities corresponding to the main tectonic events from the Carpathian Foredeep. The southern part of the basin seems to have been exposed more often due to the presence of a higher number of unconformities and paleo-soils levels. For the samples from the Carpathian foredeep the *n*-alkanes distribution indicates a mixture of terrestrial and marine input. The samples from Bulgaria indicate a more predominant terrestrial input (with higher contribution of the long chain *n*-alkanes). The estimated paleotemperatures based on branched GDGT's indicates warmer conditions than present day, up to a value of 20C deg. mean annual temperatures (MAT). The present results are for the Sarmatian sediments (8-12 My.) and we will further investigate the upper part of the Miocene.

**Keywords:** Miocene, variation, sediments, *n*-alkanes, GDGT's, MATs.



STABLE ISOTOPES ON OSTRACODS INDICATE MARINE INCURSIONS IN THE DACIAN BASIN  
DURING UPPER MIOCENE AND PLIOCENE

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The Dacian Basin was a part of the former Paratethys Sea that stretched over Eurasia during Miocene to Pliocene. During that times the Paratethys experienced high variations in its connections to the Ocean that hampered the correlation of the events to the global ones. The consequent high degree of biota endemism limited the possibility for conventional (foraminifera based  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) isotope methodology. Here, we present the first stable isotope ( $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$ ) data of the Dacian Basin spanning the latest Miocene to Pliocene. Next to mollusks, the ostracods are the groups of organisms that provide the only time-continuous biogenic carbonates in the Dacian Basin and were used for obtaining the here presented  $\delta^{18}\text{O}$  &  $\delta^{13}\text{C}$  records. These data were obtained from the well dated 2300 m thick Slanicul de Buzau reference section, with available high resolution ostracod biochronology (van Baak, et al., 2015). The new  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  data provide a first order reconstruction of the most significant changes affecting the basin during 6.3 to 3.3 Ma time interval. These data were furthermore compared to the strontium isotope data from the same Slanicul de Buzau section (Grothe et al., 2016). To minimize the effects of species dependent biosynthetic fractionation on the  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  values we target single specimen measurements, preferentially on *Cyprideis* sp., and *Tyrrhenocythere* sp. The  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  records from Slanicul de Buzau show both very large variations, in order of 13‰ (from around -11‰ to 2‰) over the sampled 3 Myr interval stretching over the 2300 m thick interval. Such large changes cannot be explained only by species or interspecies dependent variations in the biosynthetic fractionation. They must indicate important changes in the Dacian Basin water properties. There are two intervals recording much heavier  $\delta^{18}\text{O}$  values (up to 0 and +2 ‰) when compare to the rest of the record. The older one is at ~5.4 Ma and coincides with 'Bosphorian Flood', interval that is also marked by elevated  $^{87}\text{Sr}/^{86}\text{Sr}$  values close to those recorded in the oceanic waters at that time (Grothe et al., 2016). We interpret interval as a time when an influx of saltier, possibly also warmer water, affected the Dacian Basin. The second one, at around 3.4-3.3 Ma, is also marked by somehow higher  $^{87}\text{Sr}/^{86}\text{Sr}$ . Because the timing of this younger interval heavier  $\delta^{18}\text{O}$  values coincides with the Mid Pliocene Warm period we speculated that an influx of warmer, possibly also saltier water, affected the Dacian Basin. The  $\delta^{13}\text{C}$  data do not follow the trends of the  $\delta^{18}\text{O}$ . At 5.5 Ma (during the 'Bosphorian Flood') the heaviest  $\delta^{13}\text{C}$  are recorded (+2 ‰). After this interval, until the end of our record at 3.3 Ma, with some fluctuations, there is a consistent decrease in the  $\delta^{13}\text{C}$  values (up to -11 ‰). We interpret this  $\delta^{13}\text{C}$  decrease as a steady change in the environmental conditions of the Dacian Basin, from more eutrophic at 5.5 Ma to more oligotrophic towards the 3.3 Ma.

DEEP-WATER ENVIRONMENTS AT THE TORTONIAN-MESSINIAN BOUNDARY: A CASE STUDY  
ON BENTHIC COMMUNITIES FROM CRETE ISLAND (GREECE)

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**Objectives:** The Messinian Salinity Crisis (MSC) was caused by the progressive restriction of sea-water exchanges between the Atlantic Ocean and the Mediterranean Sea. Connections occurred through several gateways in Spain (Betic corridors) and Morocco (Rifian corridors). The Betic corridors underwent progressive restriction after 8.35 Ma and were fully closed at 7.2 Ma, whereas the Rifian corridors were progressively restricted since 7.2 Ma and completely closed by 6.1 Ma. We examine here the consequences of these restrictions for deep-water biological communities, for the most part poorly known in the eastern Mediterranean.

**Methods & Results:** Three sections have been sampled in three different sedimentary basins of the island of Crete (from west to east: Potamida, Kapariana, and Faneromeni). A qualitative and semi-quantitative analysis of the diverse planktonic foraminiferal fauna indicates an age bracketed between about 7.6 and 6.7 Ma (Tortonian-Messinian transition). A detailed study of the rich assemblages of benthic foraminifera, bivalves, bryozoans, and ostracods suggests that deposition took place predominantly in upper-medium bathyal environments. A shallowing-upward trend is however observed near the top of all three sections, where middle to outer shelf communities predominate. Some downslope transport in the upper part of two sections (uppermost Tortonian in Potamida, Messinian in Kapariana) is indicated by the co-occurrence in a few beds of shallow- and deep-water fossil remains. This phenomenon is attributed to sediment displacement under higher turbidity conditions and/or rafting of plant material, to which epiphytes lived attached, into deeper environments during storms. Episodic dysoxic conditions are also evidenced in the Faneromeni and Kapariana sections where laminitic beds are widespread. In Faneromeni, these events started during the Tortonian, but are particularly conspicuous during the Messinian, whereas they are limited to the Messinian in Kapariana. Reduction in oxygen content generally occurs when fresh-water input or upwelling currents elevate nutrient levels, thus limiting the development of bottom-dwelling communities and favouring taxa able to tolerate low oxygen concentrations.

**Conclusions:** The present study indicates that ecological changes in deep-water assemblages are relatively limited near the Tortonian-Messinian boundary. The most prominent feature is a significant sea-level drop during the late Miocene, as reflected by variations in benthic assemblages. Episodes of increased nutrient input in surface waters, especially during the Messinian, may also have played an important role in controlling the structure and biotic composition of these ecosystems.

**MIOCENE PALEOCLIMATE RECONSTRUCTION OF TINAZ (YATAĞAN BASIN) USING CLIMATE LEAF ANALYSIS MULTIVARIATE PROGRAM (CLAMP)**

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**Objectives:** In this research we aimed to reconstruct the climatic conditions of the Yatağan Basin (Muğla, Turkey) during the Miocene. We used a middle Miocene locality (Tinaz), the age of which is well constrained to MN6 by ungulate and carnivore remains (*Gomphoterium angustidens* Cuvier, 1817; *Percrocuta miocenica* Pavlov & Thenius, 1965). We were mainly interested in comparing a previous qualitative assessment of the flora with a quantitative climate inference and in comparing the modern climate of southwestern Turkey with the inferred middle Miocene climate.

**Methods & Results:** A total of 66 species of plants have been reported for the Tinaz flora (Güner, 2016). 567 measured specimens assigned to 57 leaf morphotypes were used for inferring selected climate parameters. The Climate Leaf Analysis Multivariate Program (CLAMP; Yang et al, 2015) was used to test the relationships between climate and leaf form (physiognomy). Using this data, CLAMP reconstructed the following climate parameters: mean annual temperature (MAT) 13.81 (+/-1.5) °C, warm month mean temperature (WMMT) 24.7 (+/-2.5) °C, cold month mean temperature (CMMT) 3.6 (+/-2) °C, length of growing season (LGS) 8.11 (+/-0.75) month, mean growing season precipitation (GSP) 134.66 (+/-40) cm, precipitation during the three wettest months (3-WET) 67 (+/-25) cm, precipitation during the three driest months (3-DRY) 20.4 (+/-7.5) cm.

**Conclusions:** The reconstructed parameters are too cool for tropical climates (the 18°C winter isotherm being a threshold for tropical climates) and indicate temperate conditions; climates fitting these parameters (Cfb according to the Köppen-Geiger climate classification) can be found today in regions known as “Tertiary relict areas” (e.g. Black Sea coast of northeastern Turkey, eastern China, Japan). These findings have important implications for reconstructing the palaeoenvironments of roughly coeval vertebrate sites including hominoids (e.g. Paşalar).

**LATE MIOCENE GIRAFFIDS FROM THE GREEK PENINSULA: THE CASE STUDY OF KERASSIA  
(EUBOEA ISLAND, GREECE)**

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**Objectives:** During the last two centuries, a large number of continental Neogene localities have been discovered in Greece and more specifically all around the coastline of the Aegean Sea. A large number of type species have been described from these fossil rich outcrops, including the type species of four giraffid genera. Being at the western edge of the “Greco-irano-afganian” province, Greek Miocene localities are characterised by the abundance of bovids and giraffids, a trend that becomes more distinct during the late Miocene. More specifically, eight different giraffid taxa have been recorded from Greek late Miocene localities, and in some cases even four different giraffid taxa coexisted in the same locality. To date four such locality examples have been recorded, Ravin de la Pluie, Nikiti 1, Kerassia Upper horizon (Kerassia 1) and Kerassia Lower Horizon (Kerassia 3 and Kerassia 4). Obviously, these species in order to coexist, they did not compete for the same food resources.

**Stratigraphy:** The actual fossiliferous locality of Kerassia is found north of the village of Kerassia. To date, seven different fossiliferous sites have been found in the locality (namely K1 to K7) where at least two fossiliferous horizons occur, an upper and a lower one. The bone bearing sediments are reddish-brown, fluvial deposits. The fossil assemblages occur as dense accumulations of bones within some of the fluvial channels. Sedimentological and geochemical evidence indicates that sites K1 and K6 belong to the upper horizon while K2, K3, K4 and K5 belong to the lower one.

**Results:** A taxonomic study of the abundant and diverse giraffid material from Kerassia, Greece has been undertaken. To date, five different species of giraffes have been determined in Kerassia. Four species were found in the lower horizon, *Palaeotragus rouenii*, *Palaeotragus* sp., *Samotherium major* and *Helladotherium duvernoyi* and four species in the upper horizon *P. rouenii*, *S. major*, *H. duvernoyi* and *Bohlinia attica*. The presence of *S. major* in both horizons indicates a middle Turolian age (MN12).

The presence of possibly two grazers, one mixed feeder and one browser in the lower horizon and conversely of one grazer, one mix feeder and two browsers in the upper horizons, indicate the prevalence of a mosaic of different vegetation habitats from woodlands to open grasslands at Kerassia during the middle Turolian and it is probable that the upper horizon represented more forested (more tree coverage) habitats than the lower one. This is also supported by the presence of some forest dwellers like *Microstonyx major* and *Dorcatherium* sp. in the upper horizon and which are absent from the lower one. A seasonal Mediterranean type, relatively temperate to warm and moist climate, can be inferred for the MN12 (Middle Turolian) of the Kerassia region.

**Conclusions:** Therefore, the coexistence of four different giraffid taxa in four different Greek localities indicates that during the latest Vallesian -Turolian in the central Greco-Anatolian territory there was a mosaic of different vegetation habitats from woodlands to open grasslands, and enough rainfall and/or waterbodies that could support them all year long.

**THE PLIOCENE SMALL MAMMAL (RODENTIA AND INSECTIVORA) LOCALITY OF VEVI (NW GREECE)**

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**Objectives:** The locality of Vevi (NW Greece) was discovered by Doukas and de Bruijn in 1993. It is situated in lacustrine deposits in the intramontane Servia-Ptolemais-Florina basin. The goal of this study is to record and describe the locality's fauna. The age and the composition of the Vevi fauna will be discussed.

**Methods & Results:** Rodent species and insectivores were recognized. The collected sediments were left to dry and placed in buckets with water. The under-study material was collected by wet screening on a set of sieves with the finest mesh used being 0.5 and 2.5 mm. The collection from Vevi is stored in the Faculty of Geology and Geoenvironment of the National and Kapodistrian University of Athens. The dimensions, length (L) and width (W) of the teeth have been measured with the use of a Leitz Wetzlar microscope and are given in mm units. The morphological description of the occlusal surface and the measurements of the teeth led to the identification of twelve rodent species. The presence of *Mus* (m1) should be noted.

**Conclusion:** This study presents the faunal list of Vevi locality. Furthermore, the fossiliferous locality is determined to be in the Pliocene (MN 15). This work enlarges the knowledge of small mammals of Greece in general and of the Servia-Ptolemais-Florina basin in particular.

**Keywords:** Pliocene, small mammals, Vevi, Greece, Rodentia, Insectivora

**MN ZONATION AND LOCAL BIOSTRATIGRAPHIC SYSTEMS. WHAT WE HAVE LEARNED?**

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**Objectives:** The MN System has been profusely used in Europe as a biochronologic framework over the last forty years. The aim of this contribution is to discuss the limitations of the system and how to deal with them.

**Methods & Results:** Since the proposition of the MN system by Pierre Mein in 1975 our knowledge of the European Neogene continental fossil record has increased significantly. All over Europe, important efforts have been made to propose or refine local biostratigraphic and chronostratigraphic scales. Nevertheless, due to the strong bioprovincialism in the Neogene of Europe, the MN system is still needed and used as a general framework for long distance correlations. This is especially true in biogeographic and paleoclimatic works where the chronologic framework is mainly based on the assignation to the different fossil associations to the MN system. Over the years, we have learned, however, that the system has limitations and we have to be aware of them. Some of the limitations arise because people do not understand and use the system in the same way. For some authors, it is a biochronologic system based on characteristic taxa or reference faunas and therefore with fuzzy boundaries (De Bruijn et al. 1992); others consider it a biostratigraphic scale based on local biostratigraphies having precise boundaries, and with a biogeochronologic translation (Steininger, 1999, Agustí et al. 2001). Another limitation comes from the fact that in separate areas the criteria used to recognize MN units are different for most of them, since are based on distinct fossil associations due to the lack of shared taxa. In each area, the proposed MN zonation is just the translation of the local biochronology or biostratigraphy and therefore the ages and duration of each unit are generally different in every area (Van der Meulen et al. 2011). Even when areas share key taxa on which the MN unit definition is based on, recent studies have demonstrated that the events are in most of the cases diachronic, sometimes strongly. Therefore, without precise chronostratigraphies in each area is very difficult to propose detailed correlations.

**Conclusions:** Despite its limitations, the MN system represents the most important chronologic framework for the European Neogene. It allowed important advances in our understanding of the biotic evolution at continental scale. Nevertheless, we need a detailed biogeochronologic scale for the Neogene of Europe to which we can correlate unambiguously the continental fossil faunas. The MN system, at its present state, represents a framework too rough to fulfil the needs for biogeographic or paleoclimatic reconstructions based on distribution of faunas. Therefore we have to take the decision if we want to improve the MN system to avoid most of its limitations or switch to a new reference system.

**INTRA-MESSINIAN TRUNCATION SURFACE IN THE LEVANT BASIN EXPLAINED BY  
SUBAQUEOUS DISSOLUTION**

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The Messinian salinity crisis (MSC) is an extreme event in Earth history during which a salt giant (>1 million km<sup>3</sup>) accumulated on the Mediterranean seafloor within ~640 ka. Erosional unconformities extending from the continental margins into the deep basins are key features for reconstructing the MSC; however, the nature of the erosional processes and their subaerial versus subaqueous origin are highly controversial. This study focuses on the Top Erosion Surface (TES) in the deep Levant basin, which is notably flat, truncating a basinward tilted Messinian evaporitic succession. Based on high resolution seismic surveys and wireline logs, we show that: 1) the TES is actually an intra-Messinian truncation surface (IMTS) located ~100 m below the Messinian-Zanclean boundary; 2) the topmost, post-truncation, Messinian unit is very different from the underlying salt deposits and consists mostly of shale, sand, and anhydrite; 3) the flat IMTS is a dissolution surface related to significant dilution and stratification of the water column during the transition from stage 2 to stage 3. Dissolution occurred upslope where salt rocks at the seabed were exposed to the upper diluted brine, while downslope, submerged in the deeper halite-saturated layer, the salt rocks were preserved. The model, which requires a stratified water column, is consistent with a complete desiccation of the eastern Mediterranean Sea.

**ICHOFAUNA RESEARCH AS A TOOL FOR UNRAVELING THE PALEOCLIMATOLOGY AND PALEOECOLOGY IN ACTIVE CONTINENTAL MARGINS: A CASE STUDY FROM THE CENOZOIC SUBMARINE FANS OF PINDOS FORELAND BASIN IN ACHAIA, WESTERN GREECE.**

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**Objectives:** Analyzing the abundance and diversity of ichnofossils, at the inner and outer part of a submarine fan environment provides an important tool to determine the paleoenvironments and how they affect the sedimentary basin and the respective palaeoclimate. The purpose of this paper is to improve the knowledge of how the sub-basin of Tritea, part of Pindos foreland basin in western Peloponnesus, developed during the Late Eocene to Early Oligocene.

**Methods & Results:** Trace fossils and ichnofabrics were studied in their sedimentological context within the stratigraphic sections and from fallen slabs collected from talus material. The Ichnofacies that have been documented are: A. The Eocene deposits contain the ichnotaxa *Ophiomorpha rudis*, *Planolites beverleyensis*, *Cosmorhapse*, *Nereites*, *Chondrites*, *Scoyenia*, *Monocraterion*, *Teichichnus*, *Skolithos*, *Zoophycos* and *Phycosiphon*, and B. The Oligocene deposits contain the ichnotaxa *Ophiomorpha rudis*, *Planolites beverleyensis*, *Aulichnites*, *Arenicolites*, *Paleodictyon strozzi*, *Cosmorhapse*, *Chondrites*, *Scoyenia*, *Skolithos*, *Monocraterion* and *Psilonichnus*.

The detailed ichnofaunal research indicates: 1. The difference between proximal and distal environment is shown by the high abundance and low diversity proximal environment and the low abundance and high diversity of the distal one. 2. Comparing the equivalent sedimentary locations e.g. a channel with a lobe in proximal and distal respectively sub-environments, the same differences as above were recognized. The tracefossils assemblages in a channel environment are higher and the diversity is lower in relation the lobe environment. The same was also recognized when interchannel with interlobe deposits, and levee deposits in an inner environment and in an outer environment were correlated, respectively. 3. The level of oxygenation in an inner fan environment, such as in a channel, interchannel or levee environment, was recognized to be low due to the high deposition rate and high energy flows, and the turbidity currents which transported material from the continental shelf and shallow upper slope towards the deeper parts of the basin. Generally, tracefossils have the difficulty to survive except of some specific species. The level of oxygenation in an outer environment was recognized to be high, in relation to the inner fan environment, due to the dilute flows, lower deposition flows and lower energy conditions. 4. Comparing Eocene and Oligocene deposits in the same sub-environments (lobe sub-environment), the studied ichnofossils provided evidence that there was a difference between diversity, the length and the thickness of the respective ichnofossils. The section with the Eocene deposits has tracefossils bigger in length, thickness and with better geometry than those of the Oligocene deposits.

**Conclusions:** The sections which are closer to the Pindos thrust are characterized by high abundance, low diversity and low oxygenation levels, in contrast to the distal areas from Pindos thrust which are characterized by low abundance, high diversity and high oxygenation level. The ichnodiversity and ichnoabundance decrease gradually upward, reflecting the impact of the changing depositional environments from basin floor fans, to slope systems and then to shelf environments. The regional basin-fill history, rather than the global climatic changes, was probably the fundamental controlling factor on the distribution of trace fossils across the E/O boundary.



DISPERSAL EVENT OF *ROCYNOCEPHALUS*/*PARADOLICHOPITHECUS*: ONE NEW SPECIMEN-TWO SCENARIOSKynigopoulou Z.<sup>1</sup>, Guy F.<sup>2</sup>, Merceron G.<sup>2</sup>, Kostopoulos D.S.<sup>1</sup><sup>1</sup> School of Geology, Aristotle University of Thessaloniki, Greece<sup>2</sup> Institut de Paléoprimateologie, Paléontologie Humaine: Evolution et Paléoenvironnements UMR CNRS 7262 INEE, Université de Poitiers, France

**Objectives:** Analysis of the external morphological features and the inner structures i.e. the maxillary sinuses of a recently discovered cercopithecine cranium allowed several new working hypotheses. The specimen comes from the lower Pleistocene locality of Dafnero 3 (DFN3), North-West Greece, originally excavated by G.D. Koufos and D.S. Kostopoulos during the 90's. The cranium can equally be ascribed to either *Procynocephalus* or *Paradolichopithecus*, both large cercopithecines that inhabited Eurasia during Pliocene to early Pleistocene. Early Pleistocene fossils of the species *Par. arvernensis* are known from localities in France, Spain and Greece, *Par. geticus* from Romania, *Par. sushkini* from Tadjikistan and *Par. gansuensis* from China. To the East, Late Pliocene/ Early Pleistocene fossils are referred to *Pro. wimani* from China and *Pro. subhimalayanus* from India.

**Methods & Results:** Many are the characteristics that both genera share in common i.e. similar body mass, size and dental morphology with low posterior premolar to first molar area ratio and a strong molar flare; narrow parabolic upper and lower toothrows with parallel molar series; small first incisors; weak to moderate anteorbital drop; short premaxillary bones; smoothly rounded anterior muzzle and weak to absent maxillary fossae in females; present fossae on the mandibular corpus; and similar postcranial morphologies of the ulna and especially humerus and talus. Moreover, both genera show a geographic distribution across the same Eurasian latitudinal belt during similar time intervals. For all of these reasons, *Paradolichopithecus* is considered as a synonym to *Procynocephalus* in this study. Morphometrical data suggest closer resemblances of the fossil cranium and other crania of the genus with derived Papionini than with macaques. Although it is believed that maxillary sinuses are of phylogenetic importance, our analysis of 3D images after CT and microCT scanning, showed that the size-range of maxillary sinuses within *Macaca* is independent of species-level taxonomy. Additionally, though DFN3 and specimen from Tadjikistan bear maxillary sinuses, other examined crania seem to lack this feature. By extrapolating a *posteriori* some morphological characters -proposed by the current study and previous research- on the three possible hypotheses regarding the phylogenetic affinities of *Procynocephalus* with *Macaca* and *Papio*, a ((*Papio*, *Procynocephalus*) *Macaca*) hypothesis is preferred as most parsimonious, triggering important biogeographic implications.

**Conclusions:** If *Procynocephalus* is closer related to macaques, as suggested by previous studies, then the genus would have diverged from European macaques and followed a parallel evolution to *Papio*; yet results of the current study fail to support this scenario. If the genus shares a more recent common origin with African Papionina, as suggested here, then it must have originated in Africa and invaded Eurasia at about 3.0Ma, dispersing through open habitats. Although *Procynocephalus* has been found only in Eurasia, there are Papionina exceeding Africa and thus such a dispersion could be possible.

**USING OTOLITHS TO RECONSTRUCT THE PALAEOENVIRONMENT: PRELIMINARY RESULTS FROM A PLEISTOCENE SEDIMENTARY SEQUENCE (SOUSAKI BASIN, EASTERN CORINTH GULF, GREECE)**

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**Objectives:** Otoliths are hard, calcium carbonate structures located directly behind the braincase of teleost fishes. They are often found fossilized in sediments and they can be used as a powerful tool for reconstructing the respective depositional palaeoenvironments. In this study, exceptionally preserved otoliths were extracted from a Lower Pleistocene sedimentary outcrop near Sousaki volcano (Eastern Corinth Gulf, Greece). The sedimentary succession of Sousaki basin consists of marly sediments that pass upwards to sandy and conglomerate layers with intercalations of organic rich sediments and diatomite layers. The basement of the basin and thus of the section consists of volcanic rocks, dated radiometrically between 2.2-2.8 Ma.

**Methods & Results:** The studied marly layer belongs to the lower part of the sedimentary sequence and has a thickness of 1,70m. The white to yellow marl was extremely rich in gastropods shells and fragments. 120 Kg of sediment from three horizons of this layer – namely upper, top and medium - have been washed and sieved through a 250 µm sieve. After drying, otoliths were handpicked using a stereoscope, and identified. In total, about 2000 otoliths were collected from each horizon. Mainly, they belong to the families Gobiidae, Cyprinidae and Cyprinodontidae. Also, there are otoliths that probably belong to the family Atherinidae.

**Conclusions:** The synthesis of the taphocoenosis reveals that the respective layer was deposited in a lake. The unusual large number of otoliths and their excellent state of preservation make the study area a hot spot for otolith studies. Furthermore, the very limited number of Pleistocene terrestrial otolith records in Greece, enhance its importance as an otolith lacustrine site from the Early Pleistocene.

**TRANSITIONAL MARINE ENVIRONMENTS FROM THE LOWER PLEISTOCENE RIO BASIN  
(WESTERN GREECE)**

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**Objectives:** Rio Basin is a region of significant stratigraphical and palaeontological interest. At the wider area continuous changes have been recorded as a result of active tectonism such as the well-known rifting process that has been occurring in the wider area during the Quaternary, and the influence of eustatic changes. For this work we investigated the distribution pattern of the microfaunal (foraminifers and ostracods) assemblages from two sections at Sichea region near the riverbed of Charadros River (Rio basin, Northwestern Peloponnesus, Greece). The studied sections, Vigla 1 and Vigla 2, have a total thickness of 88 meters.

**Methods & Results:** 300 sediment samples were collected and analyzed palaeontologically, however, herein we report our first data on the study of microfossils (foraminifers and ostracods). Multivariate analyses of samples and species of these organisms have been performed to provide an accurate description of these assemblages. Census data were obtained for different species in each sample and the statistically significant fractional abundances values ( $\geq 5\%$ ) were analyzed using Q-mode cluster analysis and correspondence analysis. The most abundant species in the studied samples from the sequences that were identified as brackish are: *Ammonia tepida*, *Cyprideis torosa f. torosa* and *Cyprideis torosa f. littoralis*. The most abundant and widespread ostracod and foraminifer species that have been determined in the more marine sequences are: *Ammonia beccarii*, *Haynesina depressula*, *Cassidulina carinata*, *Bullimina spp.*, *Elpidium spp.*, *Costa edwardsii*, *Cytheridea neapolitana*.

**Conclusions:** The sequences of Vigla 1 and Vigla 2 correspond to a transitional marine environment, which due to continuous eustatic changes, as well as to tectonism that occurred during the early Pleistocene caused gradual but continuous adjustments to the local palaeoenvironments. The environmental distribution differs from the lower to the upper part of the sequence, being a typical example for the evolution of the basin during the Quaternary. According to the microfaunal assemblages the sequence can be divided into 6 units and each one is indicative of a specific environmental type: evolving from a shallow self with high energy, to a lagoon with freshwater influxes, turning into an open lagoon with good connection to the open sea, then to an estuary ecosystem with occasional salinity changes due to temporary freshwater influxes, which passed into a closed gulf with good connection to the open sea and finally became a closed lagoon ecosystem. At the upper part of the sequence an erosional unconformity brings in contact the last facies with a red conglomerate terrestrial facies, indicative of a delta/alluvial fan.

The present work is being carried out within the framework of project E038 K. Karatheodori programme 2013.

**CLIMATICALLY FORCED CYCLICITY IN LOWER PLEISTOCENE FLUVIO-LACUSTRINE SEDIMENTS FROM SOUSAKI BASIN, EASTERN CORINTH GULF, GREECE: PRELIMINARY RESULTS**

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**Objectives:** In the Mediterranean region during the last decades there have been several correlations between lithostratigraphic units and MIS stages, but only few of them refer to the Lower Pleistocene and particularly to continental environments. A 200m thick composite section of Gelasian-Lower Calabrian age, exposed in Sousaki basin, Eastern Corinth Gulf, Greece, is presented herein. In this section cyclicity has been recorded that could be attributed to Milankovitch cycles.

**Methods & Results:** The lower part of the section (175m thick) consists of alterations of conglomerates, sands/sandstones, marly sediments and organic rich layers in cyclic alterations, that rest on the volcanic rocks and volcanoclastic sediments of the Sousaki low standing volcano, dated at about 2.3 Ma. Conversely, the upper part of the section (23m) consists of lacustrine marls with intercalations of gypsum beds and organic rich layers. In the sediments of the latter sequence detailed palaeoenvironmental reconstruction has been carried out using ostracodes and palynomorphs. In total 156 samples were collected from the fine grained sediments and were processed for micropalaeontological analyses using the standard methodology. The tests were handpicked and identified down to the species level. Percentage abundance diagrams and multivariate analysis were performed. Additionally 22 of these samples were prepared for palynological analysis. The micropalaeontological analysis revealed rhythmic changes in the salinity of a closed lagoon while the palynomorph analysis revealed corresponding cyclic vegetation changes (alternation between subtropical species and dry climate species) in a typical Mediterranean climate with the presence of some thermophilous elements.

**Conclusions:** The micropalaeontological and stratigraphical analyses thus, have revealed a climatically induced zonation both in terrestrial and aquatic environments, which could coincide with MIS stages 63, 64 and 65. The whole composite section has been superimposed to the  $\delta^{18}\text{O}$  (‰VPDB) plankton Mediterranean stack (MIS stages 63-85) and to the eccentricity curve respectively, showing that the cyclicity in the local stratigraphic record could be climatically induced and that seems to be dominated mainly by the orbital cycle of precession (with periodicity of 21kyr) and secondarily by the orbital cycle of eccentricity (with periodicity of 100kyr).

ORIGINS AND EVOLUTION OF EURASIAN HOMININES

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**Objectives:** Complex scenarios have been proposed to explain the presence great apes in Eurasia. Early and middle Miocene *Griphopithecus* is said to have dispersed into Europe and Anatolia from an *Afropithecus*-like or an *Equatorius*-like taxon, only to go extinct. The same fate befell the dryopithecins (*Anoiapithecus*, *Pierolapithecus*, *Dyropithecus*, *Hispanopithecus*, *Rudapithecus*) following a separate dispersal from a purported *Kenyapithecus*-like ancestor. Dryopithecins are interpreted by some as either stem pongines or stem hominids, doomed to extinction. Here I review the evidence for the hominine affinities of the dryopithecins and discuss the implications for dispersals accompanied by other mammals in the late Miocene.

**Methods & Results:** All available specimens of Miocene apes and a large sample of extant and extinct catarrhines were coded for 363 characters of the dentition, skull and postcranium. Though there are many equally parsimonious cladograms, all retrieve the known relations among extant catarrhines and all include dryopithecins among the Homininae.

**Conclusions:** Apes dispersed into Europe more than 17 million years ago and evolved *in situ* into hominines. Hominines dispersed from Europe into Africa (and possibly Asia) in the late Miocene, as did many other mammal lineages. If the same specimens had been found in Africa they would be accepted as hominines, yet, being from Europe makes this conclusion controversial. Koufos and colleagues have been arguing for the presence of hominines in Europe for many years. While we disagree on the exact affinities of *Ouranopithecus*, we agree that *Ouranopithecus* is a hominine.

**EASTERN MEDITERRANEAN HOMINIDS AND THEIR IMPLICATIONS FOR HOMINID EVOLUTION**

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**Objectives:** Until 2007, Eastern Mediterranean late Miocene apes were only known from *Graecopithecus* from Athens, the large sample of *Ouranopithecus* from northern Greece (often synonymized with *Graecopithecus*) and *Ankarapithecus* from Anatolia. While *Ankarapithecus* was usually attributed to the Ponginae, *Graecopithecus*, including *Ouranopithecus*, were variously attributed to the ponginae, the homininae or to Hominidae indet. Most of these samples were dated to between 9-10 Ma. It was widely believed that hominids became extinct in Europe after this time due to the drying of the eastern Mediterranean, which also represented an ecological barrier to their dispersing into Africa. The objective of this study is to review this distribution and space, time and ecology given new discoveries.

**Methods & Results:** The Eastern Mediterranean has become an epicenter of hominid evolution. Now we know that hominids are more diverse in Greece and persist until at least 7.2 Ma. They are present in Bulgaria and Iran as well. A new taxon, possibly related to *Ouranopithecus*, is now known from Turkey. The newer and younger specimens are associated with dryer environments, demonstrating that hominids at this time were in deed perfectly capable of surviving in these climates.

**Conclusions:** Together with the dryopithecins from Europe, *Ouranopithecus*, *Graecopithecus* and the Turkish ape share characters with the African apes and are best attributed to the Homininae. Dispersals of many land mammals between the Eastern Mediterranean and Africa were common at this time and it is likely that hominines were part of these dispersals.

PARATETHYS RESPONSE TO THE MESSINIAN SALINITY CRISIS

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The Black Sea and Caspian Sea are the present-day remnants of a much larger epicontinental sea on the Eurasian continental interior, the Paratethys. During the late Miocene Messinian Salinity Crisis (MSC), the Paratethys Sea was connected to the Mediterranean Sea. Unlike the Mediterranean, no salt is known to have been deposited in the Paratethys region at this time, yet a similar mechanism of deep desiccation (with a water level drop of up to 2km occurring at 5.6 Ma) has been proposed in the past to explain the late Miocene and Pliocene Paratethys basin evolution.

Here, we review the basin evolution, stratigraphy and subsurface data of the four main Paratethyan sub-basins to investigate the response to the Mediterranean Messinian event. We show that hypotheses of a Paratethys-wide desiccation synchronous to the Messinian Salinity Crisis climax at 5.6 Ma do not hold. Determinations of the magnitude of the sea level drop appear to have regularly been overestimated by speculative basin-to-margin interpretations, and often been disproven by increased age model resolution.

In the Euxinian (Black Sea) Basin, the most recent estimates for the magnitude of sea level drop vary between 50 and 500 m, yet the timing is debated. Marginal outcrops in the Dacian Basin highlight multiple switches from shallow basinal to littoral and fluvial environments during the MSC interval, but no major water level drop coincides with the 5.6 Ma event. The Paleo-Danube deposits filling in the Pannonian Basin do not indicate any influence by the MSC and show prograding patterns into the deepwater lake Pannon. The dramatic expansion of the Paleo-Volga delta in the Caspian Sea is shown to be younger than the MSC, while estimates of the amount of water level drop vary widely due to the poorly understood contribution of tectonic processes.

These changing perspectives and decreasing estimates of water level lowering are not surprising given the vast northern drainage of the Paratethys region. Precipitation and runoff from the Eurasian continent ensures a much more positive hydrological budget under isolated conditions than the vast negative hydrological budget of the Mediterranean Sea which requires constant compensation by inflowing oceanic waters.

MORPHOLOGICAL AND ODONTOMETRIC ANALYSIS OF ÇORAKYERLER HOMINOID

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**Introduction:** The hominoid locality of Çorakyerler is located on Yapraklı district road of Çankırı province in Central Anatolia region in Turkey. Çorakyerler is an important reference locality for Anatolian Palaeontology and it is the fossil locality, which gives the youngest hominoid finding of Anatolia. Until today, more than 4000 identifiable fossils have been uncovered in the excavations. The locality of Çorakyerler plays a very important role in explaining the condition just before the disappearance of the hominoids in Turkey at beginning of the Turolian. The age of fauna in Çorakyerler was determined as 8.11-7.64 My based on the Magnetostratigraphic studies done in 2007. However, the relatively high proportion of Vallesian faunal elements indicate a biochronological correlation to the lower part of MN 11 (earliest Turolian, ~ 8.7 Million years). Different animals such as *Sivaonyx*, *Chalicotheres*, *Konobelodon* and *Criootherium* that point to forest areas have been discovered in the past excavations, and the Çorakyerler biotope, once believed to represent a Turolian plane, has completely changed into a more closed environment.

**Objectives and Methods:** Anatolia is considerably rich in hominoid fossil findings. Especially *Griphopithecus alpani* and *Kenyapithecus kizili* from the mid-Miocene period and *Ankarapithecus meteai* from the early late Miocene are significant hominoid findings in Anatolia. However, recent findings have also increased our knowledge on *Ouranopithecus turkae*. Starting from the year 2000, Çorakyerler yielded over the years important hominoid fossils (ÇO 205, ÇO 300, ÇO 305, ÇO 710, ÇO 2100). With the remarkable discovery of ÇO 2800, a hominoid mask and precious rarity in hominoid fossils, the number of individuals increased to six, firmly establishing Çorakyerler's position among the important hominoid localities. The subject of this study constitutes of Çorakyerler 710. This fossil is a hominoid mandible preserving the p3, p4, m1 and m2. The fossil was described as the female individual of *Ouranopithecus turkae* in the publication in 2007. However, our subsequent morphological and odontometric analyses clearly demonstrated that ÇO 710 has different characteristics than *Ouranopithecus turkae*. Moreover, comparison of ÇO 710 with females of *Ouranopithecus macedoniensis* also showed some morphological differences.

**Discussion and Conclusion:** As a result, some doubt has arisen whether the mandible is in fact really an *Ouranopithecus*. By presenting this paper, we aim to discuss the possibility that the Çorakyerler mandible should be referred to a different genus.



**CLIMATE, ENVIRONMENTAL CHANGE AND TAPHONOMIC PROCESSES ACROSS THE PLIO-  
PLEISTOCENE TRANSITION OF THE SOUTH-WEST CASPIAN SEA**

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The Caspian Sea is the largest endorheic lake in the world and is highly sensitive to climate change. A thick series of sediments was deposited in the South Caspian Basin during the Pliocene. These sediments contain important oil and gas reserves and are called the Productive Series. A reliable, well-dated climate and palaeoenvironmental proxy record was obtained for the Lokbatan section of the South Caspian Basin in Azerbaijan. This section comprises the deltaic sediments of the Productive Series (main reservoir rock) and the overlying mudstones of the Akchagyl Formation (cap rock). A multi-proxy approach was followed in order to obtain climate and environmental information for the Lokbatan section. Magnetostratigraphy and radiometric dating (<sup>40</sup>Ar/<sup>39</sup>Ar on volcanic ashes) of the marine Akchagyl Formation assigned the Lokbatan section to the Late Pliocene-Early Pleistocene. Terrestrial and marine palaeoenvironments were reconstructed using palynology (pollen and dinocysts) and supported by particle size analysis and XRF/stable isotopes.

Pollen data were used to interpret vegetation successions as a proxy for catchment climate. The pollen record shows cyclic vegetation patterns, potentially related to obliquity-scale climate forcing. Dinocyst data presented a marine succession linked to degree of fresh water input, base level variation and inter-basin connectivity. Dinocysts and geochemical records also respond to climatic influence, but their behaviour is more strongly influenced by connectivity between the Caspian Sea and adjacent basins.

New methods were explored to constrain problems of reworking in deltaic facies deposited during the Pliocene. In particular, quality of the environmental signal was assessed using fluorescence microscopy, as delta assemblages can be dominated by older reworked palynomorphs, obscuring the contemporary environmental signal. Serious issues relating to depositional environments and taphonomy within the Productive Series were highlighted. This must be understood before the local/regional environment can be determined reliably. Overall, this work provides a step forward in the understanding of climatic effects on the sedimentary architecture of Caspian oil fields but also provides new data that could be applied to climatic modelling and to future climate studies using Pliocene analogues.

**SEDIMENTARY ENVIRONMENT AND GASTROPOD BIOGEOGRAPHY OF THE BAND-E-CHAKER FORMATION (BURDIGALIAN) IN MAKRAN (SE IRAN)**

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The Tethyan Seaway was a connection between the Indian Ocean, the Mediterranean and the Atlantic Ocean regions. This connection was of eminent palaeoceanographic importance because it allowed equatorial oceanic water circulation from the Pacific to the Atlantic and - since the Isthmus of Panama was also open - a global water exchange. Accordingly, it was one of the major drivers in the palaeobiogeographic distribution of tropical shallow marine biota during the Cenozoic. The Makran area in SE Iran is a critical area to estimate the effects of the Tethyan closure on marine faunal exchange because it was located close to the suspected *Gomphotherium*-landbridge that separated the proto-Mediterranean Sea from the Indian Ocean during Burdigalian times. It is part of a large oceanic accretionary wedge that has developed throughout the Cenozoic due to frontal accretion and underplating of trench fill sediments at the Makran Subduction Zone under the condition of high sediment input from the Indus River and extreme erosion of the inner parts of the growing accretionary prism. The Miocene sedimentary succession is described as neritic flysch-like sandstone-marl alternation with few intercalations of coral reef and foraminiferal limestones of Aquitanian and Burdigalian age. Whereas the early Miocene coral fauna of the Iranian Makran area is fairly well studied, the information about other fossil groups and the depositional environment are rather poor. We present the first palaeoenvironmental interpretation of the mixed carbonate-siliciclastic Band-e-Chaker Formation (Burdigalian). A continuous 160-m-thick stratigraphic section was logged near the village Iler at the eastern flank of the Band-e-Chakar Syncline in the Western Makran. Facies analysis documents a predominance of mangrove-fringed tidal mudflat and fine siliciclastic shallow subtidal soft bottom environments. Coral reef development was related to an episode of decreased fine-siliciclastic sedimentation. In terms of biogeography, the gastropod fauna corresponds well to coeval faunas from the Pakistani, Balochistan and Sindh provinces and the Indian Kathiawar, Kutch and Kerala provinces. These constitute a discrete biogeographic unit, the Western Indian Province, which documents the near complete biogeographic isolation from proto-Mediterranean Sea. The fauna displays also little connection with coeval faunas from Indonesia, documenting a strong provincialism within the Indo-West Pacific Region during early Miocene times.

TEPHROSTRATIGRAPHIC FRAMEWORK OF SEDIMENTATION IN THE KARPATOS BASIN, SE  
AEGEAN SEA

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**Objectives:** Upper Quaternary volcanicity in the Aegean Sea is dominated by voluminous explosive Plinian eruptions of the Santorini and Kos, Yali, Nisyros centers. Numerous tephra layers linked to these events have been identified in the deep sea sediments of the Aegean Sea, East Mediterranean and surrounding regions. In most cases studied cores cover short stratigraphic intervals and resedimentation processes severely affect tephrostratigraphy. Moreover several ash layers have been identified in single isolated cores, thus making their speculative identification questionable. Here we report on the tephra identified in the longest ever retrieved core located in the deepest basin of the Aegean Sea, the Karpathos Basin. It represents the ultimate sink of all significant sediment transporting events that are preserved in a complete time series.

**Methods & Results:** Core LC-20 is almost 24m long and its high resolution planktonic foraminifera record is matched by detailed textural and compositional analyses including OC contents. It displays the well established Aegean- East Mediterranean cyclothematic development centered on organic rich sapropel/lic lithofacies yielding up to 11% OC contents. Frequent thin to medium turbidites are clearly distinguished at all stratigraphic levels. Nevertheless the identification of typical planktonic assemblages facilitates the clear identification of S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub>, S<sub>4</sub>, S<sub>5</sub> organic rich sequences. About 15 discrete tephra layers have been identified by both XRD bulk mineralogy and under the microscope and volcanic tephra glass shards have been picked and analyzed by EDS and WDS techniques. The two prominent youngest Santorini tephra layers dated at ca 3.6 ka (Z<sub>2</sub>) and ca 22 ka Cape Riva eruptions have been identified. The Santorini Y4 estimated at ka 30ka is underlain by Yali Upper pumice, ca 35 ka and the well developed 25cm thick Campanian Ignimbrite Y5 is found further below. The Nisyros Upper pumice is clearly distinguished as an over 10cm thick tephra at 12,8m below sea bottom and its age estimated at ca 48ka. Within the stratigraphic interval of sapropels S<sub>3</sub> to S<sub>5</sub> there are at least three tephra linked to the South Aegean Volcanic Arc and are possibly to the Italian volcanoes but their distinction requires further studies. However, at the lowest part of the core we identify the upper part of a thick volcanoclastic turbidite that consistently displays a well established correlation to the biggest South Aegean Upper Quaternary eruption as the Kos Plateau Tuff (W3) dated at 161 ka. The turbiditic KPT (W3) is topped by a 20cm thick tephra settling in the water column from the ash clouds that covered the sea. Above it we also identify the Santorini linked W2 as a 20cm layer.

**Conclusions:** Geochemistry of the volcanic glass provides essential information for the correlation of tephra layers to the volcanic source but it is becoming apparent that chronically distinct volcanic phases from individual centers can produce by tephra layers of similar composition. It is thereby essential that the stratigraphic position of each tephra has to be evaluated also as the basis of other stratigraphic indicators in order to precisely pinpoint the chronological order of specific eruptions, emanating from different local volcanic centers. This study also demonstrates the existence of cryptotephra that are linked to unknown smaller eruptions of the South Aegean Volcanic Arc.

**Key Words:** Tephrostratigraphy, Upper Quaternary, marine sediments, South Aegean Sea Volcanic Arc.

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**MARINE VOLCANISM OFFSHORE METHANA PENINSULA – SOUTHERN SARONIKOS GULF**

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**Objectives:** Saronikos Gulf hosts the northwestern termination of the South Aegean Active Volcanic with the vast majority of volcanic products being accumulated along the Aegina Island - Methana peninsula centers. They consist of andesite – dacite volcanic products covering 50 Km<sup>2</sup> and 35 Km<sup>2</sup> respectively. The volcanic stratigraphy of the region is based on superposition, paleomagnetic polarity, radiometric dating and biostratigraphy of Neogene sedimentary rocks. Volcanic activity began with the deposition of pillow lavas, volcanic breccias and ryodacitic tuffs interbedded within early Pliocene marls, exposed in Aegina island. Middle Pliocene andesite and dacite lava flows are radially extending from the central Methana peninsula. Quaternary volcanism is evident mostly onshore Methana. This study uses marine geological techniques in order to map the extension of volcanic products offshore Methana Peninsula, estimate their age and compare the marine volcanic rocks to the onshore record.

**Methods & Results:** Post 2010 surveys, provided detailed multibeam data, side scan sonar imaging, chirp and sparker seismic profiles as well as gravity core samples. Processing of the swath bathymetric data along with the side scan sonar images resulted in the comprehensive mapping of the seafloor. Seismic profiles extensively record shoreline progradational units that have been recognized and associated with prominent seismic reflectors – transgressive surfaces. Seismic stratigraphic reflectors tracked in the area, have been tied to a robust chronostratigraphic framework by the use of the prograding clinoform inflection points, as correlated with equivalent clinoforms in the Aegean Sea and related with Marine Isotopic Stages. Sedimentation rates have been extracted from the recovered cores and aided further the seismic stratigraphic correlation along Saronikos Gulf.

Volcanic products have been mapped offshore, around Methana Peninsula and their surficial and sub bottom extension has been delineated, depicting a spread of the volcanic activity over an area of 100 Km<sup>2</sup>. Six new volcanic outcrops have been recognized and accurately described in the most recently active Submarine Pausanias Volcanic Field. An avalanche related hummocky field has been mapped in the northern part of Methana Peninsula. Volcanic and post volcanic phases have been also recognized all along the nearshore part of Methana Peninsula extending from 2 to 10 Km from the coastline. The age of the recognized volcanic phases has been estimated within the established chronostratigraphic framework. Correlation with the onshore volcanism has been attempted, based on the age and the proximity to the onshore volcanic centers.

**Conclusions:** Submarine expression of volcanic and post volcanic activity, in the Southern part of Saronikos Gulf, is much more extensive than previously thought and covers an area that is almost three times larger than the onshore volcanic center of Methana Peninsula. The verified chronostratigraphic framework allowed a more precise dating of the recognized volcanic phases interbedded within marine sediments, compared to the radiometric dating of the onshore volcanic formations of Methana Peninsula.

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**UPPER CENOZOIC EVOLUTION OF CYCLADES PLATEAU**

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**Objectives:** The Cyclades Plateau, in the Central Aegean Sea, in between the dozens of islands hosts several marginal basins that formed in different periods: from the Upper Miocene to the Upper Quaternary. Present day water depths of these basins range from 100m to over 700m, they are connected to the surrounding deeper basins via shallow channels or down to 600m deep straits and their geological and paleogeographic evolution can only be deduced by elucidating the marine sedimentary sequences and their bounding unconformities. Here we present collected multichannel seismic reflection data that clarify the Quaternary sedimentary evolution of the region.

**Methods & Results:** Based on the seismic stratigraphy by Anastasakis et al. (2006) in the adjacent South Evoikos Gulf, we recognize the major unconformities **B** and **C** and the erosional surface **M** in each marginal basin. All the above reflectors defined in the multichannel lines, with a resolution around 25-30 m. In the north-eastern part of Cyclades plateau and especially in Syros-West Andros basin we recognize reflector **B** that corresponds to the middle Quaternary and determines a sedimentation column of 300 msec. Below the reflector **B** we recognize the reflector **C**, that corresponds to the Upper Pliocene-Lower Quaternary unconformity, at 250-830 msec. The erosional surface **M** that corresponds to the Upper Miocene in the deeper sections of the basin prescribes a sedimentary thickness of 1500 msec. Respectively, in the western part of Cyclades plateau is distinguished the Kythnos-Sifnos basin. In this basin on multichannel records we identify the reflector **B** that corresponds to the middle Quaternary and determines a sedimentation column of 80-350 msec. Below, we recognize reflector **C** that corresponds to the Upper Pliocene-Lower Quaternary unconformity that defines a Quaternary sedimentary thickness of 400-870 msec. At the deeper part of multichannel profiles we recognize the erosional surface **M** that corresponds to the Upper Miocene. The maximum sedimentary thickness above the **M** is up to 1500 msec. The outer periphery of the SW Cyclades Plateau south of Kithnos to Milos- Folegandros contains the Folegandros basin. The Folegandros Basin forming in between Milos-Folegandros-Paros-Sifnos islands, contains up to 1500m thick marine Post Messinian sediments. In multichannel profiles we recognize reflector **B** that corresponds to the middle Quaternary and determines a sedimentation column of 100-300 msec. Below the reflector **B**, we identify reflector **C** that corresponds to the Upper Pliocene-Lower Quaternary unconformity that defines a Quaternary sedimentary thickness of 580 msec.

**Conclusions:** A consistent seismic stratigraphy can be recognized in the major basins which contain marine sedimentation. Folegandros basin contains locally thin evaporates. The subsidence of the Cyclades basins begun in the Late Miocene.

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**THE EARLY PLEISTOCENE STENONOID HORSE FROM LIBAKOS AND POLYLAKKOS  
(WESTERN MACEDONIA, GREECE): BIOCHRONOLOGICAL AND PALAEOECOLOGICAL  
IMPLICATIONS AND DISPERSAL EVENTS**

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**Objectives:** Fossil mammal remains from the fossiliferous sites of Libakos and Polylyakkos (Aliakmon Basin, Western Macedonia, Greece) were collected by Prof. H. Eltgen (Technical University of Clausthal, Germany) during his geological survey in the early '80s. The collection consists of 16 large mammalian species. The fossil horse remains represent the greatest part of the Libakos collection which consists of numerous isolated teeth and metapodials that were initially described as *E. stenonis* cf. *senezensis* by Steensma (1988).

**Methods & Results:** The equid samples from Libakos and Polylyakkos are close in morphology and they are compared with the Early Pleistocene stenoroid equids from Greece as well as with those of Western and Central Europe (Spain, France, Italy and Germany) dating from the Early to Middle Pleistocene (middle Villafranchian and Galerian). The multivariate analysis (PCA) indicated the presence of a single small-sized species. The dental characters of the Libakos and Polylyakkos equid share similarities with *Equus stenonis*; short protocone, V-shaped ligulaflexid, shallow or deep ectoflexid. However, the metapodials and phalanges are more slender than *E. stenonis*, allowing its attribution to *Equus altidens* von Reichenau, 1915. Its morphology and size coincide with *E. stenonis mygdoniensis* from the Greek locality Gerakarou (Mygdonia Basin, Central Macedonia, Greece) and thus the later it is transferred to this species. The presence of *Pachycrocuta brevirostris*, *Stephanorhinus etruscus* cf. *etruscus* and *Leptobos* sp. gives a primitive feature in the Libakos fauna. However, the presence of *Equus altidens* and *Hippopotamus antiquus* suggests an age younger than 1.8 Ma. The comparison of the Libakos faunal assemblage with the Greek Villafranchian ones indicates similarities with those of Gerakarou 1 (early Late Villafranchian, ~1.8 Ma, MNQ-18) and Apollonia 1 (Epivillafranchian, ~1.2 Ma, MNQ-20), suggesting a Late Villafranchian age for it. The limited Polylyakkos fauna with *Mammuthus meridionalis*, *Leptobos* sp. and *Equus altidens* cannot provide a confident age. The ecomorphological characters of the Libakos equid metapodials indicate a grassland savannah-like landscape in agreement with earlier results. The occurrence of *E. altidens* in Gerakarou (~1.8 Ma) agrees with the referred FAD of *E. altidens* in Dmanisi, Georgia (~1.77 Ma), suggesting the concurrent arrival of the species in Southeastern Europe and Western Asia. The arrival of *E. altidens* into Europe coincides with the extension of open grassy landscapes towards the West, between 1.8-1.2 Ma, allowing large mammals and the early humans, to disperse.

**Conclusions:** The Libakos and Polylyakkos equids belong to the stenoroid horses and they are attributed to *Equus altidens*. The Libakos fauna is dated to Late Villafranchian (1.8-1.2 Ma). The dispersal event of *E. altidens* was simultaneous in Southeastern Europe and Western Asia at ~1.8 Ma following the Late Villafranchian occurrence of open grassy landscapes.

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**HOLOCENE TEPHROSTRATIGRAPHIC RECORD IN THE NISYROS-YALI-KOS VOLCANIC CENTER: EVIDENCE OF UNKNOWN PLINIAN ERUPTIONS**

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**Objectives:** This research aims to resolve the imprint of Holocene volcanism in the Kos – Yali – Nisyros volcanic center of the South Aegean Volcanic Arc. Holocene volcanic activity is manifested by poorly dated, thin tephra deposits on the islands of Nisyros and Yali.

**Methods & Results:** Textural and electron microprobe (WDS) analyses were performed on 20 samples derived from cryptoash layers detected above and within S1 sapropel of seven cores recovered within the offshore SE termination of the South Aegean Volcanic Arc. These cores were scanned for magnetic susceptibility, split, logged and sampled at one cm resolution. Carbonate content analyses were performed continuously and selected intervals were analyzed for grain size, organic carbon content, and bulk mineralogy by XRD, in order to identify lithostratigraphic levels with enhanced volcanoclastic minerals. Chronology was inferred from the upper and lower limits of the well-developed S1 sapropel substantiated by five AMS <sup>14</sup>C dates on planktonic foraminifera. Eight different geochemical types of volcanic glass were recognized during the microprobe analysis. These types compositionally correlate with Nisyros Lower and Upper Pumice, Yali pumices and Kos Plateau Tuff, and are mostly found mixed within the studied ash layers. This suggests that the volcanic glass is reworked from previous deposits and transported by various processes including turbidity currents. However cryptoash layers consisting of one single glass shards population occur within cores retrieved from the rise which separates West from East Kos Basin, northwest and northeast of Yali, respectively. These beds geochemically resemble to the uppermost Yali – 4 pumice which was found interbedded within Neolithic artefacts, and their homogenous composition proves that they are not reworked. The aforementioned layers are composed by grains of small size with diameters mostly in the range 60 - 90 microns. The above characteristics combined with the physiographic position of the cores which contain these tephra, namely offshore Yali, suggest that these are likely air – fall deposits that were dispersed at least 10 km far from Yali Island within the frame of 8 – 10 Kyrs BP. Moreover, two compositionally homogenous, and therefore not reworked, cryptoashes are traced within a core from Kalymnos basin. These layers are geochemically correlative to the Minoan Ash and, although they predate this deposit (as their assigned ages are 7 – 8.5 Kyrs BP, approximately), their chemical composition indicates Santorini origin.

**Conclusions:** This study confirms the occurrence of small early Holocene Plinian eruptions on two active volcanoes of the South Aegean Volcanic Arc: Yali and Santorini.

**Key words:** Tephrostratigraphic record, South Aegean Sea Volcanic Arc, Holocene, Plinian eruptions, cryptoash

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**STRAITS TO EXTINCTION. THE SENSITIVITY AND THE DESTRUCTIVE POWER OF MARINE GATEWAYS**

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**Aims:** The marine gateways are an important element in the geographic and paleogeographic architecture of oceans and seas. They influence the heat and chemical exchange between neighboring water bodies, mixing or segregating them and influencing the climate and the ecosystems. In extreme configurations, they contribute to the formation of evaporites, faunal turnovers or onset of extinction events. However, the geologic records in the areas of the gateways are poorly preserved and detailed information on the sensitivity, functioning and the significance of the gateways remains scarce.

To counter the lack of reliable records in the area of the gateways, our approach is to focus our research on the study of the records from seas adjacent to problematic gateways, already identified as potential triggers of major environmental catastrophes.

**Methods & Results:** We study the accessible, well-exposed marine sediments from basins that belonged to the Neogene system of seas and lakes of Eurasia (Paratethys). We focus on an area close to the Barlad strait, which during the Middle Miocene has connected the Central and Eastern Paratethys.

Integrated magneto-bio-stratigraphy, in the sub-basins that mirror the Barlad Strait, has allowed high-resolution correlations between Central and Eastern Paratethys segments that are in the vicinity of the gateway. Ecosystems collapse and significant faunal losses occur at synchronously east and west of the gateway 12.65 Ma ago. Further geochemical and mineralogical analyses confirm a significant modification of the exchange mechanism between Central and Eastern Paratethys but reveal that the chain of events differs greatly east and west of the strait.

**Conclusions:** The environmental catastrophes that occurred 12.65Ma in Central and Eastern Paratethys are interpreted as the results of a significant reconfiguration of the Barlad strait. The strait increased its size and switched from inefficient, with limited water exchange, to a “pump” where the density contrast between the two seas accelerated the water exchange. The exchange of waters with different chemistries led to extinctions on both sides of the gateway ending the Konkian and Badenian seas and replacing them with the new Sarmatian fauna. From the global point of view, the activation of the gateway correlates with a relatively small sea-level rise (<10m) and occurs in a context of tectonic subsidence of the gateway zone. The fact that such small changes in the sea level can influence the behavior of the gateway so greatly, raises questions on the behavior of marginal seas such as the Black sea in the near future the context of the projected sea-level rises.



**PALAEO GEOGRAPHIC EVOLUTION OF THE LATE MIOCENE MEDITERRANEAN-ATLANTIC GATEWAYS: RECONSTRUCTIONS FROM SURFACE AND SUBSURFACE DATA**

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Several gateways connected the Mediterranean with the Atlantic during the late Miocene but the timing of closure and therefore their role prior and during the Messinian Salinity Crisis (5.97-5.33 Ma) is still under debate. Such a connection is required to supply the salts for the formation of the thick evaporite successions deposited during the MSC. Potential candidates for a Mediterranean-Atlantic connection are the Guadalhorce Corridor through southern Spain, and the northern and southern branches of the Rifian Corridor through Morocco.

Especially the timing of closure of the corridors is disputed as the common lack of marine microfossils hamper precise age determination. Existing biostratigraphic constraints of unspecified late Tortonian – Messinian age are insufficient to test the hypotheses. Here we present new biostratigraphic age constraints on the sediments of these three corridors. The general presence of *Globorotalia menardii* 4 in the youngest deep marine sediments of the Guadalhorce region indicates a late Tortonian age, older than 7.51 Ma. We thus conclude that the Guadalhorce Corridor closed during the late Tortonian, well before the onset of the Messinian Salinity Crisis and that the late Tortonian tectonic uplift of the eastern Betics extended into the western Betics.

We also present integrated surface-subsurface palaeogeographic reconstructions of the Rifian Corridor with improved age-control. Information about age and timing of the closure have been derived from high-resolution biostratigraphy, palaeoenvironmental indicators, sediment transport directions, and the analysis of onshore subsurface (core and seismic) datasets. We applied modern taxonomic concepts to revise the stratigraphy of the Rifian Corridor and propose astronomically-tuned, minimum-maximum ages for its successions. Several successions located in foredeep and wedge-top basins tectonic positions record the closure of the corridor via a continuous marine to continental-lacustrine transition. The last dated marine sediments represent a good approximation of the age of seaway closure. The closure of the South Rifian Corridor is constrained to 7.1–6.9 Ma; the North Rifian Corridor termination is more uncertain and ranges from 7.35 to ca. 7 Ma. We conclude that the Rifian Corridor was already closed in the early Messinian and did not contribute to the restriction events that resulted in the MSC. Because the Betic Corridor is also assumed to have closed by the early Messinian, the modern Gibraltar Straits remain the sole option in the Western Mediterranean as last Messinian seaway that was open during the MSC. An early, pre-Pliocene connection through the Strait of Gibraltar is in agreement with growing evidence that the Mediterranean Sea was deep, non-desiccated basin during most of the MSC.

**EARLY DIAGENETIC GREIGITE AS AN INDICATOR OF PALEOSALINITY CHANGES IN THE MIDDLE MIOCENE PARATETHYS SEA OF CENTRAL EUROPE**

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The Miocene epicontinental Paratethys Sea of central Eurasia has experienced multiple restriction and reconnection events to the open ocean. Magnetostratigraphy is an important dating tool to better understand the temporal and spatial paleoenvironmental variations associated with these changes. Magnetostratigraphy in the Paratethys domain, however, is complicated by the presence of greigite (Fe<sub>3</sub>S<sub>4</sub>). Here, we report rock magnetic and X-ray fluorescence data of the Tisa section (Romania) which was previously magnetostratigraphically dated. This section comprises the Badenian Sarmatian Extinction Event (BSEE), which is marked by a major salinity change from marine to brackish environments, related to the opening of the connection between the Central and the Eastern Paratethys basins.

In the marine Badenian sediments below the BSEE, the pyritization process is shown to be complete because of abundant sulfate supply. In the brackish Sarmatian deposits, four intervals with early diagenetic greigite are observed, and linked to insufficient sulfate in the water column. These four greigite intervals appear to correspond to maxima in the ~100 kyr eccentricity cycle. We propose that increased fresh water from the Eastern Paratethys basin during eccentricity maxima restricted the sulfate availability in the Tisa area, leading to a reduced HS<sup>-</sup> production and enhanced greigite preservation. The early diagenetic formation of greigite enables a quasi syn-depositional recording of the paleomagnetic field, which allows reliable paleomagnetic dating in this section. Moreover, our results suggest greigite as a potential indicator for salinity changes during marine/brackish transitions.

**PALEOMAGNETISM IN THE PANNONIAN: PROBLEMS, PITFALLS AND PROGRESSION**

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**Objectives:** Magnetostratigraphic dating of Late Miocene (Pannonian) Lake Pannon sediments has proven difficult due to the endemic nature of biota, scarcity of reliable radio isotopic data and generally inconsistent, erratic results of previous paleomagnetic studies.

**Methods:** Here we present an investigation into the viability of the Late Miocene Lake Pannon sediments for a paleomagnetic correlation using samples from three recently drilled well-cores from the Pannonian basin in Hungary. We found that significant intervals of the cores contain contradictory magnetic polarities within the same horizon. These multi-polarity samples consist of a medium temperature (MT) and high temperature (HT) component, in many cases with anti-parallel directions.

**Results:** Our rock-magnetic results indicate that both components are carried by the magnetic iron sulphide greigite. Alternating field demagnetization results in directions equal to the dominant component intensity wise, which is variable throughout the cores, resulting in erratic, incorrect polarity patterns. Separating the greigite components is preferably done by using a combination of thermal and alternating field demagnetization. The HT component represents the ChRM, and is of early diagenetic origin, whilst the MT component records a delayed acquisition and thus is of late diagenetic origin. Using the directions obtained from the HT component magnetostratigraphic correlations can be established.

**AN INTEGRATED BIO-CHRONO-STRATIGRAPHICALLY CONTROLLED FRAMEWORK FOR THE LAST 85 KYR AND ITS APPLICATION TO THE SEDIMENTARY MARINE RECORD OF THE NORTH AEGEAN SEA**

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**Objectives:** The reconstruction of the Late Quaternary climate variability needs a detailed eco-chrono-stratigraphic control. High-resolution biostratigraphic records of deep-sea cores provide a notable contribution for paleoclimatic studies, facilitating large-scale correlations between various oceanographic basins. In particular, the identification of foraminiferal bioevents all over the Mediterranean facilitates a precise correlation of various sub-basins and offers a better comprehension of their paleoceanographic history as it is possibly modified by the impact of more local events. In such a regional context, the Aegean Sea represents an ideal basin to investigate the major climatic fluctuations observed during the Late Pleistocene to Holocene, as it is the butt end of the eastern Mediterranean and connected to the Black Sea through a narrow shallow strait. Within this framework, the aim of the present work is to define a high-resolution bio-lithostratigraphic scheme for the last 85 kyr, which would be considered as a useful paleoclimatic and stratigraphic reference record in the entire Mediterranean region.

**Methods & Results:** We refine and extend previous biostratigraphic events and present a detailed centennial climatic record over the last 85 kyr from the deep-sea core M-22-67 located in the Chios basin (north Aegean Sea). Quantitative analysis of planktonic foraminifera, coupled with sedimentological data and paleomagnetic measurements provide an integrated stratigraphic time-framework over the last 85 kyr (time interval between late Marine Isotopic Stages 5 and 1; MIS5-MIS1). The temporary appearance and disappearance as well as several abundance peaks in the quantitative distribution of selected climate-sensitive planktonic foraminiferal species allowed the identification of several eco-bioevents, which were correlated with relevant western and eastern Mediterranean data, while climatic global events (sapropels S1 and S3, Younger Dryas, Heinrich events H1-H6) were also recognized. Finally, owing to the robust chronological framework of the studied core, and in order to achieve a large scale comparison, all the above data have been correlated to the GISP2 ice core record ( $\delta^{18}\text{O}$  and their resulting SSTs), revealing that the long and short term climate changes recorded in Greenland ice cores were worldwide recognizable and contemporaneous to the eastern Mediterranean.

**Conclusions:** This multidisciplinary approach underlines the utility to support conventional dating methodologies with different constraints, and further reveals a powerful tool for reliably correlating marine records between interconnected deep-sea settings and/or an original dating tool for coeval sequences of this region.

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PRE-EVAPORITIC PERIODS OF MAXIMUM NORTHERN SUMMER INSOLATION ON GAVDOS ARE MARKED BY DIATOMITES AND IN CENTRAL CRETE BY SAPROPELS: PRODUCTIVITY OR PRESERVATION?

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**Objectives:** The gradual restriction of the Mediterranean Sea leading to Messinian Salinity Crisis (MSC) was reflected in synchronous lithological transitions throughout the Mediterranean area. The lithological expressions differ from region to region, probably related to an early Messinian phase of basin restriction. At around 6.7 Ma lithological transitions occurred all over the Mediterranean area, with a different expression of the pre-evaporitic sedimentary sequence between locations. Marl-sapropel cycles in the Metochia section on Gavdos island change-over to marl-diatomites cycles, whereas no such a transition is observed in Aghios Myron section in the northern Heraklion Basin (central Crete). The post-6.7 Ma cycles in Aghios Myron are made up of marl-sapropel couplets, whereas those in Metochia are characterized by marls and diatomites. In this study we investigate the causes of the above lithological offset by presenting planktonic foraminiferal and sedimentological data from both eastern Mediterranean sections.

**Materials & Results:** The Metochia section is one of the standard sections for the late Miocene astronomically calibrated time scale. Aghios Myron section is a 25 m section, which sedimentary cycles (consisted of hemipelagic homogeneous marls and sapropels) are calibrated to the Metochia cycles using biostratigraphy and ash layers, and span the time interval 7.05–6.7 Ma. To understand whether the observed lithological offset is related to spatial differences in the preservation or production of biogenic silica, or both, we have counted the planktonic foraminiferal faunas in the Aghios Myron section in accordance with the already published planktonic foraminiferal assemblages for the Metochia section. Planktonic foraminiferal analyses allow direct comparison between the diatomite faunas of Metochia and those in the equivalent sapropels of Aghios Myron. Particularly, the productivity-related species (Neogloboquadrinids and *G. bulloides*) are statistically increased in Metochia relative to Aghios Myron sediments, providing a good explanation for the observed lithological inconsistency. Moreover, the planktonic foraminiferal distribution patterns are characterized by the upward increase of *T. quinqueloba* and *G. glutinata* during the deposition of Aghios Myron sediments in contrast to Metochia section. The increase in abundance of such opportunistic species, which can survive under extreme environmental conditions, could be related to the progressive isolation of this basin during that time. The depth offsets between the two studied sections, as reflected by the planktic/benthic ratio, further highlight the role of depositional depth on the observed lithological transition. However, its relationship with the factor of preservation could be considered critical, and will be the next step of this study through the presence/absence of diatoms in both sapropel- and diatom-sequences.

**Conclusions:** The biological and oceanographic response of the eastern Mediterranean to the astronomical climatic oscillations during the Messinian was mainly controlled by periodic changes in the hydrographic structure of the water column, which promoted the progressive replacement of different groups of species as they adapted to changing food availability. The depositional depths of the studied sub-basins, coupled with potential differences of silica preservation, seem to be an additional factor on the sensitivity of the system due to the Mediterranean climate amplification.

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INTEGRATED ISOTOPIC, FORAMINIFERAL, PTEROPOD AND PALYNOLOGICAL EVIDENCE OF HOLOCENE CLIMATIC INSTABILITY IN THE NORTH AEGEAN SEA

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**Objectives:** An integrated high resolution study based on a high sedimentation rate gravity core (AEX-15) collected from the North Aegean Trough was carried out in the frame of “YPOTHER” project, funded by the National Strategic Development Program EE. The overall objective for the present study was to reconstruct palaeoclimate and palaeoceanographic conditions and further extend our knowledge of the climatic variability in the North Aegean (eastern Mediterranean Sea) during the Holocene.

**Methods & Results:** The stratigraphic framework, based on a combination of Accelerator Mass Spectrometry (AMS) radiocarbon (<sup>14</sup>C) datings and additional control points of planktonic foraminiferal and pteropods bioevents, spans the entire Holocene. The results are based on high-resolution micropalaeontological data (planktonic foraminiferal, pteropods, and pollen), stable isotopes ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ) and other indicators inferring Sea Surface Temperature (SST), Sea Surface Productivity (SSP) and precipitation changes during that period.

From 10.6 ka to the onset of the sapropel S1 layer, climate amelioration is observed by the gradual depletion of  $\delta^{18}\text{O}$  and the high percentages of warm water species. The early Holocene is also expressed in vegetation pattern which is probably driven by precipitation changes, especially summer precipitation, and are correlated with inputs from local and regional rivers since vegetation changes occurred prior to SST increases. Generally, pollen-based temperature reconstructions follow patterns reconstructed using other proxies in the NE Mediterranean, with an increasing W-NW climatic influence. Warm and stratified surface conditions during S1 are characterized by the abundance of *Turborotalira quinqueloba*, *Globigerinoides ruber rosea*, *Orbulina universa* and *Globigerina bulloides* and the absence of the deep mixing species *Globorotalia inflata*, and *Neogloboquadrina pachyderma*. In this interval the epipelagic pteropods *Creseis* spp., *Cavolinia* sp., and *Heliconoides inflatus*, are dominant, whereas bathypelagic species such as *Clio* spp. and *Peracle* spp. are lacking. The abrupt heavy  $\delta^{18}\text{O}$  signal and the enriched  $\delta^{13}\text{C}$  at 8.6 ka are probably associated with the northern hemisphere cold event at 8.2 ka BP. The termination of S1 at 7.0 ka is marked by the occurrence of the deep mixing species *G. inflata*, *N. pachyderma* and *Peracle* spp. which reflects the overall improvement of water ventilation. Towards the late Holocene, warm oligotrophic species implicate the cessation of elevated primary productivity. Decrease in *Globigerinoides sacculifer* and *O. universa* reveals a river-runoff reduction, and further coincides with the  $\delta^{13}\text{C}$  enrichment. The reduction in the surface water Black Sea outflow at around 4.5 ka has caused an increase in sea surface salinity, which is also testified by the slightly heavier planktic  $\delta^{18}\text{O}$  record and the entering of the stenohaline species *Styliola subula* at 3.3 ka. The combined fauna, flora, and isotopic records support the general trend to climatic aridification over the Late Holocene, which is in accordance with the salinity increase and oligotrophic and dry nature of the water column of the modern North Aegean Sea. Several Holocene cold events, coeval with the Bond events in high latitudes are also documented in all records.

**Conclusions:** Our findings highlight the millennial-scale climate variability during the Holocene in the eastern Mediterranean Sea.

FACTORS CONTROLLING PLANKTONIC FORAMINIFERA SHELL MASS IN THE EASTERN MEDITERRANEAN

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**Objective:** Planktonic foraminifera comprise the second largest marine calcifying group of organisms after coccolithophores. Marine calcifiers form a major component of the global carbon cycle, acting as both a source and sink of CO<sub>2</sub>. Understanding factors that affect calcification in these organisms is therefore critical in estimating calcite budgets and predicting how the oceans and the marine ecosystems will respond to increased CO<sub>2</sub> concentrations in the atmosphere. It has been observed, in the paleoceanographic record, that these organisms produce heavier shells during glaciations while the amount of secreted shell calcite is less during the interglacials. The reason behind this behavior is still not clear. Investigators have proposed different controlling factors such as [CO<sub>3</sub><sup>-</sup>], temperature, optimum growth conditions, salinity, and [PO<sub>4</sub><sup>-3</sup>] but there is no consistency between results from different species or oceanographic regimes.

**Methods & Results:** Downcore results from the North East Atlantic, core NEAP 8K, revealed a good correlation between the shell mass of *Globigerina bulloides* tests and density values reconstructed from combined Mg/Ca and δ<sup>18</sup>O measurements on the same weighed shells. Combined Mg/Ca and δ<sup>18</sup>O measurements on the same planktonic foraminifera specimens is proposed as a novel method for surface seawater paleodensity reconstructions. In order to calibrate the core results we tested the above hypothesis by investigating modern foraminifera from available core top samples from different Mediterranean localities. Due to the diagenetic calcite overprint on foraminifera tests that alter their geochemical (Mg/Ca, δ<sup>18</sup>O) signal, their shell masses were compared to in-situ T-S data.

**Conclusions:** We provide evidence that ambient seawater density changes may account for the observed planktonic foraminifera shell mass variations. The mechanism behind this behavior may be buoyancy regulation for optimum depth acquisition between a denser glacial ocean and a diluted interglacial one.

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**FIELD OBSERVATIONS AND SEDIMENTOLOGICAL IMPLICATIONS OVER FINE-GRAINED REPLENISHED BEACHES: THE MEDITERRANEAN ANALOGUE OF “BARCELONETA BEACH, SPAIN”**

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**Objectives:** Beach scarping as a controlling factor of replenished beach morphodynamics is receiving increasing attention among coastal engineers and sedimentologists, especially in attractive tourist areas where large amounts of money are spent on periodic beach replenishment projects. As the number of these nourishments has abruptly increased during the last decades, new questions arise on the adaptation of the coastal system after such large artificial schemes have been implemented. Therefore, it is particularly interesting to determine beach scarp morphodynamics (generated after beach artificial nourishment activities), in terms of scarp persistence and evolution, which would lead us to understand their behavior and furthermore to enhance our ability to predict their formation. This contribution presents the results of a combined sedimentological, mineralogical and geochemical study of the beach scarp sediments formed as a consequence of beach nourishment on a fine-grained beach of Spain (Barceloneta).

**Methods & Results:** Standard sedimentological techniques, such as field inspection, and grain size analysis have been carried out. The research depended on X-ray Diffractometry (XRD) mineralogical analysis from which cementing agents, other than evaporites, were found within the scarp's mass. Further geochemical analysis involved pH, water and carbonate content measurements, while stable isotopes analysis clarified the carbonate source. The microstructural examination involved petrological thin sections studies and Scanning Electron Microscopy (SEM) analysis of the cliff-like formation.

**Conclusions:** The present study suggests that the processes leading to scarp formation on such replenished beaches are not the same with the physical processes leading to scarp formations on natural beaches, but scarping of artificial beaches is a product of chemical (cementation related) processes within the sediment from recharge operations.



THE VOLCANIC HISTORY OF PYRGOUSA – VOLCANISM BEFORE THE ERUPTION OF THE KOS PLATEAU TUFF

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**Aims:** The islet of Pyrgousa, 8 km west of Nisyros, has proximal deposits of the Kos Plateau Tuff (KPT) that overlie andesites of unknown age and affinity (Di Paola, 1974). This study investigated the age, geochemistry and petrogenesis of this pre-KPT volcanism and made incidental observations on the KPT deposits and the overlying MIS 5e carbonate-rich raised terrace.

**Methods:** An E–W transect of the islet was examined in detail, principally along the fresh outcrops at the shoreline. Igneous rock samples were analysed for major and trace element geochemistry by ICPMS. Rock textures and minerals were studied by SEM. One biotite separate was dated by the <sup>40</sup>Ar/<sup>39</sup>Ar technique.

**Results:** Most of the northern and eastern coastline of the islet exposes andesite domes, probable flows, and associated talus breccias. Marginal dips on domes are locally as steep as 70°. Four samples were analysed geochemically: three andesites and one basaltic andesite. Their chemistry is similar to that of late Quaternary basaltic andesite and andesite from Nisyros (Vanderkluyzen et al., 2005). Most plagioclases are andesine, but labradorite-bytownite is also present. Pyroxenes are augite and enstatite, amphiboles are magnesio-hornblende and tschermakite; biotite is phlogopite. There is widespread evidence of magma mixing from zoned minerals, similar to that described from the Kefalos peninsula on Kos, 10 km to the NNW (Pe-Piper and Moulton, 2008).

<sup>40</sup>Ar/<sup>39</sup>Ar dating of a biotite separate from sample CS216 yielded a total gas age of 1.7±2.8 Ma with a good plateau at 1.7±0.1 Ma. This age is similar to the older rhyolite domes in the Kefalos peninsula (Bellon et al., 1979) and substantially older than the oldest crystallized zircon ages in the Kos Plateau Tuff (–0.35 Ma; Bachmann et al. 2007).

The KPT unit on Pyrgousa is >5 m thick and comprises massive, structureless tuff with dispersed pumice and lithic clasts generally <5 cm in size, but near the top with lithic (volcanic) clasts up to 1 m in size and blocks of mud or marl >0.5 m. The basal contact was not found.

The terrace limestones are 8–10 m above sea level in the east, and close to modern sea level in the west. They include bioclastic limestone, in places overlying cobble conglomerate with a limestone matrix. The upper limestone is karstic and overlies the higher andesite domes.

**Conclusions:** The andesite domes of Pyrgousa are similar to the Pliocene domes in Methana that mark the onset of volcanism in that area of the western Hellenic Arc. There is no evidence on Pyrgousa for a stratovolcano precursor of the KPT eruption and the younger Nisyros volcano. The radiometric age of 1.7 ka suggests that only a small volume of magmatic products were erupted prior to the KPT eruption. The KPT deposit resembles unit Dm reported by Allen (1998) on Pachia islet, where the KPT overlies unconsolidated mud, apparently similar to the lithic clasts on Pyrgousa. This underlying mud is consistent with the interpreted absence of a stratovolcano prior to the KPT eruption.

POST-DEPOSITIONAL ALTERATION OF FOSSIL WOOD AND PYROCLASTIC ROCKS OF THE SIGRI PYROCLASTIC FORMATION, LOWER MIOCENE, LESBOS, GREECE

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**Aims:** An Early Miocene petrified forest is preserved in the Sigi Pyroclastic Formation of western Lesbos. The purpose of this research is to identify the origin of silica-iron-manganese mineralization of the fossilized trees and their host rocks.

**Methods:** The approach used is to identify mineral assemblages present in petrified wood, the altered Jithra ignimbrite, the altered fine-grained sediments underlying the ignimbrite, and mineralised veins in faults cutting tuffs. A Scanning Electron Microscope, EDS and WDS chemical analyses and Raman spectroscopy were used to identify the minerals.

**Results:** The petrified wood shows cells filled with amorphous silica, followed by replacement of cell walls by silica, then a silica+Fe-oxide mixture, and finally Fe-oxide, in some cases with minor As and Zn, which are bioessential elements that may indicate microbial mediation. A fault zone nodule is mineralogically zoned. The inner zone is entirely microcrystalline or amorphous silica. The middle zone comprises a silica+Fe-oxide mixture with Mn-oxide aggregates. The outer zone consists of host tuff partly replaced and cemented by Fe-oxides/hydroxides and the silica+Fe-oxide mixture. As the nodule was found in an altered fault zone, it may have been a pathway for hydrothermal solutions that first altered the country rocks in the outer zone and finished with the final filling by yellow siliceous veins.

Altered ignimbrite and underlying fine-grained sediments exhibit more extreme alteration. Mineral assemblages in the altered ignimbrite are: (1) K-feldspar +silica +illite +minor apatite, zircon, TiO<sub>2</sub> minerals; (2) Jarosite +hematite +amorphous silica; and (3) Mn-oxides–hydroxides. Hydrothermal K-feldspars appear to have formed by replacement of volcanic glass, hornblende and plagioclase crystals. Jarosite replaced hornblende already partly replaced by amorphous silica. Assemblages from the altered fine-grained sediments are predominantly smectite +silica +TiO<sub>2</sub> minerals ±hematite ±monazite. Smectite replaces crystals of biotite, plagioclase, and glass fragments.

**Conclusions:** Among possible analogues in the literature, the epithermal system of the Taupo volcanic zone in New Zealand has a very similar setting to the Sigi Pyroclastics. The types of alteration produced by different circulating waters show many similarities. However, the distinctive amorphous silica +Fe-oxides are chemically and mineralogically comparable with jaspers found in marine exhalative systems. Faulting and complex hydrothermal mineralisation may have been related to the emplacement of laccoliths around 18 Ma; the silicification of the fossil wood was probably earlier.

NEW INSIGHTS INTO THE AGE, STRATIGRAPHY AND DEPOSITIONAL SETTING OF THE SIGRI PYROCLASTIC FORMATION, EARLY MIOCENE, LESBOS, GREECE

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**Aims:** The Petrified Forest of Lesbos comprises silicified tree fossils at multiple stratigraphic levels within the Early Miocene Sigrí Pyroclastic Formation. The objectives of this study were to date the pyroclastic rocks and to interpret their volcanological setting.

**Methods:** Detailed field investigations were made at the Bali Alona Petrified Forest Park, at Nissiopi, along the Jithra–Antissa–Sigrí Road, and southward to Skala Eressou. Sections were logged in detail for lithology, sedimentary structures and hydrothermal alteration. Orientations of fallen fossil trees were measured. Samples were taken for mineralogical, geochemical and geochronological analysis. <sup>40</sup>Ar/<sup>39</sup>Ar dating was carried out on mineral separates from four samples.

**Results:** Widespread andesite-dacite domes, the Eressos Formation, intrude and overlie metamorphic basement and were previously dated near Eressos at 21.6±0.5 Ma (K-Ar, hbl; Pe-Piper & Piper, 1983). A correlative weathered red dacite (LL816) at Nissiopi gave a new total gas age on hornblende of 22.9±4.3, with a plateau age of 19.9±0.56 Ma.

The Sigrí Pyroclastic Formation comprises several hundreds of metres of pyroclastic flow tuffs, interbedded fluvial conglomerate and volcanoclastic sandstone, and minor mudstones, airfall tuffs and paleosols. Tree fall-directions are predominantly NNW–SSE at Nissiopi and NW–SE at Bali Alona. The proportion of fluvial conglomerates in the Sigrí Pyroclastic Formation increases eastward from Bali Alona towards Vatoussa. Two crystal tuffs were dated. One from low in the section on Nissiopi (LL817, biotite) gave a total gas age of 20.0±1.8 Ma and a plateau age of 18.38±0.34 Ma. The other from the middle Sigrí Pyroclastic Formation east of Bali Alona (LL820, biotite+hornblende) gave a total gas age of 21.7±2.7 Ma and a similar plateau age of 21.83±0.51 Ma.

A prominent ignimbrite is interbedded with the upper Sigrí Pyroclastic Formation west of Antissa and is down-faulted farther east at Jithra. Previous work showed tephra orientations →N and NW at Antissa and →NW at Jithra (Pe-Piper, 1977). The Jithra ignimbrite (LL840; biotite) was dated at 18.49±0.54 Ma (total gas) and 18.39±0.16 Ma (plateau). The shallow andesitic laccolith at Moni Ipsolou cutting the middle Sigrí Pyroclastic Formation was previously dated at 17.9±0.6 by <sup>40</sup>Ar/<sup>39</sup>Ar on hornblende (Pe-Piper et al., 2003).

**Conclusions:** The oldest known volcanic rocks in Lesbos are widespread andesite-dacite domes directly overlying metamorphic basement between Eressos and Sigrí. One dome near Eressos dates from 21.6 Ma (Aquitanian); a weathered dome at Nissiopi may be younger (20 Ma if the plateau age is reliable). The middle Sigrí Pyroclastic Formation at Bali Alona yielded a date similar within error to the underlying Eressos dome, whereas the lower Sigrí Pyroclastic Formation on Nissiopi is substantially younger (18.4 Ma), and similar within error to the age of the Jithra ignimbrite within the upper Sigrí Pyroclastic Formation. The Nissiopi–Sigrí area was a horst during most of the deposition of the Sigrí Pyroclastic Formation that accumulated distal pyroclastic rocks only during deposition of the upper part of the formation. This horst deflected pyroclastic flows and river channels to the north or south, accounting for the tree fall-directions.

## MESSINIAN FISH OTOLITH ASSEMBLAGES FROM CRETE AND ZAKYNTHOS ISLANDS

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We reconstruct the Messinian fish fauna of the eastern Ionian Sea and the south Aegean Sea before the salinity crisis based on the otolith record from four sections: Kalamaki (Zakynthos Island) and Kapariana, Faneromeni, and Potamida (Crete Island). In Kalamaki section, we identify the following taxa: Gonostomatidae indet., *Maurolicus muelleri*, *Vinciguerria poweriae*, *Ceratoscopelus maderensis*, *Diaphus cavallonis*, *Diaphus* cf. *pedemontanus*, *Diaphus rafinesquii*, *Diaphus rubus*, *Diaphus taaningi*, *Myctophum coppa*, and *Physiculus* aff. *huloti*, *Gadiculus argenteus*, *Gadiculus labiatus*, Gobiidae, *Lepidopus caudatus*, *Buglossidium* sp. The Kapariana section Messinian sediments reveal *Benthoosema suborbitale*, *Diaphus befralai*, *Diaphus splendidus*, *Diaphus acutirostrum*, *D. cavallonis*, *D. rubus*, *Myctophum fitchi*, and *Bregmaceros albyi*. The Messinian sediments in Faneromeni section include otoliths of *B. albyi*, *D. cavallonis*, *Lobianchia dofleini*, *M. fitchi*, *Deltentosteus* aff. *quadrifasciatus*, *D. rubus*, *Diaphus splendidus*, *Lesueurigobius friesii*, *Rhynchoconger pantanellii*, *Hygophum hygomii*, and “Gobiida” aff. *bicornuta*. Finally, the Messinian sediments in Potamida section include *B. suborbitale*, *C. maderensis*, *H. hygomii*, *Lampadena dea*, *Lampanyctus latesulcatus*, *L. dofleini*, *M. fitchi*, *Notoscopelus elongatus*, *Scopelopsis pliogenicus*, *G. labiatus*, *Scopelogadus* sp., *Pagellus* cf. *acarne*, *D.* aff. *quadrifasciatus*, *L.* aff. *friesii*, *Pomatoschistus* sp., and ?*Mesogobius* sp.

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**A ZANCLEAN FISH FAUNA FROM THE EASTERN IONIAN DOMAIN**

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Fish otoliths from the Zanclean deposits of Agia Triada section (southwestern Peloponnesus, Greece) reveal a rich fauna comprising mostly Myctophidae, Clupeidae, Sparidae, Gobiidae, Congridae, and Gadidae. Characteristic taxa include: *Ceratospopelus maderensis*, *Pterothrissus compactus*, *Dentex macrophthalmus*, *Paraconger notialis*, *Sardina pilchardus*, *Aphia minuta*, *Dentex maroccanus*, *Pagellus erythrinus*, *Micromesistrius poutassou*, *Lesueurigobius sanzi*, and *Oblada melanura*. Compared to the known Zanclean fish faunas of the Aegean Sea, the studied assemblages are more diversified. In addition, we compare these otolith assemblages with those from the pre-evaporitic Messinian of the Ionian domain. It is clear that the Agia Triada fish fauna includes pelagic, mesopelagic-bathypelagic, and benthic-benthopelagic species, corresponding to population that re-inhabited and became fully established in the Mediterranean Sea after the Messinian salinity crisis.

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**BIOGENIC CARBONATE STORAGE AND ITS POTENTIAL SIGNIFICANCE TO EASTERN MEDITERRANEAN CLIMATE DURING THE LATE MIOCENE**

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**Objectives:** Planktonic foraminifera are major contributors to the pelagic calcareous production and the carbon dioxide (CO<sub>2</sub>) flux of the oceans. When foraminifera produce calcite shells CO<sub>2</sub> is released to the ambient water. In this respect, planktonic foraminiferal test production changes the surface water carbonate system, impacts the oceanic and atmospheric CO<sub>2</sub> and eventually influences the environmental changes. In order to estimate the amount of carbonate produced during the Tortonian-Messinian time period in the Eastern Mediterranean, weight measurements were performed on foraminiferal shells from specific size fraction according to their mean size.

**Methods & Results:** The studied material comes from Faneromeni section which is located in the eastern part of the island of Crete. A qualitative and semi-quantitative analysis of the diverse planktonic foraminiferal fauna (>125µm) indicates an age bracketed between about 7.6 and 6.7 Ma, including the Tortonian-Messinian (T/M) transition at 7.2 Ma. In order to estimate the amount of the deposited foraminiferal carbonate, the total number of foraminifera in each sample was calculated from the splitted initial known sample quantities. It was found that planktonic foraminifera comprise on average 60% of the sample and their number mainly exceeded that of the benthic foraminifera. Furthermore, the absolute individual numbers were combined with weight measurements of the most abundant, climate-sensitive and orbital-tuner planktonic foraminiferal species *Globigerinoides obliquus* from a narrow size fraction. Where possible, 50 shells from 250-300µm sieve fraction were weighed on a micro-balance. Their mean sieve-based weight was calculated before the stable isotope analyses. The total number of shells was then combined with their average weight, and the amount sedimentary carbonate deposits were estimated. The amount of carbonized calcium, as reflected by the number of foraminifera, shows productivity increase during the Tortonian, which is accompanied by a remarkable descending cast around 7.2 Ma.

**Conclusions:** The deposits of calcium carbonate continuously increase until the T/M boundary, and after some perturbations they reach their maximum about two million years later. The image of carbonized calcium's increase matches the isotopic curve showing a coeval temperature rise.

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**MASSIVE PYROCLASTIC VOLCANICLASTIC INPUT IN THE WEST KOS BASIN**

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**Objectives:** The volcanic islands of Kos-Yali-Nisyros surrounding the over 510m deep West Kos Basin record the volcanic activity, which was initiated at the end of Neogene. All the major volcanic events of the region culminated after 0.5 Ma and volcanoclastic sedimentary faces indicate a source located within the West Kos Basin. This study records the seismic stratigraphy of all major volcanically derived deposits interlayered within marine sediments in the West Kos Basin.

**Methods and Results:** Post 2010 multibeam and sparker medium to high resolution data clearly depict three massive beds that are separated by continuous to semi continuous subparallel reflectors of obvious marine nature. More specifically from top, we distinguish:

1. A rather turbulent to semi-chaotic horizon delineated by a strong reflector at its base, which is erosional. This layer is found at 2-5m below the seafloor and its thickness varies from 1-9m and abruptly ends at the faulted shelf of the West Kos Basin.
2. A wider massive acoustically incoherent unit at 10msec (~7m) sub bottom on some slopes and typically about 15-25msec (13-21m) and up to 50msec (42m) sub bottom on the basin floor. It can be clearly correlated from one seismic profile to another and its thickness varies from near zero on shelves of up to 200msec (170m) thick in the central West Kos Basin. Its base is profoundly erosional and locally we can distinguish further chaotic subunits.
3. Below 50-250msec (42-212m) sub bottom and below a mostly well stratified continuous reflectors there is another acoustically incoherent unit, 100-180m thick deposited above well stratified reflectors.

Sedimentation rates calculated in the basis of short cores in the West Kos Basin indicate sedimentation rates exceeding 20-25 cm /1000 years over the past 20.000 years.

**Conclusions:** The West Kos Basin hosts massive acoustically turbulent to incoherent beds that relate to massive volcanoclastic gravitative flows. The middle unit is correlated to the Kos Plateau Tuff and the Lower chaotic unit to the "Kefalos tuff Ring". The deposition of thick volcanoclastic beds spanning a period of at least half a million years suggests that the area of the deep basin was not the site of a huge caldera as postulated by some authors.

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## THE LATE MIOCENE CAMPO COY GYPSUM UNIT (SE SPAIN): PETROLOGY AND GEOCHEMISTRY

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The Campo Coy Basin is a small inner basin located in the eastern part of the Betic Cordillera (SE Spain), structured during the Late Miocene. During the Serravalian and Early Tortonian this region was part of the North Betic gateway connecting the Atlantic Ocean and the Mediterranean Sea. During the Late Tortonian, these marine connections were restricted and finally interrupted forming different evaporite units. The Campo Coy Gypsum Unit (CCGU) was deposited in the Campo Coy Basin during the transition from marine to non-marine conditions. The CCGU is 350 m thick and has more than 8 km of lateral continuity. This study is focused on the stratigraphy, petrology and geochemistry of the CCGU.

The stratigraphic sequence of Campo Coy basin is >1000 m thick. This sequence begins with a detrital succession of marls and some interstratified conglomerates and sandstones (Basal detrital Unit) in contact with the Triassic deposits. The predominant presence of planktonic foraminifera *N. acostaensis dextra*, *N. humerosa* and *G. suteræ* indicates a Late Tortonian age for these materials. Similar foraminifera fauna has been described in the Hondo Fm. and at the base of the La Serrata Fm. in the nearby Lorca Basin with the same chronological results (Krijgsman *et al.*, 2000; Corbí *et al.* 2012). This fossil content suggest that these basins were connected during the beginning of the restriction of the North Betic gateway (Corbí *et al.* 2012). The CCGU overlay the basal marine marls (Basal detrital Unit) and is divided in two evaporite subunits, the lower gypsum (80 m thick) and the upper gypsum (250 m thick). The different gypsum lithofacies in both evaporite bodies are preserved as primary gypsum and partially transformed to secondary gypsum after anhydrite. These gypsum subunits are separated by a detrital unit rich in forams quite similar to the Basal detrital Unit. Overlaying this evaporitic unit a thick alluvial (300 m) unit occurs (Upper detrital Unit), capped by lacustrine carbonates with vertebrate fossils. The sulfur  $\delta^{34}\text{S}$  and oxygen  $\delta^{18}\text{O}$  isotope compositions of gypsum samples show the isotopic signature of Triassic marine sulfates in the Betic Range (Ortí *et al.*, 2014). The strontium isotope ratios ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) show values between 0.707788 -0.707888 falling within the range of Triassic marine sulfates  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios. These geochemical data of the CCGU suggest that gypsum deposition is related to a higher continental water influx recycling Triassic evaporites. Variations in the water balance of the basin controlled the type of sediments. Periods with higher marine water input lead to the deposition of marine foraminifer rich-marls while gypsum precipitation took place during periods of major restriction when continental water inputs predominate in the basin.



**REEF CORAL CALCIFICATION IN A GLOBALLY WARM CLIMATE (AQUITANIAN, SW-FRANCE)**

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Coral reefs are limited to the north and south by minimum sea surface temperatures (SST) of < 18 °C and a saturation state of seawater with respect to aragonite  $\leq 3.1$ . For the distribution of reefs of the deep past and the near future, the modern ocean is no good analogue, however, because present-day temperatures of the warm pools are lower and pH values higher than during the interglacials of the Neogene and in the near future. Reef coral diversity during interglacials was lowest near the equator and the geographic range of many taxa was shifted poleward. Hence, in addition to minimum temperatures and aragonite saturation limiting coral distributions, high temperatures were also a critical factor during interglacials and will be a factor in the near future. Low continental ice volumes, particularly in the northern hemisphere, and available atmospheric pCO<sub>2</sub> data from the Miocene are suggestive of a warmer-than-present climate. So far, no data have been presented on coral calcification during this critical period of time.

Here we present the first records of reef coral calcification in combination with serial stable isotope data as proxy records of sea surface temperature and coral – algal symbiont relationships from the Early Miocene (Aquitania) in SW-France. While skeletal density of the Miocene corals is fully compatible with modern reef corals, annual extension rate and calcification rate were lower or among the lowest recorded in the literature of modern reefs. Causes underlying low extension rates are manifold; the most important seem to be turbid water, water depth (deep water), and SST (low SST). In the Miocene example, no evidence exists for deep or turbid water since the corals were sampled from coarse sediment and do not display ragged outlines being the typical expression of growth under siltation stress. Thus, low SSTs may represent the prime factor since the reefs of SW France were in a rather high latitude position even at that time. It should be noted, however, that all data of extension rates available from Early Miocene and Neogene reef corals worldwide are low compared to modern and suggest an additional environmental factor playing an important role. Coral oxygen isotope data document mean SSTs were 22 - 23 °C and seasonality between 4 - 5 °C, which is substantially above/below that encountered in the Bay of Biscay today (~19/~9 °C). While the estimate of mean annual SSTs depends on assumptions and may represent an overestimation, seasonality can be considered rather robust. Carbon stable isotope data clearly indicate open marine water and active algal photosynthesis; the Aquitania corals were thus biologically fully compatible with their modern relatives. All in all, this evidence seems to imply that likely neither low nor high SSTs were the essential drivers of low calcification rates of reef corals during the Neogene. We suggest to search the unknown environmental factor for low calcification rates in the saturation state of the ocean with respect to aragonite coupled with high atmospheric pCO<sub>2</sub>. This finding would imply rates of coral calcification to decline in the future upon continuing anthropogenic emissions of CO<sub>2</sub>.

MIDDLE MIOCENE STEPWISE CLIMATE EVOLUTION IN THE MEDITERRANEAN REGION  
THROUGH HIGH-RESOLUTION STABLE ISOTOPES AND CALCAREOUS PLANKTON RECORDS

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**Climatic framework and study area:** The middle Miocene is marked by a changeover from a warm climatic period (Miocene Climatic Optimum= MCO, ~17-14.7 Ma), to a transitional phase (Middle Miocene Climatic Transition= MMCT), culminating in a cold stage (Icehouse Mode= IHM, ~13.8 Ma). This period is described by a positive excursion of  $^{13}\text{C}$  ("Monterey Excursion"), showing a series of  $\delta^{13}\text{C}$  maxima (CM events of Woodruff and Savin, 1991) punctuated by peaks of  $\delta^{18}\text{O}$  values (Mi events of Miller et al., 1991, 1996). DSDP Site 372 recovered a high-resolution record from the middle Miocene of western Mediterranean (Balearic Islands), and represent one of the best marine sedimentary record for the considered time interval.

**Results:** In this study, high-resolution stable isotope and quantitative calcareous plankton records for the Langhian to early Serravallian time interval are presented. Through this approach, a well evident climatic evolution have been depicted. During the first stage (MCO; up to 14.55 Ma), an initial warm-surface-water, oligotrophic, high salinity and restricted environment is recorded, which is followed by an open marine setting (starting from 15.18 Ma) within still warm-surface-water and oligotrophic conditions. The rifting event associated with the development of the Valencia Trough could have triggered this latter environmental change. From 14.55 to 13.75 Ma (second stage, MMCT) an initial (up to 14.05 Ma) temperate-warm-surface-water and eutrophic environment occurred, followed by the onset of warm-surface-water, oligotrophic and slightly restricted marine conditions. The third stage (IHM, from 13.75 Ma onwards) points to the development of a cold-water, eutrophic, high salinity environment in an open-marine setting.

**Conclusions:** The stable oxygen and carbon isotope records allowed us to recognize and chronologically frame the Mi and CM events falling between 15.82 and 13.04 Ma. Furthermore, integrating the stable isotope data and those obtained by the quantitative analyses of the calcareous plankton content, the three-folded climatic and environmental evolution was outlined for the considered time interval in the western Mediterranean region.

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**NEW STRATIGRAPHIC AND PALEOCEANOGRAPHIC INSIGHTS IN THE MESSINIAN UPPER  
METOCHIA SECTION (GAVDOS ISLAND, GREECE)**

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**Objectives:** The Metochia section (Gavdos Island, Greece) records the pre-evaporitic phase of the Messinian salinity crisis (MSC). The coiling ratio of *Neogloboquadrina acostaensis* and the precession-related cyclostratigraphic pattern have been used for bed-by-bed correlations with the Mediterranean and Atlantic successions (Krijgsman et al., 2004) and contributed to the idea of a synchronous MSC onset. According to Pérez-Folgado et al. (2003) the phase relation of the lithological cycles with the insolation parameter in the 6.62 - 6.54 Ma interval is different in respect to the Sorbas basin (Sierra et al., 2003) because the insolation maxima would correspond to the diatomites (dominance of neogloboquadrinids), instead of the sapropel (dominance of *Globigerinoides* spp.) and the insolation minima would correspond to the marls (dominance of *Globigerina bulloides*), instead of the diatomites (dominance of *G. bulloides*/turborotalids). On the other hand, Drinia et al. (2007) observed that changes in foraminifer assemblages indicate periodical restrictions of the circulation and raised sea surface salinities, likely triggered by tectonic activity and glacio-eustatic cycles. We aim to reconstruct the paleoceanographic evolution of this sector of the Mediterranean during the uppermost part of the pre-evaporitic phase for a comparison with the coeval reference sections of the Western and central Mediterranean.

**Methods & results:** We integrate the quantitative study of planktonic foraminifera with the cyclic stacking pattern of the upper Metochia section. The upper Metochia section is characterized by 14 sapropel-diatomite-marl cycles with a laminated carbonate layer occurring between cycles 12 and 13. On top of this cyclical interval clastic carbonates are present. The following biostratigraphic events were identified: influx of *N. acostaensis* s.s. coiling (cycle 6), influx of *Globorotalia scitula* (cycle 7), top of *Turborotalita multiloba* (cycle 8). Foraminifers decrease above cycle 8 (ca. 6.07 Ma) and the top of planktonic and benthic foraminifers (>125µm) are identified in cycles 12 and 13, respectively.

The disappearance of foraminifers slightly predates the base of the MSC at 5.97 Ma, which is recognized by means of bio-cyclostratigraphy in cycle 14. As observed in the Tokhni section (Cyprus, Manzi et al., 2016), the MSC onset is preceded by a laminated carbonate layer and it is not revealed by the deposition of primary evaporites, but by clastic carbonates.

**Conclusions:** Regarding the different response of the basin to the precessional signal in respect to the Sorbas basin, we observed that the studied dataset (6.22 - 5.98 Ma) also show some differences: a) planktonic foraminifers are reduced in abundance at the sapropel/diatomite transition, at a different stage within the cycle compared to the Sorbas basin (upper marl/insolation minima); b) benthic are also generally absent or rare in the diatomites other than in the sapropels; c) *Globigerinoides* spp. are poorly represented, overall, and are strongly reduced from cycle 5 (6.14 Ma), which is four precessional cycles earlier than in the Sorbas and Caltanissetta basins.

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LATE MIOCENE RESTRICTION OF THE BETIC CORRIDOR THROUGH GUADIX-BAZA BASIN (SE IBERIA): NEW OUTCROPS AND SEISMIC DATA

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The time of disconnection between the Atlantic and Mediterranean through the Betic corridor is still unclear. This is in part consequence of the limited outcrops showing the marine to continental transition in this region and the difficulties to obtain accurate dates for the last marine and the initial continental sediments. Like in other inner Betic basins, it is assumed that the continentalization of the Guadix-Baza basin was consequence of the Late Miocene tectonic uplift of the Betic Cordillera. Available marine outcrops from the Guadix-Baza seaway are located near the margins of the basin where erosional processes dismantled part of the last marine sediments before the initial continental sedimentation showing erosional surfaces between both units. A refined paleogeographical evolution of this seaway is still in construction. An initial proposal suggested that the Atlantic connected the Mediterranean via Guadix and through the Campo Coy-Lorca corridor after the Almanzora seaway was closed. On the basis of paleontological data, it was also proposed that the transition from marine to continental regime occurred without important sedimentary hiatuses. Recently vertebrate fossils from Cortijo de la Piedra site indicate that the marine connection between the Guadix-Baza and the Campo Coy basins disappeared when marine conditions still persisted in Guadix. In addition, a study in la Lancha section, suggested a sedimentary hiatus of about 2Ma between the marine and continental sediments based on the presence of the vertebrate *Paraethomys meini* in the basal continental sediments. Here we show a new outcrop with deltaic deposits in the Negratin reservoir, showing the marine to continental transition in Guadix. These deltaic deposits occur away from the margins of the basin and include forams and vertebrates that allow to constrain the age of the succession. Our preliminary paleomagnetic and foraminifers-based biostratigraphic data confirm that the Globorotalia suterae biozone (MMi12b; latest Tortonian) is represented in the marine record of the basin. The studied section complements the stratigraphy of La Lancha section where a deep marine unit is covered by a shallow marine unit that underlies continental sediments. Our stratigraphic study indicates that the Negratin deltaic sediments are contemporaneous and even younger than the last marine deposits of La Lancha section. In addition, we show that the presence of *Paraethomys* has been recorded at 6.23 Ma in the Cabriel basin (East Iberia) reducing the proposed sedimentary hiatus in the Guadix. On the other hand, the clastic composition of the delta foresets with metamorphic pebbles from the Nevado-Filabride complex are one of the first evidence in this basin of the exhumation of the internal zones of the Betic cordillera, indicating a general uplift and as a consequence an increased restriction on the Guadix corridor. In addition recently acquired geophysical data along three seismic profiles shows more than 2km of sedimentary infill in the Baza basin depocenter. This infilling includes different seismic facies that represents the marine and continental stages and the transition between both environments. The seismic units are separated by progressive or minor angular unconformities that reveal the sedimentary tectonic activity during basin infill.

TRACING PHYLOGENY OF EURASIAN MIOCENE HOMINOIDS USING VIRTUAL ANTHROPOLOGY AND GEOMETRIC MORPHOMETRICS: THE *OURANOPITHECUS MACEDONIENSIS* PARADIGM

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**Objectives:** The hominoid *Ouranopithecus macedoniensis* is known from the late Miocene deposits of Axios Valley (Macedonia, Greece) in the form of several mandibles, a number of teeth and a partial cranium (XIR-1). The face of XIR-1, which was originated from the fossiliferous site Xirochori 1, is well preserved but slightly distorted as a result of taphonomic processes. The right side of the lower face is complete, and a big portion of the frontal bone as well as part of the left side of the face is preserved. The age of *O. macedoniensis* ranges between 9.6 – 8.7 Ma, based on magnetostratigraphical and biochronological data. The aim of this study is, first, to virtually restore symmetry to the deformed face of the XIR-1 cranium, and to reconstruct its facial anatomy using mirror imaging, a virtual anthropology technique. Second, to conduct a comparative analysis of the specimen's reconstructed facial morphology using 3D geometric morphometrics and a comparative sample of other fossil hominoids and extant great apes, in order to test the hypotheses proposed for its phylogenetic position. Over the years, *O. macedoniensis* has been hypothesized to represent either a sister group of the australopithecines and *Homo* or as the ancestor of *Gorilla* or *Pongo*.

**Methods and results:** High-resolution computed tomography (CT) was used to create a digital representation of the XIR-1 specimen, while the virtual reconstruction of its facial area was achieved by using a mirror image of the better-preserved side, so as to restore bilateral symmetry. Additionally, a set of anatomical landmarks was registered on adult crania of extant great apes and fossil hominoids from Eurasia and Africa and multivariate statistical analyses were applied. In the shape-space PCA *O. macedoniensis* falls within the *Gorilla* convex hull and close to Eurasian dryopithecines (*Dryopithecus* and *Hispanopithecus*), while the allometric relationship of shape and size also places it closer to the *Gorilla* specimens.

**Conclusions:** The preliminary results indicate that the overall shape of the face of *O. macedoniensis* is more similar to *Gorilla* and Eurasian dryopithecines than to *Homo*, *Pan* or *Pongo*. This study forms the first attempt of correcting the symmetry of the XIR-1 cranium, using 3D geometric morphometrics, while the efforts to better understand the phylogenetic relationships of the early hominoids are continued, extending the analyses and comparisons onto the mandible.

**DIVERSE ACTINOPTERYGIAN ASSEMBLAGES FROM THE MESSINIAN ESTUARIES OF SAHABI, LIBYA**

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**Objectives:** During the late Miocene, widespread aridification in Northern Africa gave birth to what is nowadays the Sahara Desert. Still, several major freshwater bodies were active in the region, with the Nile River and Lake Chad persisting to date. Evidence for the presence of another large-scale fluvial system comes from the late Miocene–Pliocene deposits of the Sahabi Formation, in Northeastern Libya. The shallow marine to fluvial facies exposed in the area yielded a rich fossil vertebrate fauna, containing terrestrial and aquatic mammals (e.g., proboscideans, carnivorans, bovids, primates, cetaceans, sirenians etc.), birds, reptiles (crocodilians and testudins) and fishes (actinopterygians and chondrichthyans). However, until recently, collection and study emphasis had been given to tetrapods, whilst fishes remained largely undersampled and understudied. In 2010, the ELNRP conducted the first systematic collection of fossil fishes from the area. We examined the taxonomic composition, as well as the paleoenvironmental and paleobiogeographical significance of the newly recovered actinopterygian fossils.

**Methods & Results:** Fossil fish sampling was focused on the most-prolific “Upper Member” (Messinian, approx. 6.8–5.96 Ma) of the Sahabi Formation. Our large sample consists mostly of disarticulated bones, corresponding to over 22 actinopterygian taxa, many of which were previously unreported from the site. Dry skeletons of recent marine and freshwater fishes from the region, as well as available paleontological literature, were employed for comparative purposes. The new actinopterygian faunal list is as follows: *Polypterus* sp. (Polypteridae), cf. *Labeo* sp. (Cyprinidae), *Hydrocynus* sp., *Alestes/Brycinus* sp. (both Alestidae), Siluriformes indet., Ariidae indet., *Bagrus* sp. (Bagridae), *Auchenoglanis* sp., cf. *Clarotes* sp. (both Claroteidae), *Clarias/Heterobranchus* spp. (Clariidae), *Synodontis* spp. (Mochokidae), Mugilidae indet., Percomorpha indet., *Semlikiichthys rhachirhynchus* (incertae sedis), *Lates niloticus* (Latidae), *Pomadasys* sp. (Haemulidae), *Argyrosomus* sp. (Sciaenidae), *Sparus* sp., *Diplodus* sp., cf. *Dentex* sp. (all Sparidae), Pseudocrenilabrinae indet. (Cichlidae), and Tetraodontidae indet. Although taxa of freshwater affinities are more abundant in the macroscopic part our sample, those of primarily marine affinities are not rare, indicating the presence of estuarine/lagoonal depositional environments. Localized clay lenses with articulated freshwater fishes (mostly mochokids), within the otherwise time-averaged sandy deposits, are correlated with rapid sedimentation and low salinity events, which could have occurred at a seasonal basis. Preliminary results on the paleobiogeographical affinities of the ichthyofauna point towards ephemeral connections between the (Eo)Nile Basin and Sahabi, during the Messinian.

**Conclusions:** Our study provides a unique insight into the actinopterygian diversity, and the dynamic, estuarine/lagoonal paleoenvironments present at Sahabi during the late Miocene, before the onset of the Messinian Salinity Crisis. Furthermore, the presence of remains of primarily marine genera, such as *Argyrosomus* and *Pomadasys*, which are otherwise poorly represented in the skeletal record of the Tethyan Neogene, highlights the importance of studying estuarine microvertebrate assemblages for understanding the evolution of marine fishes and ecological niches.

**THE ELBOW OF *MESOPITHECUS PENTELICUS* FROM PIKERMI, ATTICA (GREECE)**

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**Objectives:** The postcranial fossil material of *Mesopithecus pentelicus*, from the classic middle Turolian (MN12) locality of Pikermi (Attica, Greece), has been previously studied in order to infer substrate preferences. More specifically, emphasis has been given to forelimb anatomy, which can better differentiate primate locomotor groups. In this study we have attempted to analyse skeletal features of the elbow of *M. pentelicus* in order to reconstruct its locomotor behaviour.

**Methods & Results:** For the purposes of the study, 15 humeral and 8 ulnar linear measurements and 4 angles from 4 fossil humeri and 5 ulnae of *M. pentelicus* as well as 106 humeri and 97 ulnae belonging to 8 genera and 11 species of extant Colobines, with known substrate preferences, were used in multivariate analyses. All linear measurements were standardised in order to control for size differences and angles were transformed into radians. The standardised data were analysed with a Principal Components Analysis (PCA) and a Discriminant Function Analysis (DFA). Both analyses placed *M. pentelicus* in the vicinity of semi-terrestrial colobines. In addition, *M. pentelicus* appeared to cluster near *Trachypithecus* and *Presbytis*.

**Conclusions:** The preliminary results point to *M. pentelicus* retaining an elbow with more terrestrial than arboreal affinities, corroborating to previous findings. *Mesopithecus pentelicus* is sensibly considered a semi-terrestrial colobine that populated the savannah-woodland habitats of Pikermi. Although, the ulna retains some primitive characters related to arboreal ancestry, the humerus shows more clear semi-terrestrial functional affinities.

**Keywords:** locomotion, *Mesopithecus, pentelicus*, middle Turolian, Pikermi.

**SULFATE ISOTOPES IN MSC EVAPORITES: EVIDENCE FOR A DEEP-WATER DEEP-BASIN MEDITERRANEAN**

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Sulfate isotopic compositions of  $\delta^{34}\text{S} \sim 22 \text{‰}$  and  $\delta^{18}\text{O} \sim 11 - 12 \text{‰}$  should be expected for Late Miocene marine evaporites according to Middle Miocene (Badenian) evaporites, worldwide Late Miocene marine barite, and structurally substituted sulfate in calcite.

Accurate sulfate isotopic data of Lower Gypsum deposits (MSC Stage 1) deposited in onshore marginal basins in Spain, Sicily, Apennines and Cyprus show a narrow range of compositions ( $\delta^{34}\text{S} \sim 23 \text{‰}$  and  $\delta^{18}\text{O} \sim 13 - 14 \text{‰}$ ). The overall increase, mainly in  $\delta^{18}\text{O}$ , suggests enrichments of heavier isotopes by biogenic redox processes.

The second stage of the MSC is characterized by thick primary halite and by clastic gypsum deposits in some marginal basins (Sicily, Cyprus). The main MSC seismic offshore units (Lofi et al., 2011) correspond to this stage (Roveri et al., 2014). Saline Units A and D in Caltanissetta (Sicily), precipitated from relatively less concentrated halite brines, show intermediate isotopic compositions ( $\delta^{34}\text{S} \sim 22 - 23 \text{‰}$ ,  $\delta^{18}\text{O} \sim 14 - 17 \text{‰}$ ) between Lower and Upper Gypsum fields.

The third stage of the MSC is represented by the Upper Gypsum deposits in Sicily and Cyprus while evaporite-free deposits dominate in northern (Apennines) and eastern marginal basins (Spain). Sulfate isotopic compositions of Upper Gypsum are similar with respect sulfur to those of Lower Gypsum ( $\delta^{34}\text{S} \sim 23 \text{‰}$ ) but higher in oxygen ( $\delta^{18}\text{O} \sim 17 - 19 \text{‰}$ ).

The isotopic homogeneity in contemporaneous gypsum deposits from distant marginal basins, enriched in heavier isotopes with respect to oceanic evaporites, support the deep-water deep-basin model for the Mediterranean during the complete MSC.



**HOW MEANINGFUL ARE BIOGEOGRAPHIC INFERENCES WHEN TAXONOMIC RESOLUTION IS LIMITED IN PALYNOFLORAS? EXAMPLES FROM THE MIOCENE OF TURKEY**

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**Objectives:** Palaeopalynology is commonly used for terrestrial stratigraphy and fossil fuel (mainly coal) exploration. For these fields of application light microscopy (LM) was used and an abiological (artificial, morphology-based) nomenclature was used. During the last decades, much effort was used to provide the botanical affinities for most of these morpho (fossil) taxa, which is reflected in the publication of voluminous handbooks for Neogene palynomorphs.

**Material & Methods:** Recent taxonomic studies, combining LM and scanning electron microscopy (SEM), on the middle Miocene pollen floras of three lignite mines of the Yatağan Basin, Muğla province, Turkey are used to test the effect of different taxonomic treatments of dispersed spores and pollen on biogeographic studies. I provide representative examples for taxa identified either (I) “*overly specific*” or (II) “*too broad*” and (III) as “*form taxa*” including affinities to families not previously considered.

**Conclusions:** An example for (I) are dispersed ruptured papillate Cupressaceae pollen, falling in the morphological range of the fossil (form) species of, among others, *Inaperturopollenites concedipites*, *I. dubius*, and *I. hiatus*; for these, commonly *Taxodium* or *Glyptostrobus* are used for biogeographic inferences, while almost indistinguishable pollen is also produced by extant Sequoioideae, Taiwanoideae, and the remaining Taxodiaceae, *Cryptomeria*. Even when investigated with SEM unambiguous determination is impossible/ only possible in the case of exceptional preservation.

The family Oleaceae (including the Mediterranean olive tree) serves as an example of (II). All Oleaceae share tricolporate and reticulate pollen and in Neogene palynological studies have either not been differentiated or only assigned to three taxa, namely *Fraxinus*, *Olea* and *Phillyrea*. In our investigation we identified at least six different morphotypes, which can be associated either to taxa with Northern Hemispheric (*Fraxinus*, *Osmanthus*), African/Madagascan (*Noronhia*, *Linociera*), Afro- Eurasian (*Olea*) and Eurasian (*Fontanesia*, *Ligustrum*, *Syringa*, *Phillyrea*, *Chionanthus*) distribution. Interestingly, the extant Eurasian genera are represented by a single species in Europe (except for two in *Syringa*), while being quite diverse in eastern Asia.

Eventually, case (III) is illustrated with the fossil genus *Tricolporopollenites megaexactus* commonly reported from Mediterranean palynofloras, the botanical affinities of which have been sought among the tropical to warm temperate Clethraceae (Americas, Caribbean) and Cyrillaceae (Americas, South-east Asia, Madeira). In our investigation all pollen falling in the range of the *Tricolporopollenites megaexactus* morphotype turned out to belong to *Decodon*. This monotypic genus of the Lythraceae today is restricted to temperate eastern North America but its fossil record reveals a more widespread northern hemispheric distribution and a higher diversity during the Paleogene and Neogene. Additional to the middle Miocene presence of *Decodon* pollen in Turkey, recently, seeds of this genus were reported from the early Pleistocene Çameli Basin carpoflora.

Although these are but a few examples they demonstrate the enormous impact of (erroneous) taxonomy on both palaeobiogeographic and palaeoclimatic inferences.

**PANNONIAN OSTRACOD FAUNA FROM PÉCS-DANITZPUSZTA IN S HUNGARY**

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**Objectives:** Present study is focused on Lower Pannonian marly series of Lake Pannon exposed in a sand pit in Pécs-Danitzpuszta. The investigated layers consist of calcareous marls, claymarls and calcareous sands belonging to the the Endrőd Marl Formation. They belong to the Lymnocardium schedelianum mollusc biozone, with an age of ~11-10 Ma. The sequence is heavily tilted, nearly vertical and is conformably overlain by Pannonian sand layers famous for their unique Middle to Late Miocene reworked terrestrial and marine vertebrate remains.

**Methods & Results:** Well preserved, relatively diverse benthic ostracod faunas were recovered from the studied 23 samples. Twenty-one euryhaline benthic ostracod taxa could be identified suggesting a limno-brackish environment with low-energy conditions based on their morphological and ecological characteristics. The ostracod assemblages of the older layers in the studied sequence are dominated by several species of *Candona* s.l. beside *Cyprideis*, *Cypria* and *Loxococoncha* suggesting a mio- to mesohaline (3-9‰), littoral/shallow sublittoral (with ca. 10-15 m water depths) environment. Towards the younger strata the ornamented specimens of the genus *Cyprideis* become dominant beside *Herpetocyprilla*, *Hemicytheria* and *Amplocypris* indicating meso- to pliohaline (5-16 ‰) sublittoral (with 10-80 m water depths) conditions. Based on the biostratigraphical interpretation of the ostracod faunas, the studied section belongs to the *Hemicytheria tenuistriata* Zone of Lower Pannonian.

**Conclusions:** In summary, the sedimentological variability of the sequence and the palaeoecological evaluation of the ostracod faunas indicate a nearshore position of the section during the early Late Miocene and a slight increase in salinity and in water depth towards the open lacustrine depositional environment in this subbasin of Lake Pannon.

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**SYNTHESIS OF METHODS FOR THE STUDY OF STRATA WITHIN THE EASTERN PARATETHYS**

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Geology in the modern sense is a complex science, consisting of a number of ways. Each of them solves its particular problem. This includes research and selection techniques. But any geological study is based on stratigraphy. Thus this geological trend is considered to be fundamental. However, so far there are a number of deposits, which are not easily subject to dissection when using traditional methods and techniques, and thus remain unresolved or wrong based on their research.

Rocks of Maikop series (throughout the territory of their spreading from the foothills of the Carpathian Mountains and to the foothills of Kopetdagh, including Azerbaijan which is considered to be an integral part) are related to one of such hardly dissected complexes. One of the main reasons dealing with the difficulties of stratigraphic studies of Maikop is their poor faunistic characterization and heterogeneity of rocks composing them, as well as significant variability of paleogeographic depositional environment, both in space and in time.

Summing up to what has been said above it should be noted that, that the deposits Maikop series were studied for the first time from the perspective of system analysis that enabled to bring together a large number of methods and techniques. As a result of obtained data there appeared a possibility not only to conduct dissection of Maikop into stratigraphic units, but to study depositional conditions from new positions throughout the territory of Azerbaijan during the Maikop period. Integrated study enabled to use both traditional and non-traditional methods to solve stratigraphic objectives.

The obtained results allowed to consider this lithogeodynamic complex of deposits and almost solve the basic problems of stratigraphy and paleogeography:

- to dissect all studied sections as outcropping and penetrated by wells into stratigraphic units and conduct corresponding correlation between them;
- for the first time compile thickness maps and lithofacies maps for each stratigraphic unit of Maikop;
- to trace that Maikop paleobasin within the territory of Azerbaijan had a special mode of slowly regressing paleobasin during this period of time. It was not a deep as previously thought, but a shallow sedimentation basin- a modern analogue of the Archipelago Sea, in the straits between the islands of which there occurred accumulation of argillaceous sediments.

**CLIMATE-CONTROLLED VARIATIONS IN ORGANIC MATTER SOURCES AND ACCUMULATION DURING THE MESSINIAN SALINITY CRISIS: INSIGHTS FROM INORGANIC AND ORGANIC GEOCHEMICAL PROXIES**

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In basins with deep to intermediate water depths, the progressive restriction of the gateway(s) connecting the Atlantic Ocean with the Mediterranean Sea during the Messinian salinity crisis (MSC) is recorded by organic-rich sediments, which are thought to represent the deep water counterpart of primary evaporites in shallow basins. The deposition of these organic-rich sediments was possibly controlled by astronomically driven climate change, which in turn controlled the source of organic matter, its transport through the water column, accumulation, and final preservation. Because of the lack of macro- and microfossils, the reconstruction of the mutual relationship between climate and the supply and accumulation of organic matter necessitates the integration of cyclostratigraphic, sedimentological, and geochemical investigations.

We studied a sequence of fine grained sediments (organic-rich shales and marls) from the Piedmont Basin (NW Italy), encompassing the onset of the MSC, with a multi-proxy approach including inorganic geochemical (major and trace elements) and organic geochemical (molecular fossils) paleoclimatic and paleoproductivity proxies. The applied methodology allows us to monitor the effects of orbitally-driven climate change on organic matter production and accumulation at the northernmost offshoot of the Mediterranean Basin. The influence of short-term climate oscillations on sediment deposition across the MSC onset is demonstrated by a marked lithological cyclicity (alternation of shale/marl hemicycles), which is in phase with fluctuations of major (Ti, Al, Si, Mg, K) and trace (Zr, Ba) elements. These fluctuations reflect the alternation of humid (shale-dominated hemicycles with low Ti/Al ratio) and arid (marl-dominated hemicycles with high Ti/Al ratio) climate, corresponding to times of insolation maxima and minima, respectively. The fluctuation of inorganic proxies is accompanied by changes in organic carbon content and composition. In particular, the distribution of land-plant derived long chain *n*-alkanes and *n*-fatty acids reveals an overall increasing trend in the MSC deposits, but especially in the shale-dominated hemicycles. We suggest an intensification of terrigenous organic matter input during the deposition of shales (humid phases at insolation maxima), most likely driven by an enhanced riverine runoff. Coeval increases in Ba content (up to 890 ppm), a common paleoproductivity proxy for marine environments, agree with an enhanced nutrient supply during the humid periods, promoting phases of eutrophication in the basin. Molecular fossils pointing to water column stratification (e.g. tetrahymanol, lycopane) were also found in the same deposits.

Our integrated data set from a northern Mediterranean sub-basin provides evidence that organic matter supply and accumulation during the initial phases of the MSC were strongly controlled by climatic fluctuations at a precessional scale. These changes were superposed to the progressive restriction of the basin; such restriction may have favored eutrophication driven by the input of terrigenous organic matter and nutrients. A concomitant effect of basin restriction was the intensification of water column stratification and the establishment of reducing bottom conditions, which were most likely responsible for the decline of eukaryotes.

THE ECOLOGICAL NICHE OF “ROBUST” HIPPARIONS DURING THE LATE MIOCENE AND  
PLIOCENE IN THE BALKANS

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**Objectives:** Hipparions with relatively short and wide metapodials are commonly referred to as “robust”. In the Balkans there are robust hipparions from the Late Miocene (Vallesian) to Pliocene. The Vallesian representatives include the *Hippotherium primigenium* and *Hippotherium sebastopolitatum*, the Turolian forms include the *Hippotherium brachypus* and *Cremohipparion proboscideum*, and the Pliocene representatives include the “*Hipparion*” *crassum* s.l. These forms in some cases are the only equids in the fauna (Nesebar, Vallesian; Milia, Pliocene, MN16a). In other localities, from the late Vallesian (MN10) in Ravin de la Pluie to the end of Turolian and probably Pliocene (MN15), robust hipparions coexist with one to three slender forms, generally smaller in size and more cursorial. Individuals of robust species can be either very rare (e.g. Kryopigi, Ravin des Zouaves-5) or almost equally represented as those of slender species (e.g. Pikermi, Hadjidimovo). We examined the robustness of robust hipparions of the Balkans and the relation of robustness to environmental adaptations.

**Methods & Results:** The term “robust” is defined using the index of robustness (IR) of the metapodials: the ratio of the distal articular width to length (%). In about four hundred 3rd metatarsals from 19 localities and 26 species, the IR ranges from 13.7 to 20.9 (n=192, s=0.95, mean=15.95) for the robust hipparions, and from 9.3 to 15.5 (n=213, s=1.06, mean=12.71) for the slender ones. The observed overlapping indicates that “slender” species also include “robust” individuals and *vice versa*. Discriminant analysis is applied to create a cut-off point. The IR is positively correlated (n=368, slender and robust 3rd metatarsals, r=0.8,  $\alpha=0.05$ ) to body-mass (range 54–489 kg). This means that larger in size hipparions tend to be more robust, although there are remarkable exceptions such as *Hipparion longipes*, which is large but with extremely long and slender metapodials.

To investigate the environmental parameter, the “habitat score” (HS) *sensu* R. S. Scott is estimated for 3rd metatarsals from various Balkan localities. In Vallesian, the hipparion from Ravin de la Pluie appears to be close to the Höwenegg standard, which is a forest dweller, whereas the Nesebar population displays adaptations in more open environment. In Turolian, *C. proboscideum* s.l. is represented by metatarsals that indicate open environment in Ravin des Zouaves-5 and Perivolaki, and more closed environment in Vozarzi. *Hippotherium brachypus* displays HS indicative of relatively closed environment in Pikermi, Strumyani, Azmaka and Kryopigi localities, in contrast to the population of Hadjidimovo, which is similarly robust but seems adapted to a relatively more open environment. During Pliocene, the robust “*Hipparion*” *crassum* s.l. of Milia is clustered with earlier forms of closed environments.

**Conclusions:** The robustness of robust hipparions appears to decrease from Vallesian to Turolian, but increases in the Pliocene where its maximum appears. According to the results, different populations of the same species seem to differ in robustness and environmental adaptations (e.g. *Hippotherium primigenium*), and similarly robust hipparions of the same species (*Hippotherium primigenium*, *Hippotherium brachypus*) can nevertheless be adapted to different environments. *Hippotherium brachypus* inhabited more closed environments, unlike most other slender hipparions.

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MESSINIAN DIATOMACEOUS DEPOSITION IN THE MEDITERRANEAN AND ITS POSSIBLE RELATIONSHIPS WITH THE GLOBAL BIOGEOCHEMICAL SILICA CYCLE

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**Objectives:** Messinian diatomaceous sedimentation in the Mediterranean (~7-6 Ma) has been traditionally interpreted as a prelude to the evaporitic conditions in the marginal basins, resulting from the progressive isolation from the Atlantic Ocean. Nevertheless, during the late Miocene (and the early Zanclean) a remarkable intensification of the biosiliceous productivity globally occurred, reaching its acme between ~7 and 4.5 Ma. This suggests that global scale processes of silica enrichment possibly also controlled the Mediterranean diatomaceous deposition.

**Methods and results:** A comprehensive analysis of recent studies highlighted that terrestrial ecosystems play a fundamental role on the release of dissolved silica from continents to oceans. In particular, grasslands may accumulate, as phytoliths, huge amount of amorphous silica easily convertible in dissolved silica. Through the rapid foliar turnover and the recurrence of grazing and fires, open grassy biomes represent exceptional silica mobilizers, whose contribution to opaline production in the Cenozoic world oceans has been, however, underestimated. The Neogene continental record suggests an intriguing combination of abiotic and biotic factors able to provide a substantial release of dissolved silica to the oceans. In the Mediterranean, such a release was reasonably provided by the wide drainage network of the African continental interiors, where a spread of grassy biomes occurred about 7 Ma, together with intensive monsoonal rainfalls.

Remarkably, Messinian Mediterranean diatomites are often rhythmically interbedded to sapropelitic layers; this sedimentological pattern suggests a prolonged stratification of the water column, induced by the periodical intensification of river runoff, and a consequent bottom oxygen depletion. Such conditions may lead to the proliferation of specific diatom assemblages (the so-called "shade flora") adapted to exploit the deeper part of the photic zone, and to the dissolution of biogenic silica through an increase of alkalinity likely driven by an active bacterial sulphate-reduction. In this context, an interpretative model of sapropel-diatomite couplet is proposed. It is based on i) the conversion of continental-derived dissolved silica into biogenic silica by the shade flora, during periods of intense water column stratification in the basin; ii) the progressive dissolution of diatom frustules on the bottom under anoxic condition, leading to the reconversion of biogenic silica in dissolved silica and the consequent formation of diatom-free sapropel layers; iii) the reinjection of dissolved silica, previously trapped in the lower, anoxic part of the water column, at the surface, through a more efficient remixing of water column; iv) the conversion of the recycled dissolved silica in biogenic silica, and its definitive burial in diatomite layers deposited on a more oxygenated seabottom.

**Conclusions:** We suggest that the early Messinian diatomaceous event in the Mediterranean was promoted by a remarkable increase of silica fluxes from surrounding regions. The periodic intervention of sulphate-reducing bacteria is proposed to explain the diatomite-sapropel couplet.

**MULTIPROXY RECONSTRUCTION OF THE MT. POŽEŠKA GORA (NE CROATIA) LAKE DEPOSITION PRECEDING MIDDLE MIOCENE MARINE TRANSGRESSION OF THE SOUTHERN PANNONIAN BASIN**

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**Objectives:** During the Early-Middle Miocene transition, large parts of the Pannonian Basin in Central Europe were lowlands characterized by fluvial and lacustrine deposition. During the Middle Miocene the region was successively transgressed by the Paratethys Sea. The study area at Mt. Požeška gora in NE Croatia is located in the Southern Pannonian Basin, between the Sava and Drava depressions, close to the Dinaride orogenic belt.

**Methods & Results:** By integrating quantitative mineralogical and palynological data along with semi-quantitative ostracod, mollusk and fish otolith data, we provide a paleoenvironmental reconstruction of the continental series underlying the Middle Miocene marine deposits. The results suggest deposition in littoral to shallow profundal settings of a long-lived, stable, perennial freshwater lake. The succession shows two mud-sand coarsening and shallowing upward parasequences. The smectite- and illite-dominated muddy intervals show an increased (>30%) carbonate component. The sandy intervals bear abundant plant remains and frequent shell accumulations. Conifers dominate the palynomorph spectra; riparian tree and fern spores are intermittently abundant. The topmost sandy interval shows increased abundance of freshwater algae spores. A total of 20 ostracod taxa were detected, dominated by freshwater forms tolerating increased salinities. Seven taxa are shared with Miocene freshwater and brackish deposits of the North Alpine Foreland Basin. We detected 4 fish species, all shared with the latter deposits and including the brackish-marine species *Eleogobius gaudanti*.

**Conclusions:** Based on these data, the brackish-water S Pannonian Lake System is reconstructed with a hypothetical connection to the Central Paratethys along the Mura-Zala Basin. Regional data indicate a middle Miocene age for the studied succession.

**FOSSIL FAUNA OF THE GLOVELIER KARSTIC POCKET**

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**Objectives:** The karstic fillings of Glovelier, known as “La Petite Morée”, are located in the Swiss Jura, near the town of Glovelier. The karstic pocket 1, with thickness of two meters, is placed in the Oxfordian limestone. The fossil remains of the pocket indicate sedimentary influence both from continental and marine environments. The small mammal assemblage indicates a MN4a age, whereas the marine foraminifers and shark point at a Burdigalian age. Thus, the pocket was deposited during the transgression phase of the Upper Marine Molasse and represents one of the rare continental records (equivalent to the Upper Freshwater Molasse) of that time. In fact, the north coast of the OMM Sea was at its northernmost location at that time and the Aquitanian tectonic uplift did not allow the deposition of sediments in the Jura. With both terrestrial and marine fossils, Glovelier is already a unique deposit. Moreover, it was set as the reference locality for the “*Democricetodon franconicus* – *Megacricetodon collongensis*” interval zone. Thus, the aim of this study is to provide more data on faunistic assemblage and the palaeoenvironment.

**Method and results:** Among all Glovelier fissure fillings the most fossiliferous is the pocket 1, which is the focus of the present study. The karstic pocket of two meters height is filled with clay and sandy sediments. The upper 80 cm of the sediments is represented by thin laminated sands with reworked clays from the underlying layers.

New samples of the horizon have been screen-washed and provided more fossil material. The continental fauna of vertebrates is represented by salamanders, frogs, lizards, snakes, turtle, glirids, lagomorphs, cricetids, eomyids and artiodactyls. Aside from them, marine taxa such as fish teeth, shark teeth and benthic foraminifera have been found as well. The fossiliferous layer provides also reworked Mesozoic invertebrate, especially echinoderms and mollusks remains. With its rodent fauna, Glovelier can be considered as one of the first few Early Miocene localities with two cricetid species, after the Early Miocene so-called “cricetid-vacuum”. Among the reptiles, a *Varanus* sp. is present in the fossil assemblage and represents one of the earliest occurrences of the genus in Europe. The rare glirid genus *Simplomys*, considered as an endemic genus from Spain, suggests the presence of a connection with the west.

**Conclusion:** The terrestrial and marine fossils of Glovelier provides a window of terrestrial and marine fossils from the Early Miocene of the Central Europe especially for the Jura region. Among the faunistic elements, Glovelier contains both taxa with Asian affinities (e.g. cricetids, *Varanus*) as well as truly European forms (*Simplomys*). Moreover, a comparison between Glovelier and other European localities of MN4 age will enable a better understanding of the Early Miocene faunistic interchanges and palaeoenvironmental condition. In addition to this, the fossil locality will enlighten the history of the Swiss Molasse Basin during the OMM-OSM transition. Importantly, the presence of some key species also provides an opportunity for the reconstruction of the paleoenvironment and climatic parameters of the late Early Miocene of the North Alpine Foreland Basin.



**GEODETTIC AND SEISMIC CONSTRAINTS ON STRAIN ACCUMULATION ON THE HELLENIC SUBDUCTION ZONE OFF CRETE**

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We use our most recent GPS velocity field and seismic observations to investigate the active tectonics of the Aegean region. The central and southern Aegean Sea, and eastern Peloponnese region, have internal strain rates of  $< 5 \times 10^{-9}$ /yr. The western and eastern sections of the Hellenic Arc have distinctly different motions with respect to the slowly deforming, central Aegean. The eastern part moves towards the trench with rates increasing from central Crete to near Rhodes Island, while the western part has smaller, westward, more trench-parallel motions (i.e., extending the arc) with respect to the central Aegean. A present-day velocity gradient of  $\sim 4\text{--}5$  mm/yr of trenchward motion from west to east occurs in a narrow zone in central Crete. The cause of this apparent gradient is not clear. Recent faulting in central Crete indicates predominantly east-west extension with no pronounced right-lateral faulting. However, there are other clear differences between the two halves of Crete. The western side has generally higher topography and higher rates of incision, forming large canyons in the southwest, and has distinct uplifted paleo-shorelines that have been identified as relating to large earthquakes, the 365 AD, M=8 earthquake being the most recent. Although earthquake damage is reported from Minoan times (1500–1100 BC), no uplifted shorelines identified with specific earthquakes have been reported in eastern Crete. Longer observed seismic travel times beneath western Crete relative to eastern Crete may result from the presence of thick accreted material encroaching on or being subducted at the trench. Subducting low density material would also account for the high topography of western Crete and the permanent uplift of the 365 AD western Crete earthquake shoreline. Assuming that the 5 mm/yr difference in western Crete represents elastic strain accumulation due to differential coupling of the plate interface between eastern and western Crete, episodic release of this strain, seismically or aseismically, may account for the absence of significant strike-slip faulting in central Crete. Given the  $\sim 35\text{--}40$  mm/yr Nubia-Aegean plate convergence rate at Crete, and assuming that the 5 mm/yr differential motion in Crete is due solely to coupling on the plate interface, roughly 10-15% of convergence would be contributing to strain accumulation on the segment of the arc below western Crete. This is consistent with the observed lack of seismic moment release compared to the plate convergence rate over the length of the Hellenic subduction zone.

## A MEDITERRANEAN APPROACH TO DATE THE PARATETHYAN BADENIAN FLOODING IN ROMANIA

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**Rationale:** During the early-middle Miocene the Paratethys Sea was connected with the Mediterranean via several sea straits. Still, the spatial and temporal evolution of the Paratethys Sea in this period is poorly constrained due to the lack of high quality independent age data and the use of different (Atlantic vs Mediterranean) calcareous plankton zonations and biochronology to date important boundaries. This complicates the correlation of key stratigraphic events, such as marine floodings or extinction events, to the Global Time Scale. Recently, we published a chronostratigraphic overview of three marine phases during the early-middle Miocene (Ottangian, Karpatian and Badenian sea) (Sant et al., 2017). We specifically incorporated the most recent Mediterranean biozonations and biochronology to reevaluate and date key Paratethyan successions. This approach resulted in a consistent younger age for the Badenian transgression in most basins of Central Europe.

**Objectives:** Here, we discuss the new overview and present a case study on the marine flooding at the base of the middle Miocene 'Badenian' Sea in the easternmost satellite basins of the Central Paratethys (Romania). We aim to pinpoint the timing and character of the transgression more robustly by integrating the most recent Mediterranean biostratigraphy (calcareous nannoplankton and planktonic foraminifera) with independent dating techniques (<sup>40</sup>Ar/<sup>39</sup>Ar dating and magnetostratigraphy).

**Methods & Results:** Specifically, we sampled the basal succession of the Badenian in five sections; in four of these, we included part of the underlying brackish-continental strata. In all the sections the lower Badenian strata are associated with volcanic clasts and ashes of the Dej/Slanic tuff complex. According to the biostratigraphic data, the marine flooding occurs within the calcareous nannofossil MNN5a zone and () within the planktonic foraminifer MMi4c (*pars*, after the First Occurrence of *P. glomerosa glomerosa*)-MMi5a zones of Iaccarino et al. (2011), narrowing it down to an age interval between 15.15 (Turco et al., 2017) and 14.36 Ma (Abdul Aziz et al., 2008). This timing is in line with new and previous radiometric ages at the base of the tuff complex in the Transylvanian Basin, being around 14.4 Ma (de Leeuw et al., 2013). The pre-flooding sediments are often reworked, but do contain early-middle Miocene calcareous nannofossil assemblages indicating the MNN4a-4c zones of Iaccarino et al. (2011). Therefore, if no large hiatus is present below the flooding base, the underlying continental strata could be >~15.37 Ma.

**Conclusions:** Our new data confirm that the marine flooding reached the eastern part of the Pannonian Basin and Transylvanian Basin after 15.15 Ma. This age calibration of the flooding may differ over 1 Myr if we adopt the low latitude Atlantic biochronology for the First Occurrence of *P. glomerosa* (Wade et al., 2011).

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**THE SULPHUR LIMESTONES FROM THE LORCA BASIN (SE SPAIN): NEW SEDIMENTOLOGICAL AND PETROLOGICAL DATA**

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**Objectives:** The late Miocene pre-evaporitic succession of the Lorca basin is characterized by alternations of marls, limestones and diatomites of the Varied Mb interbedded between the basal marls of the Hondo Fm and the evaporitic unit of la Serrata consisting of gypsum and halite (Geel 1976, Montenat et al., 1990; García-Veigas et al., 1994; Rouchy et al., 1998). This succession records the progressive isolation of the basin during the late Tortonian (Krijgsman et al., 2000). Seven layers of sulphur-bearing limestones are described within the Varied Mb in the central part of the basin and correlated to eight gypsum beds cropping out at the NE margin of the basin (Rouchy et al., 1998). These gypsum beds are preserved as secondary gypsum (after anhydrite) and present nodular lithofacies with chicken-wire textures. The sulphur limestones were considered as the product of diagenetic transformations, driven by bacterial sulphate reduction, of precursor gypsum layers formed in a shallow water basin in response of precessional-driven climate changes and were used to tie the succession to the astronomical polarity time scale (Krijgsman et al., 2000). In particular, the sulphur-bearing limestones were correlated to arid phases at times of precession maxima (insolation minima), when evaporation exceeded precipitations. However, this interpretation contrast with the sedimentological features and the paleontological content of the hosting sediments (marls and diatomites), which provide evidence for a relatively deep marine environment characterized, at least temporarily, by anoxic to dysoxic bottom conditions.

**Methods & Results:** To elucidate the origin of these peculiar layers, we carried out new sedimentological and petrological studies in two sections exposed along the La Serrata ridge. Field observations show that these limestones layers, together with the sediments in which are intercalated, exhibit evidence of sinesedimentary deformation (slumps) and contain intraclasts of various size of diatomites and marls and locally, abundant sponge spicula. In addition, the sulphur bearing limestones occupy different positions in the Varied Mb cycles: some of them are found at the base of the diatomite packets, others at their top or even within the marly intervals. A prominent feature in these diagenetic limestones is the presence of millimetric to centimetric gypsum crystal pseudomorphs included in a carbonate matrix. The origin of the gypsum in the depocenter of the basin can be related to saturate interstitial waters related to periods of water stratification that favors the presence of brines in the deep part of the Lorca basin or to the emplacement of detrital gypsum from older evaporitic units that occurs at the East margin of the basin (Playa et al 2000). In both cases, the mixing of organic-rich sediments and sulphate provided the ingredients necessary for bacterial sulphate reduction reactions, responsible for intense carbonate precipitation.

**Conclusions:** In conclusion, we suggest that the sulphur limestones from Lorca are the product of diagenetic transformation of layers formed in a relatively deep basin and not to gypsum facies deposited in a shallow environment.

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**LATE BURDIGALIAN SEA RETREAT FROM THE NORTH ALPINE FORELAND BASIN: NEW  
MAGNETOSTRATIGRAPHIC AGE CONSTRAINTS**

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**Aim & Method:** Accurate paleogeographic reconstruction of the North Alpine Foreland Basin (NAFB) during the Burdigalian (Early-Middle Miocene) is hampered by a lack of reliable age constraints. In this high resolution magnetostratigraphic study we try to solve a long-lasting age bias for the onset of freshwater deposition in the neighboring S-German and Swiss Molasse Basins. We measured ~600 samples from eleven drill cores covering the transition from marine to brackish to freshwater environments in the S-German Molasse Basin.

**Results & Conclusions:** The magnetostratigraphic pattern based on the highest quality profiles provides two possible age correlation options (model 1 and 2). In model 1, the base of the brackish succession lays within C5Cr (~16.7–17.2 Ma), and the onset of freshwater deposition has an age of ~16.5 Ma. Correlation model 2 suggests the transition to brackish conditions to be within C5Dr.1r (~17.7–17.6 Ma), and yields an age around 16.7 Ma for the shift to freshwater environments. Most importantly, both models argue for a much younger age (~0.7 Myr) for the onset of freshwater deposition than previously suggested, namely a late Burdigalian age of maximum 16.7 Ma. This new age tie point is useful for future biostratigraphic and paleogeographic reconstructions.

**EXPLORING THE FEEDING ECOLOGY AND HABITAT OF THE PRIMATE FROM DAFNERO-3**

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**Objectives:** The aim of our study is to characterize the environmental context and feeding habits of the fossil primate genus *Procynocephalus* from the Early Pleistocene site of Dafnero-3 (MNQ-17), Northern Greece.

**Methods and Results:** The dental microwear textures of herbivores, as plant direct consumers, reflects the vegetal resource availability in the habitat and is therefore a good proxy to characterize paleo-environments. By being plastic deer constitute appropriate taxa for paleoenvironmental reconstructions. Here we explore the dental microwear texture of *Eucladoceros ctenoides* (n=3) and *Metacervoceros rhenanus* (n=6) from Dafnero in order to decipher the paleoenvironmental context of the primate locality Dafnero-3. To do so, our results are compared with those of two contrasted reference populations of extant *Cervus elaphus*. Lugar Nuevo (n=116), Southern Spain and Bialowieza (n=23), Eastern Poland. The wide range of dental microwear textures for both *Eucladoceros ctenoides* and *Metacervoceros rhenanus* from Dafnero, occupying the entire ecospace between the two reference localities reflects the diversity of food categories available in the locality. Most *Metacervoceros rhenanus* occupy a grazing ecospace similar to extant red deer from Lugar Nuevo reflecting the consumption of abrasive herbaceous monocotyledons. In a second time, the dental microwear texture data and 3D enamel thickness (micro CT scan imaging) of the *Procynocephalus* (DFN3-150) are explored in order to better understand the feeding ecology of this taxa in the environmental context of Dafnero-3. Furthermore, two indices that describe the molar flare are measured: molar flare index (**MF**) and dentine flare index (**DFI**). The results are compared with a set of fossil *Papio* specimens (n=75) and 6 primate species with different dietary habits (*Papio cynocephalus* n=27, *Papio ursinus* n=12, *Theropithecus gelada* n=12, *Semnopithecus entellus* n=8, *Gorilla beringei* n=16, *Macaca fascicularis* n=20). The microwear textural characteristics of *Procynocephalus* from Dafnero-3 differ from the extant folivorous primates compared and instead resemble more closely to the textural signal of the omnivorous primates. The comparisons of enamel thickness combined with data from the two indices **MF** and **DFI**, indicate that *Procynocephalus* from Dafnero-3 possessed thick enamel and pronounced molar flare.

**Conclusions:** The wide range of variation of the dental microwear signal from Dafnero deer illustrates the high diversity of available vegetal resources in the habitat. These results are in accordance with previous paleoenvironmental reconstructions that stated that Dafnero was a savannah-like woodland habitat. In that mosaic habitat *Procynocephalus* from Dafnero-3 may have included a wide spectrum of food items from fruits, seeds to herbaceous monocots and dicots depending on spatial and seasonal availability. This is consistent with previous suggestions about the paleoecology of *Procynocephalus* genus from the Upper Siwaliks, India.

**THE SHORT-LIVED GRIP OF THE GLOBAL OCEAN ON THE MIOCENE SEAS OF EURASIA.  
PALEOGEOGRAPHIC EVOLUTION, ENVIRONMENTAL CRISES AND CHANGING INTERACTIONS  
IN THE SEAS OF THE PARATETHYS-MEDITERRANEAN REALM**

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Marine gateways prove to be important factors for changes in the ecology and biochemistry of marginal seas. Changes in gateway configuration played a dominant role in the Middle Miocene paleogeographic evolution of the Paratethys Sea that covered Central Eurasia.

**Approach:** Here, we focus on the connection between the Central (CP) and Eastern Paratethys (EP) to understand the paleoenvironmental changes caused by the evolution of this marine gateway. We first construct an integrated magneto-biostratigraphic framework for the Langhian-Serravallian (Tarkhanian – Chokrakian – Karaganian – Konkian – Volhynian = Lower Sarmatian) sedimentary record of the eastern domain, which allows a correlation to the well-dated successions of C.P.

**Results:** The magneto-biostratigraphic results from the sections in the Eastern Paratethys show that the Kozakhurian/Tarkhanian boundary has 14.8Ma Tarkhanian/Chokrakian boundary has 14.7Ma Chokrakian/Karaganian boundary has an age of 13.8 Ma, the Karaganian/Konkian boundary is dated at 13.4 Ma, and the Konkian/Volhynian boundary at 12.65 Ma.

**Conclusion:** We identify a couple of major phases on gateway functioning that are reflected in specific environmental changes. During the **Tarkhanian**, marine waters flooded Eastern Paratethys terminating a long period of anoxia and open-marine conditions were established briefly. This would correspond to the second Badenian flooding that also brought marine conditions in the eastern half of Central Paratethys in the Early Badenian.

**Chokrakian**, the following stage in E.P., is characterized by the slow disconnection from the global ocean and would correlate with the remainder of the Lower Badenian from C.P. Given that the lower Badenian of C.P. remained fairly well connected to the global ocean the closing gateway must have been located between E.P. and C.P.

The isolation trend culminates in the following stage, the **Karaganian**, when E.P. turned into a lake-sea that supplied a unidirectional flow of low-salinity waters to the west. In the mean time C.P. that was experiencing its Badenian Salinity Crisis (middle Badenian/*Wieliczian* substage). This configuration of this salt factory is remarkably similar to the Mediterranean during its Messinian Salinity Crisis.

A new marine transgression, reinstalled open-marine conditions in the C.P. and led to marine incursions in the E.P. during the **Konkian**. This corresponds with the upper Badenian (*Kosovian*) substage of C.P. where full marine conditions were installed. The connection between C.P. and E.P. proved to weak to pass the marine transgression further east.

Finally the fragmentation of the Paratethys realm ends at the onset of the **Volhynian** (Lower Sarmatian according to the Eastern Paratethys scheme). A new gateway configuration, larger in size, allowed exchange between C.P. and E.P. This led to relatively uniform marine environments conditions all over the Paratethys. At this time the connection to the Mediterranean was weak enough to prevent the continuation of marine conditions in the unified Paratethys. Marine taxa among which corals and echinoderms were lost in a bang and never returned to Paratethys and a new brackish endemic fauna developed instead.

band changes in C.P. It is the last phase in the evolution of Paratethys when sea-level variations, coupled with regional tectonics and local events are the main agents of environmental change. Beginning with the Volhynian, the direct influence of the global ocean on the basin all but disappears giving room to a new phase where climate and moisture transport become the elements that govern the evolution of Paratethys.

**A NOVEL APPROACH TO ASSESS MULTI-CENTENNIAL VARIABILITY IN DEEP-SEA OXYGEN DEFICIENCY IN THE EASTERN MEDITERRANEAN DURING SAPROPEL S5 (EEMIAN)**

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Sapropel S5 sediments deposited under anoxic conditions in the Eastern Mediterranean offer the rare opportunity to assess multi-centennial climate variability during a “warmer-than-present” interglacial (Eemian; ~125 kyr BP), with good age control. Here, we present sapropel S5 data of a piston core from the Nile delta region, which was analyzed through XRF core scanning in unprecedented sub-mm resolution. Specifically we focus on Ba/Ti, Br/Ti, Mo/Ti, as they are proxies for paleo-productivity, marine organic carbon and sediment anoxia, respectively.

A high correlation between our element ratios in core 64PE-406-1 and the oxygen isotope ( $\delta^{18}\text{O}$ ) record of the Soreq cave was found, which is due to the link between sapropel conditions (recorded in the sediments) and Mediterranean Sea surface water freshening (recorded in Soreq- $\delta^{18}\text{O}$ ). We therefore tuned our data to the Soreq cave  $\delta^{18}\text{O}$  record, obtaining an initial age model. A time-frequency analyses indicated significant frequency content in the multi-centennial band, although the frequency components drifted over time. By assuming spectral simplicity (i.e. the signal can be described by a minimal amount of frequency components in the time domain), we can correct for changes in sedimentation rate on a multi-centennial time scale. This novel approach grants a higher resolution age model, calibrated on the comparatively low-resolution Soreq cave  $\delta^{18}\text{O}$  record. The resulting variability in sedimentation rate is similar to records of monsoon variability, indicating a possible link between low-latitude climate and eastern Mediterranean sedimentation. Moreover, the periodicities found in the sapropel XRF time series are similar to the frequency content of Holocene total solar irradiance and sunspot records. Hence, our data suggest that cyclic intra-sapropel variability is likely linked to solar cycles.

**FOLIATED GOUGE ARCHITECTURE AND KINEMATICS OF A LOW-ANGLE NORMAL FAULT IN MENOIKION MT. (NORTHEASTERN GREECE). IMPLICATIONS FOR THE LATE CENOZOIC KINEMATICS IN RHODOPE METAMORPHIC CORE COMPLEX**

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**Objectives:** The present study aims to lit the Late Cenozoic tectonic evolution of the SW parts of the Rhodope metamorphic core complex, which is under constant debate concerning the timing of the basement exhumation. This effort deploys new abundant kinematic evidence derived from the firstly observed foliated gouges of a major, unprecedented low-angle fault separating the metamorphic basement from a referred as Miocene sedimentary cover, which outcrops at the SE sections of Menoikion Mt.

**Methods:** Detailed field observations (up to mm-scale) at two outcrop locations with exceptionally wide (up to 30 m) fault zone, orientation measurements of the fault zone and the foliated gouges, revealed an extraordinary rather than simple structure involving well developed multi-oriented striations, cross-cutting shear planes & shear bands (Riedel shears),  $\sigma$ -type objects, domino and boudinaged structures, asymmetric folds, crescentic fractures, whose orientations have also been recorded. Macroscopically indiscernible striations over silky-glowing planes, confirmed to be present in submillimetric scale, under optical microscope. Observations of the deformation (shear fractures, faults, map-scale folds) of the footwall and hanging wall rocks have also been taken into account in order to be adjoined with the kinematic evidence of the fault zone.

**Results:** Total thickness of the fault zone (damage zones + fault core + transitional zones) varies from 1 up to ~30 meters. It dips gently towards SSE, although its current position might not be the original, due to latter block tilting in the broader area. Basal strata of the hanging wall are truncated. The damage transition towards the intact wall rocks is abrupt towards the hanging-wall, while it's gradual towards the footwall. The presence of survivor blocks, slices and grains is common, dominantly incorporating hanging-wall fragments. The fault core contains at least five major surfaces of intense shearing while the lowest is the most pronounced being about 15 - 30 cm thick. These surfaces have suffered total pulverization (clay gouge) and intense caolinitization which formed sheared globular masses. The striations showed a wide distribution of dipping directions varying from the 75° to 195°. Between these two edges have been distinguished three areas of high pole concentration. In 120°, 170° and 190° with the 170° being the most outstanding. Dip angles varying from 5° up to 50°. Dip directions of the shear surfaces showed similar geometry and distribution, although they are not respectively associated with the striations, e.g. the 120° dipping shear surface is commonly bearing the 170° dipping striation.

**Conclusions:** Present study suggest that the deformed sedimentary cover of Miocene age comprises an allochthon, originating from an area NW from the current. The exceptionally great thickness of the fault zone suggests an intense, relatively long lasting and probably direction-shifting tectonic event. This suggestion is supported by several other observations such as: strong cluster of striation strikes and high angles of R shears indicating their formation within an already friable rock (low  $\phi$  angle value) context. The kinematic data (top-to the SE) do not support the association with the Strymon detachment (top-to the SW) and thus Menoikion Mt. area should further be studied under this new perspective.



**GEOHERMAL CONDITIONS AND HYDROCARBON GENERATION AT THE WESTERN FLANK OF THE SOUTH CASPIAN BASIN, AZERBAIJAN**

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**Objectives:** The study reports results of 2D modeling of the hydrocarbon systems within the western flank of the South Caspian Basin (SCB) for determining the geothermal conditions of hydrocarbon generation. The main objective is identifying the hydrocarbon generation interval and the potential source rocks which could contribute in oil and gas reservoirs of Productive Series of the Lower Pliocene.

The South Caspian Basin is an area of sustainable compensated subsidence with very high sedimentation rates, especially during Pliocene-Quaternary time. The western flank of SCB is the most subsided part of the basin with the thickness of sedimentary cover reaching 25-30 km, 10-11 km of which are of Pliocene-Quaternary age. Due to rapid subsidence and high sedimentation rates the sediments did not have enough time to heat up and they are staying in abnormally low thermal conditions to the depth of 6-8 km.

**Method and results:** Existing geological, geothermal and geochemical database from oil and gas fields in the study area have been analyzed and integrated into modeling. Palynological analyses of rocks, oils and formation waters have been performed and compared with geochemical data. Several cross-sections along the western flank of SCB have been chosen for modeling of burial, thermal, maturity and hydrocarbon generation histories of sedimentary cover from Jurassic to Present.

Analysis of thermal models showed the degree of heating of different stratigraphical complexes at different geological periods and at present day. Geothermal models were calibrated by temperatures and by vitrinite reflectance values measured in wells. Modeling of thermal history indicates that the temperature development is regular and corresponds to the tectonic architecture of the region. A low temperature gradient and heat flow cause the extremely extended oil and gas generation windows from 5 to 16.5 km, including the full range of hydrocarbons generated. The reconstruction of the burial and thermal history shows the degree of maturity of the Meso-Cenozoic complexes of rocks. So, the section including the Cretaceous rocks up to the lower part of Low Pliocene rocks are involved into the oil and gas generation windows. Jurassic rocks are overmature and the rocks above the lower part of Low Pliocene are immature. So, results of modeling suggest several stratigraphically, hypsometrically and laterally isolated pots of hydrocarbon generation in Eocene, Oligocene-Miocene and Low Pliocene deposits. These intervals can be considered as a main source rocks in the studied area. The results of modeling correspond to the geochemical and palynological data.

Results of modeling of evolution of HC generation pots allow estimation of the degree of HC generation potential realization of the source rocks with different geochemical characteristics. Results of modeling suggest that at present Eocene rocks realized 40-50% and 80-90% of their HC potential at the flank and at the subsided part, accordingly. Degree of HC potential realization of Oligocene-Lower Miocene rocks is 20% at the flank and reaches 60-70% with subsidence. Middle and Upper Miocene rocks realized only 20-25% of their HC potential.

**Conclusions:** Results of investigations suppose existence of the much extended hydrocarbon generation interval within the western flank of the South Caspian Basin. Burial pattern and low geothermal gradient suggest the very favorable conditions for the full zonality of hydrocarbon generation, including the dry gas generation zone. The Eocene and Oligocene-Miocene rocks have different degree of maturity depending on depth and they are the main source rocks in the region according to geochemical and palynological characteristics and results of basin modeling. The geothermal conditions are very favorable for preserving the oil and gas accumulations up to the depth 8-9 km.

**PALAEOVEGETATION OF THE YATAĞAN-TINAZ BASIN (MUĞLA-TURKEY) IN THE MIDDLE MIOCENE**

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**Objectives:** The sedimentary deposits contain the plant remains investigated formed in a lacustrine depositional setting and most of these sediments contain lignites. This study is based on detailed palaeobotanical investigations of middle Miocene coal deposits exposed in the Southwest Aegean region. Specifically, field work was conducted in Muğla, Yatağan-Tınaz and surroundings. We examined the macro fossils as a part of the paleovegetation. Furthermore, an aim was to sample and protect the well-preserved leaf fossil flora that is currently threatened by extensive coal mining in the Tınaz coal mining area.

**Methods & Results:** Palaeobotanical samples were collected from the Sekköy formation that contains the main coal seam at the bottom and marls in the upper parts. 1132 identifiable macrofossils were collected from marls of the Sekköy formation. In these samples, 13 algae, 2 fern, 23 gymnosperm and 1094 angiosperm fossil samples were identified. Gymnosperms comprise 3 taxa of 2 families, angiosperms comprise 76 taxa of 13 families (2 of them are monocots, 74 dicots). Totally 300 specimens could not be identified and remained indeterminated.

According to the macro floral studies and IPR (integrated plant record) analysis, during the middle Miocene, the Tınaz basin enjoyed a temperate zone climate that fostered temperate broadleaf deciduous forests.

**Conclusions:** We suggest that during the middle Miocene in the Tınaz Basin river-fed marshes and riparian forests thrived while broadleaf deciduous forest was present in the surroundings of the basin. Furthermore, the macro flora reflects humid temperate climate conditions. These temperate conditions are in concert with the numeric climate values and the palynoflora of the basin.

**OS PETROSUM EXTERNAL MORPHOLOGY OF THE ENDEMIC *HIPPOPOTAMUS CREUTZBURGI*  
FROM THE ISLAND OF CRETE, GREECE**

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**Objectives:** The petrosal bone as part of the auditory apparatus represents the inner part of the auditory system, where the sound is conducted through the middle ear and in particular the three ossicles. It is also responsible for the sensory systems of balance via the bony labyrinth, located inside the petrosal bone. This study focuses on the petrosal bones of *Hippopotamus creutzburgi*, based on material excavated from the Pleistocene locality of Anaskama at Katharo plateau, located at the eastern part of the island of Crete.

**Methods & Results:** The external morphology of the *H. creutzburgi* os petrosum emerged from the description of eight fossilized petrosal bones. This research focused on the description of the tympanic external surface of the petrosal bone and the cerebellar surface, which is the side of the periotic facing the cranial cavity. Some of the specimens were fragmented in such way that allowed us to define a few internal structures, such as the position of cochlea and the number of its coiled turns. The results presented here, even though preliminary and hampered by the preservation of the samples, can highlight specific adaptations of *H. creutzburgi*, as the petrosal bone can provide information on locomotive behavior and auditory perception. We expect that in comparative analysis with other species a fully description of its functional morphology can be extracted, as the structures described here vary from species to species in terms of size and shape.

**Conclusions:** The *Hippopotamus creutzburgi* petrosal bone has never been properly described before. The present effort to map the structures of this bone is the basis of a research that will lead to a full description of the species inner ear components, both externally and internally. Such a study will provide valuable information for future comparisons with other endemic mammals, especially from the Mediterranean region.

**Keywords:** inner ear, petrosal bone, *Hippopotamus creutzburgi*, Crete, endemic

**THE INNER MORPHOLOGY OF PETROSAL BONE OF INSULAR MAMMAL: *ELEPHAS TILIENSIS*,  
WITH THE USE OF MICROCT**

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**Objectives:** The petrosal bone houses the bony labyrinth which represents the sensory systems of balance and hearing. While the overall structure of the bony labyrinth is very hard to be identified, with microcomputed tomography the study of these structures has become possible. The purpose of this study is to visualize and quantify precisely the complex inner ear structures of insular mammal *Elephas tiliensis*.

**Methods&Results:** This study focuses on imaging the shape of the cochlea as well as its semicircular canals, based on three petrosal bones of *Elephas tiliensis* that were imaged with microCT and processed with Avizo 8.1. Shape and size analysis of the cochlea allowed us to assess morphological differences between species and the abilities that can offer to each one. The significance of the semicircular canals can be found on the basis that as part of the vestibular apparatus of the inner ear, they are involved in the detection of angular motion of the head, for maintaining balance and movement behavior. Specifically, measuring the dimensions of inner ear components as well as the angular distances can express the variation in their balancing abilities and the frequencies of their auditory perception.

**Conclusions:** The microCT made possible to extract the morphological characteristics that lead to an animal with little agility and low frequency ranges. We are inclined to believe that the approach presented here has great potential in future studies as high resolution computed tomography has become a vital technique to study fossils and their internal structures in particular.

This research is financed by Greek national funds of Special Account of Research Grants of National and Kapodistrian University of Athens (NKUA 70/3/10323)

**Keywords:** microtomography, 3D modelling, inner ear, petrosal bone, *Elephas tiliensis*, bony labyrinth.

**OBSERVATIONS ON THE INNER MORPHOLOGY OF OS PETROSUM OF *PHANOURIOS MINOR*  
WITH THE USE OF MICRO CT**

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**Objectives:** The inner ear, housed in the petrosal bone, is correlated with the sensory systems of hearing and balance. The purpose of this study is to represent these internal structures in three dimensions and interpret them, using high resolution computed tomography.

**Methods & Results:** This research focused on imaging the shape of the cochlea and its semicircular canals based on four petrosal bones of *Phanourios minor*, excavated from the locality of Ayia Napa of Cyprus. These petrosal bones were scanned with microCT and processed with Avizo 8.1 software. The 3D representation of these specimens allowed us to assess the morphology of the bony labyrinth, responsible for the balance of the animal, and the range of the hearing frequencies. Especially, measuring the angular distances and the dimensions of inner ear structures describes the variation in each species balance abilities and the different ranges of frequencies they were able to hear. The analysis of the shape and size of the bony labyrinth also provided the information about the coordination of the head movement and revealed whether this animal was agile or not. Comparisons with previous studies and also with the study of postcranial material give an insight to its locomotion behavior.

**Conclusions:** Even though, there is little known about the petrosals of *Phanourios minor* and its morphologies, microtomography facilitates things nowadays, and results into a medium slow agile animal with low frequency hearing range adaptations. So, previously unknown morphological information can be obtained through this method, as it has great future potentials.

This research is financed by Geological Survey of Cyprus (NKUA 70/3/12637)

**Keywords:** microtomography, inner ear, petrosal bone, *Phanourios minor*, bony labyrinth

**STUDY OF *CRICETODON* (RODENTIA, MAMMALIA) FROM THE LOWER MIOCENE LOCALITY OF KARYDIA (RHODOPE, NORTH GREECE)**

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**Objectives:** Two of the richest MN4 assemblages with small mammals in Greece come from the localities of Karydia (Northern Greece) and Aliveri (Euboea island). Both localities include taxa dating from the Lower Miocene, associated with humid conditions. One of the common genera in these localities is the rodent *Cricetodon*. This genus is represented in Aliveri locality by *Cricetodon aliveriensis*. However, the same species was mentioned in Karydia, but has never been confirmed. The subject of this study is to record and describe the material of this genus from the Greek locality of Karydia and to prove whether it belongs to the same species.

**Methods & Results:** All material was collected by wet screening on a set of sieves with the finest mesh used being 0.5 mm. The collection from Karydia and Aliveri localities is stored in the Faculty of Earth Sciences of the University of Utrecht. It includes specimens of *Cricetodon* from Karydia 1, Karydia 2 and Karydia 3. A detailed description of the morphology and numerous statistical methods confirmed that the *Cricetodon* material from the three fossiliferous localities, Karydia 1, Karydia 2 and Karydia 3, represents one species. As a result, it has been merged into one sample (Karydia). The comparison of the *Cricetodon* from Karydia and Aliveri confirms the presence of *C. aliveriensis* in the former locality. However, *C. aliveriensis* from Aliveri appears to be smaller and more primitive than that from Karydia. Moreover, *C. aliveriensis* has been compared with the Anatolian species of *C. kasapligili* from Yapinti, *C. versteegi* from Kinik, *C. aff. kasapligili* from Sabuncubeli and *C. aff. versteegi* from Kargi. From these species, *C. kasapligili* from Yapinti and *C. aff. kasapligili* from Sabuncubeli are closer in dimensions to *C. aliveriensis*.

**Conclusion:** This work includes the first description of *C. aliveriensis* from the locality of Karydia and will contribute to any future comparison with other species from Karydia or other localities so that the Early Miocene of Greece, especially in the study of micromammals, can be described in more detail. Karydia's *C. aliveriensis* will expand the paleontological database, will help to clarify the paleontological gap between SE Europe and Anatolia during the Early Miocene and will finally shed light on the migration events that took place between these geographical areas.

**Keywords:** Micromammals, *Cricetodon aliveriensis*, Karydia, Greece, MN4

**EARLY MIOCENE MICROGASTROPOD ASSEMBLAGES FROM THE THE EASTERN MEDITERRANEAN AND THEIR PALEOENVIRONMENTAL SIGNIFICANCE**

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**Objective:** Microgastropod assemblages are studied here with an aim to assess the molluscan biodiversity of the proto-Mediterranean, as well as understanding the ecological characteristics and biogeography of the faunas.

The early Miocene was a time of climate change and paleogeographic reorganisation, which have stimulated the radiation of certain taxonomic groups of gastropods (*i.e.* Melanopsidae). Data concerning molluscan faunas from the earliest Miocene of the Mediterranean is quite scarce, therefore the present work is trying to implement the fossil record and better understand the processes that were at work during the beginning of the Neogene.

**Methods & Results:** A new section of Aquitanian age was sampled; the samples were then sieved using 125 and 250 µm sieves in order to retrieve both microfossils (foraminifers etc.) and molluscs. Gastropods were picked from the sediment and their taxonomic diversity was analysed, whereas benthic foraminifers were used for supporting paleoenvironmental results.

Two assemblages were found: a low-diversity brackish/lagoonal assemblage and a high-diversity shallow marine assemblage. Common species from the Paratethys, the north-eastern Atlantic and the Mediterranean in Turkey (where the Aquitanian is poorly documented) were found such as *Vitta picta*, *Granulolabium plicatum*, *Mesohalina margaritacea*, *Sandbergeria perpusilla* and *Ringicula minor*. The largest taxonomic diversity was found in the marine assemblage, within the family Pyramidellidae comprising 12 species belonging to 6 genera. The most abundant gastropod in the same assemblage was the cerithid *Bittium larrieyense*.

**Conclusions:** 13 species are reported in Greece for the first time for the Aquitanian. The proto-Mediterranean Sea seems to have had still many species in common with both the Paratethys and the north-eastern Atlantic. This suggests a rather homogenous "western-Tethyan" bioprovince that persisted during the warm lowest Miocene.

**CORAL DIVERSITY AT THE PALEOGENE-NEOGENE BOUNDARY IN THE EASTERN MEDITERRANEAN (MESOHELLENIC BASIN, NW GREECE)**

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**Objective:** The transition from the Oligocene to the Miocene marked a climatic transition from Greenhouse to Icehouse; this resulted in a change of the biogeography of reef corals in the Mediterranean Basin. In Greece, scleractinian corals from the Oligocene of the Mesohellenic Basin have been studied in the past mainly for assessing their taxonomic diversity. The goal of the present work is to compare the coral diversity of the Oligocene to the Miocene fossiliferous locations of the Mesohellenic Basin (Grevena area, NW Greece) at the species and generic levels.

**Methods & Results:** Samples from the Chattian (Late Oligocene) and the Aquitanian (Early Miocene) from two localities (including one new) were studied as to their taxonomic diversity. A total of 26 species were found, 16 are present in the Chattian and 11 in the Aquitanian. The generic diversity as well as the specific diversity was compared to faunas from the Eastern Mediterranean (Italy, Turkey, and Egypt). Generally, a decrease in coral diversity is observed through the Paleogene-Neogene boundary; also, large reefs are absent in the Miocene of the Mesohellenic Basin.

In the Oligocene, the most diverse family is the Faviidae with 7 species. This family is also present in the Miocene, where *Tarbellastraea*, *Porites*, *Favites* are also present. These genera are amongst the most common genera for the Miocene of the Mediterranean.

**Conclusions:** As reported in previous works, in the Mediterranean, coral diversity decreased during the Aquitanian, before reaching its maximum diversity for the Neogene during the Burdigalian. Maximal coral diversity is reached during the warming that occurred during the Late Oligocene, which is in accordance with our results. The samples treated in the present work report of the break and climatic turbulences from the Oligocene to the Miocene are depicted in a decrease in coral diversity. The Chattian well-preserved reefs do not have equivalents in the Aquitanian, and although taphonomic factors may interfere, taxonomic diversity is clearly lower for the Aquitanian.



**A TERRESTRIAL PERSPECTIVE ON THE EARLY-MIDDLE PLEISTOCENE TRANSITION FROM SOUTHERN ITALY POLLEN RECORDS**

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**Objectives:** Palynological analyses in the marine Montalbano Jonico succession (MJs; Southern Italy) were carried out, in the interval between ~890 to ~650 ka, to provide: i. the documentation of past interglacials which is key for understanding the present interglacial, and for anticipating the future effects of global climate change; ii. direct land-sea comparisons which allow reliable stratigraphic reconstructions and the chronologic definition of marine and terrestrial events. iii. a contribution to improve the selection of the Middle Pleistocene reference section (GSSP) iv. quantitative data for both numerical modelling of past climate and the reconstruction of the main climate parameters.

**Methods & Results:** At the MJs, pollen analyses (150 samples with more than 120 taxa detected) carried out in the frame of multi-proxy researches document changes in floristic and vegetational assemblages which are interpreted in terms of major environmental and climate modifications at the orbital and sub-orbital scale. Interglacials (MIS 21, 19 and 17) are expressed by the dominance of a mesophilic vegetation typical of a (warm) temperate and relatively humid climate. Deciduous *Quercus* dominated fully temperate arboreal forest already devoid of subtropical taxa; however, a number of relict tree genera is still present, and there is no evidence of clear patterns of extinction. Millennial to sub-millennial-scale climate variability is evidenced by several short-term pollen events usually characterized by the dominant increase of the cosmopolitan herbaceous component. Those within MIS19c, for example, have been evaluated in terms of the linkage with changes in geomagnetic field intensity close to the Matuyama-Brunhes paleomagnetic boundary as well as of intra- interglacial variability (e.g. harmonics of precession band oscillations). Wooded steppes to steppes expanded during glacials (MIS 22, 20 and 18) when cold and dry conditions prevailed. Glacials are punctuated by warming events which apparently reproduce the last Glacial Dansgaard–Oeschger (D-O) cyclicity. The significant cold and arid climate phase in the late MIS 20 fits Termination IX whose significance in the North Hemisphere is underlined by prominent peaks of North Atlantic ice rafted debris and Mediterranean aeolian dust.

**Conclusions:** In the area between 39-40°N and 16-17°E, the documentation of nearly two millions years of climate variability, including more than 45 G/I cycles, from MIS 97 is now available. This composite climatic record is one of the longest obtained from Quaternary sediments in the central Mediterranean region, a key area for studying past and present climate changes.

MILLENNIAL-SCALE VARIABILITY AND PLANKTONIC FORAMINIFERA DURING TERMINATION V  
IN THE WESTERN MEDITERRANEAN (ALBORAN SEA)

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**Objectives:** The MIS 12-11 transition (Termination V) links the most extreme glacial of the last 500 ka with the longest-lasting warmer interglacial of the last 1.0 Ma. This study aims to reconstruct climate variability during Termination V in the western Mediterranean.

**Methods & Results:** We performed quantitative planktonic foraminifer analyses at ODP site 977 in the Alboran Sea. Sea surface temperatures were calculated for different seasons based on Artificial Neural Networks (ANN). This SST record was compared with the alkenone-based SST record from the same samples and with the stable oxygen isotope record measured in *Globigerina bulloides*. Fluctuations in surface water d18O were calculated correcting the *G. bulloides* d18O record for ice volume changes and SST effects, using the SST derived from neural networks. The SST record obtained in this study was compared with other records from the Atlantic and Mediterranean.

Species typically living today in subpolar and polar regions, such as *Neogloboquadrina pachyderma* sin and *Turborotalita quinqueloba*, were abundant during the last part of MIS12, especially during two episodes that are probably equivalent to Heinrich-stadial events. A pronounced and sharp warming event was observed between 425 and 423 ka, during which subpolar-temperate planktonic foraminifers were replaced by subtropical and tropical species, such as *Globorotalia inflata*, *Globigerinoides ruber* (white and pink), *G. scitula* or *Globigerinoides sacculifer*. In the middle part of MIS 11 at around 410 ka, deep-dwelling species, *G. truncatulinoides* (sinistral) and *G. inflata*, increased their abundances replacing *G. truncatulinoides* (dextral) and *N. pachyderma* (dextral).

**Conclusions:** This event is similar to that observed in the Holocene, around 8 ka ago, suggesting a higher influence of the Azores Current at the entrance of the Mediterranean. The regional temperature gradients can be originated by changes in meridional ocean heat transport.

**HOLOCENE CLIMATIC VARIABILITY IN THE SOUTHERN TYRRHENIAN SEA  
(GULF OF PALERMO)**

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**Aims:** The main goal of this study is the paleoclimatic reconstruction of the southern Tyrrhenian between ~ 9.2 and 2.9 ka through the study of the planktonic foraminiferal assemblages and stable isotopes, comparing data with other coeval intervals.

**Methods and Results:** A sedimentary core (196 cm long) was collected in the Gulf of Palermo at 990 m bsl and sampled every 2-cm. Micropaleontological and geochemical analyses were performed in 98 samples, and three AMS <sup>14</sup>C dating were measured. The calibrated AMS <sup>14</sup>C ages, together with planktonic foraminiferal fluctuations and *Globigerina bulloides* oxygen isotope record, were used to develop an age model of the studied interval. Twenty species and eco-morphotypes were recognised in the planktonic foraminiferal assemblage and grouped on depending their climatic and feeding affinity. The warm-water species, minus the typical cold-water species, were used to obtain the paleoclimatic curve, whilst the herbivorous/carnivorous ratio has permitted to reconstruct the trophism of the southern Tyrrhenian. In particular, during between ~ 9 and 7.5 ka, an important warming phase was recognised, well indicated by the increase of *Globigerinoides* gr. *ruber* and *G. gr. quadrilobatus*. This interval corresponds to the deposition of Sapropel S1-equivalent stage, when high SSTs and oligotrophic conditions characterised the entire Mediterranean region. *Neogloboquadrina pachyderma* and *Turborotalita quinqueloba* are the best cold-water indicators that increase in abundance during the *Bond events* (B2, B3, B4, B5, B6) and other rapid cooling events (WM3, WM5, WM7; TC2, TC3, TC4) that characterised the western Mediterranean during the 9.2-2.9 ka interval.

**Conclusions:** Planktonic foraminifera and oxygen isotope variations highlight the climatic oscillations of the relatively stable Holocene stage. These oscillations are linked to the North Atlantic millennial scale climatic variability, that forced cool/high productivity periods and warm/oligotrophic conditions.

**BIOSTRATIGRAPHICAL PRECISION OF THE OLIGO- MIOCENE SERIES OF CAP NEGRO,  
NORTHERN TUNISIA**

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A multidisciplinary approach based on micropaléontology, biostratigraphy and facies sedimentology has been applied to the study of the Oligocene- lower Miocene series of the Cap Negro cross sections in northern Tunisia in order to establish a biostratigraphic and chronostratigraphic division of the numidian flysh in the Mogods chain.

This study was carried out on samples from the predominantly marly series of Sidi Mechreg section and flyshoid one of Cap Negro. In this area deposits have proved to be very rich in foraminifers and ostracods.

Based on the abundance and stratigraphic distribution of planktonic foraminifer's species in the different lithological units, we have been able to establish a fine biozonation in this area and to compare with the general scheme of the Cenozoic chart. Seven planktonic zones are recognized: five zones in Oligocene and two in Lower Miocene (Aquitanian).

Micropaleontological analysis shows the occurrence of about 200 species of microfossils in these formations (benthic, planktonic foraminifers and ostracods). While in Cap Negro section, only agglutinated foraminiferal assemblage are recognized. Analysis of agglutinated foraminifera revealed a unique and diverse Oligocene –Miocene fauna that is described for the first time in Tunisia.

The benthic foraminifers of Sidi mechreg show an upper bathyal depositional environment, with a paleobathymetry included between 200- 500 m. While Cap Negro section was deposited at middle to lower bathyal and probably abyssal palaeodepths.

**MONITORING OF CLIMATE OSCILLATIONS IN THE MEDITERRANEAN SEA OVER THE LAST TWO MILLENNIA USING PLANKTONIC FORAMINIFERA**

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**Aims:** This work is part of the NextData project and the main goals are: i) the paleoclimatic reconstruction of the last millennia in the Mediterranean Sea; ii) the biotic and abiotic characterization of possible paleoanalogs of the present day climatic conditions; iii) the reconstruction of the sea surface temperature (SST) from marine fossil archives over the last two millennia by using planktonic foraminiferal and stable isotopes oscillations.

**Methods and Results:** The present study focused on the composite marine sequence of the core SW 104\_ ND2, 117 centimeters below the sea floor (cmbsf) length, and core ND2, 452 cmbsf length, recovered in the eastern part of Sicily Channel, at 89 m water depths during the NextData 2013 oceanographic expedition onboard of R/V URANIA-CNR. The correlation between cores SW 104\_ ND2 and ND2 is based on the planktonic foraminiferal distribution patterns and a composite record of 463 cm has been obtained.

The two cores were studied sampling every 1cm, and contain a well-preserved and continuous stratigraphic record. Several AMS <sup>14</sup>C radiocarbon analysis and radionuclides <sup>210</sup>Pb and <sup>137</sup>Cs analysis were used to obtain the age model of the studied interval. Based on the radiometric ages, the studied marine record covers the last 1400 yr, thus the high sedimentation rate provides an excellent dataset to reconstruct the Mediterranean climatic variability.

Twenty planktonic foraminiferal species were recognized and grouped in relation to their specific environmental characteristic according to the purpose of this study. In particular, the planktonic foraminiferal paleoclimate curve was constructed following Capotondi et al. (2016) to document the main climatic oscillations recognized in literature over the last 1400 yr in the central Mediterranean Sea. It represents the algebraic sum of warm water species percentages (expressed as positive values) and cold-water species percentages (expressed as negative values) based on ecological preferences and modern habitat characteristics.

The paleoclimatic curve shows an alternation of cool and warmer periods, and the abundance fluctuations of *Globorotalia truncatulinoides* and *G. inflata* reflect the sunspot variabilities. The obtained curves were compared with the Total Solar Irradiation (TSI) of Steinhilber et al. (2012) and with the paleoclimatic curve of the Santa Barbara Basin (Fisler et al., 2008).

**Conclusions:** Several climatic periods were identified (ie. the Dark Age, the Medieval Cold Period, the Medieval Warm Period and the Little Ice Age with the Wolf, Sporer, Maunder and Dalton cold events). Finally, the Sicily-Malta continental platform is an excellent marine area to resolve the climatic evolution of the last 1400 years in the central Mediterranean and provides excellent natural archives for past climate reconstruction.

**MIDDLE MIOCENE CONNECTIVITY OF THE EASTERN PARATETHYS: A STRONTIUM ISOTOPE RECORD**

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**Objectives:**

To reconstruct the connectivity of the Paratethys during the Middle Miocene

**Methods & Results:**

In (semi-)isolated basins strontium isotope ratios ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) are excellent recorders of variations in the input and mixing of different water masses. For example, strontium isotopes from the Mediterranean Basin during the Messinian Salinity Crisis (5.97-5.33 Ma) markedly shifted from values typical for a (well-mixed) global ocean to ratios indicative for local inputs recording the restriction of the Mediterranean from the Atlantic Ocean.

The land-locked Paratethys provides also an excellent setting where strontium isotopes can be used to study the connection of this sea with the global ocean and the connectivity among the different sub-basins. A connection with the open ocean would result in  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios that are extremely close to oceanic values, while an exclusively fresh water supply would be reflected in values typical for the local inputs, such as rivers and/hydrothermal vents.

Here we present new strontium isotope data measured on mollusks from the Belaya section in Southern Russia, Ciscaucasia, which provide insights in the connectivity of the Eastern Paratethys during the middle Miocene (15 – 12 Ma). This time interval includes the regional Tarkhanian stage (2 samples), Lower Chokrakian (7 samples), Upper Chokrakian (2 samples), Karaganian (4 samples), Konkian (9 samples), and Volhynian substage (2 samples).

**Conclusions:**

**Sr-ratios of the Paratethys reflect very well changes in basin connectivity.**

SIZE DECREASE OF CALCAREOUS MICROFOSSILS AT THE BEGINNING OF THE MESSINIAN SALINITY CRISIS

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**Objectives:** The Messinian salinity crisis (MSC) is a short lived (5.97-5.33 Ma) dramatic paleo-oceanographic event occurred in the Mediterranean area as result of the reduced hydrological connection with the Atlantic ocean. The beginning of the MSC, marked by the deposition of gypsum in the marginal basins, triggered an immediate response of the biota, and particularly of the calcareous microfossils. In detail, the first 21 kyr of the crisis were characterized by very peculiar calcareous nannofossil and foraminiferal assemblages preserved in the first Primary Lower Gypsum (PLG) cycle (*Sphenolithus abies*, *Umbilicosphaera rotula*, and *Rhabdosphaera procera* peaks, *Globorotalia scitula* and *G. suteri* peaks; Lozar et al. in press). Also, in the lower PLG cycles some foraminiferal taxa exhibit a sharp size decrease (e.g. *Turborotalita quinqueloba*), (e.g. Cita et al., 1978; Corbi et al., 2016), the significance of which is still unclear. However, no information regarding the size of the calcareous nannofossils is available so far.

**Methods & Results:** Samples from three sections cropping out in the Piedmont Basin (northern Italy) and straddling the MSC onset yielded the *Sphenolithus abies* specimens measured for this work. Total length and basal width of the specimens were measured. The basal width sharply decreases from the MSC onset upward, whereas total length does not follow a regular trend. As for other calcareous microfossils, among the foraminiferal assemblages from the same cycles, the >125 µm fraction is devoid of foraminifers, whereas the 45-63 µm and 63-125 µm fractions contain abundant *Turborotalita quinqueloba* and minor *Bulimina* spp., thus showing a sudden size decrease in the cycle where most foraminiferal taxa abruptly disappear (Violanti et al., 2013). The disappearance of foraminifers and nannofossils at the beginning of the crisis was traditionally related to a sharp salinity increase, in turn responsible for the deposition of the evaporites recorded in the marginal basins of the Mediterranean Sea. Conversely, the size decrease among calcareous nannofossils and foraminifers described in this study suggests that the surface water was characterized by high nutrient supply, possibly derived by increased runoff from the continent. The eutrophication is also supported by the presence of *Umbilicosphaera* spp. blooms, a calcareous nannofossil genus considered to better flourish when nutrient supply is high, by the presence of diatom frustules, and by other independent geochemical data (e.g. high Ba concentration; see Natalicchio et al. this volume).

**Conclusions:** The calcareous microfossil assemblage and their size decrease recorded in this study thus suggest that the beginning of the MSC was characterized by high nutrient input to the basin, possibly derived by increased runoff from the continent.

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**POSSIBLE RECORD OF A NEW *HIPPOPOTAMODON* (SUIDAE, MAMMALIA) FROM  
ÇORAKYERLER (LATE MIOCENE), CENTRAL ANATOLIA**

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**Introduction:** Çorakyerler vertebrate fossil locality was discovered during the “Lignite Deposit Exploration in Turkey” project in 1969. It is located on the road of Yapraklı district of Çankırı province in Central Anatolia. Çorakyerler hominoid locality is one of the most diverse faunas from the Anatolian Late Miocene (Early Turolian). Nearly 3500 fossil material have been discovered from the site and %3 percent of these materials belong to suidae specimens.

**Objectives:** Because of morphometric and morphological characters, Çorakyerler suid specimens have been assigned to *Hippopotamodon major*. However, the recently discovered partial mandible specimen is complicated and, to this respect, a new question is emerged: Is there a second suid species? This study aims to analyze the fossil material with number 18CO-3396 with its overall aspects.

**Methods:** In the context of study, morphometric and morphological analyses are conducted. 18CO-3396 numbered partial mandible is compared with Eurasian Late Miocene localities. Comparative dimensions were obtained from the literature and our own measurements. Bivariate plots and principal components analyses (PCA) have been done.

**Discussion and Conclusion:** Vallesian form *Hippopotamodon antiquus* differs from Turolian suids because of their wider and longer cheek teeth. There are no serious morphological differences between *Hippopotamodon* species in terms of the cheek teeth. At this point, morphometric studies become important. Çorakyerler suids have a wide variation range and some specimens are among the largest European *Hippopotamodon major*. The molars and the p/4 of 18CO-3396, which is the subject of this study, falls within the range of variation of *Hippopotamodon antiquus*, while the whole characters of the anterior premolars (p/1-3) are in accordance with *Hippopotamodon major*. In conclusion, such a record has never been defined in any of the localities of Anatolia. New suinae record from Çorakyerler, as possibly hosting a Vallesian relict, will be helpful to analyze of *Hippopotamodon* lineage and the faunal dating of Çorakyerler hominoid site.



**FRESHWATER DISCHARGE FROM EQUATORIAL AFRICA AND NORTHERN HEMISPHERE ICE-SHEETS GOVERNED THE MEDITERRANEAN TRANSFER OF HEAT AND SALT TO THE ATLANTIC OCEAN INTERIOR OVER THE LAST 250 KYR**

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**Objectives:** A study at site U1389 in the contourite sedimentary system in the Gulf of Cadiz was carried out to investigate past changes in the strength of the Mediterranean Outflow Water (MOW) along the last 250 kyr.

**Methods and Results:** We used the content of fine sand in the sediments, in particular the fraction between 62 and 150 microns, to identify important fluctuations in grain size that were interpreted as changes in the velocity of the MOW.

**Conclusions:** Prominent sandy contourite layers were deposited at times of precession maxima when MOW velocity reached maximum speed, while the intensity of the flow collapsed at times of precession minima, resulting in muddy contourite deposits.

During the last 250 ky, 10 muddy contourite beds were recognized associated with very weak MOW velocities. They were correlated with sapropels S1 to S9 in the eastern Mediterranean. Both, sapropels and muddy contourites in the Gulf of Cadiz were the result of high freshwater discharge from the Nile and higher annual rainfall in perimediterranean catchment areas. Grain-size changes at millennial scale were also observed, especially during MIS3. More sandy contourite beds were formed during stadials, while mud contourite beds were laid down during interstadials. An exception to this pattern was seen in the middle of Herinrich stadials, where a short event of weak MOW was identified, coinciding with maximum meltwater discharge from the European and American ice sheets.

Although changes in settling depth of the MOW within the Atlantic may have influenced the velocity of the MOW at site U1389, we attribute the orbital and millennial-scale variations in bottom water flow to Mediterranean changes in heat and freshwater forcing that generated density gradients between Mediterranean and Atlantic water at Gibraltar. Other scenarios, such as differential cooling between the Atlantic and eastern Mediterranean were also explored.

**PRECIPITATION DEVELOPMENT IN THE EASTERN PARATETHYS FROM THE VOLHYNIAN TO MAEOTIAN**

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**Objectives:** The Eastern Paratethys had a dynamic palaeogeographic development forced by tectonic activities and climatic changes resulting in sea level fluctuations and connections and disconnections with and from neighbouring basins. From the Volhynian (12.8 Ma) onwards until the Khersonian-Maeotian boundary, the Eastern Paratethys is considered to lose gradually the connection with the global ocean. Becoming an isolated basin, the hydrological balance of the Eastern Paratethys depends directly on the discharge of the river systems from the north (e.g. Palaeo-Dnester, Palaeo-Don, Palaeo-Volga). In turn, the latter determined by the water amount collected from the catchment areas of the river drainages supplied from the precipitation. Thus, reconstructing the palaeoprecipitation development of the Eastern Paratethys from the Volhynian to Maeotian will provide data to test proposed changes in the hydrological balance of the basin.

**Methods and results:** For the estimation of the palaeoprecipitation values, the bioclimatic method, based on amphibian and reptile assemblages, has been used. From the Eastern Paratethys for 10 localities the mean annual precipitation (MAP) values have been estimated. Around 20 localities from Central Paratethys and western Mediterranean region, the MAP estimates have been calculated and included into comparison. The ages of the localities have been dated using small mammal biochronology. For some localities from the Eastern Paratethys, which contain marine faunas of mactrid bivalves, also the biostratigraphy of these mollusks has been used for the age definition.

The precipitation data show both in Central and Eastern Paratethys overall increasing precipitation value from the latest Serravallian (MAP=486-584 and 900 mm) to mid Tortonian (MAP=1000 and 1500 mm), and in the late Tortonian significantly drier climate (MAP=496 mm) with very humid phases in the Eastern Paratethys (MAP=1300 mm). The early Maeotian was significantly more humid than in the late Khersonian (MAP=712-800mm) in the Eastern Paratethys. In the western Mediterranean the climate was dry from the latest Serravallian to mid Tortonian, and in the late Tortonian it is much more humid than before.

**Conclusion:** For the first time, an attempt has been done to provide precipitation evolution in the neighbouring areas Eastern and Central Paratethys and western Mediterranean (Spain). The climate evolution in the Central and Eastern Paratethys had comparable development whereas in the western Mediterranean it is opposite to them. In the Eastern Paratethys MAP is always higher than in the Central Paratethys. Most probably, more rainfall in the Eastern Paratethys resulted from enrichment of the atmospheric moisture by evaporated water masses from the large areas of the Pannon Lake. It is important to note that in the late Khersonian the climate was drier but, most probably, with short humid phases (MAP=1343, 7.6-8.7 Ma).

**PALEOCLIMATE OF YATAĞAN-TINAZ BASIN IN MUĞLA (WESTERN TURKEY) IN MIDDLE  
MIOCENE, BASED ON CLIMSTAT PROGRAM**

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**Objectives:** Turkey is very rich in Cenozoic plant bearing sediments. A large number of coal basins with active mining across the whole country provide ideal conditions for palaeobotanical investigations. The sedimentary deposits which occurred due to tectonic features of Western Anatolia are formed in lacustrine depositional setting and most of these sediments contain coal. This study is based on detailed palaeobotanical and palynological investigations of Neogene aged coal deposits exposed in the Southwest Aegean region in Muğla, Yatağan-Tınaz and surroundings.

**Methods & Results:** Palaeobotanical samples were collected from Sekköy formation that contains the main coal seam at the bottom and marls at the upper parts. In addition to palynological samples, a large collection of middle Miocene macrofossils from the Tınaz basin was recovered. In this study, 1132 macro fossils were collected. The identified leaf fossils showed that the Tınaz basin had temperate zone plant elements in the middle Miocene. A climate reconstruction using Climstat for macro flora also showed that temperate climate was dominant and that seasonality existed during that time.

**Conclusions:** The qualitative and quantitative climate reconstructions explain why a number of the recent Black Sea flora elements were present in the south western part of Turkey in the middle Miocene.

**CHANGES IN BOTTOM WATER CIRCULATION AT THE MIOCENE-PLIOCENE BOUNDARY IN RESPONSE TO THE OPENING OF THE GIBRALTAR STRAIT**

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**Objectives:** One of the main goals of IODP expedition 339 in the Gulf of Cadiz was to explore the evolution of the Mediterranean Outflow Water (MOW) during the Messinian and especially its response to the opening of the Strait of Gibraltar after the Mediterranean Flooding.

**Methods and Results:** To investigate this we studied planktic and benthic foraminifer stable isotopes and analyze the grain size and physical properties of the sedimentary record at site U1387, which was the only site crossing the Miocene Pliocene boundary.

**Conclusions:** During the latest Messinian, when the Lago mare, Salt and Lower gypsum units were deposited in the Mediterranean, our results indicate very reduced or absent MOW in the Atlantic. Sedimentation in the gulf of Cadiz margin was mainly controlled by cyclical variations in sediment input to the basin. At times of NH summer insolation maxima a higher input of clay was recorded by more muddy layers, while more silty sediments were found during insolation minima. These sedimentary cycles are similar to those described in other sections and outcrops on the Atlantic margin of Spain and Morocco.

By contrast, the impact of Mediterranean outflow is clearly visible at the onset of the Pliocene. During the earliest Pliocene, sedimentation in the upper slope of the Gulf of Cadiz was strongly controlled by cyclical changes in the interaction between the MOW and North East Atlantic Central Water (NEACW). We linked the occurrence of beds with coarser grain-size, low benthic  $\delta^{18}\text{O}$ , high benthic  $\delta^{13}\text{C}$  and higher Zr/Al ratios to episodes of acceleration of bottom waters originated in the Mediterranean. They alternate with periods of weak bottom currents, typically showing higher benthic  $\delta^{18}\text{O}$  and lower  $\delta^{13}\text{C}$  and Zr/Al ratios. These physic-chemical properties indicate Atlantic sourced bottom waters. We suggest that MOW was active at the bottom in site U1387 at times of insolation minima and was replaced by NEACW during insolation maxima. Proxies for sea surface physic-chemical properties, such as the proportion of subtropical planktic foraminifers and planktic  $\delta^{18}\text{O}$ , usually display opposite patterns to those seen at the bottom, suggesting very peculiar modes of surface and bottom water circulation during the earliest Pliocene.

**TETRIARY CONIDAE FROM CRETE, GREECE, SHOW THEIR TRUE COLORS UNDER UV LIGHT**

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**Objectives:** Color patterns of shells are well known characters that help us identify species for almost two hundred years and hence, this is a method to improve the typological and traditional methods. Unfortunately, they are rarely visibly preserved in fossils and therefore they are not particularly used as a diagnostic feature in systemic descriptions of fossil molluscs. Recently, a lot of effort has been done to reevaluate the species record of gastropods from Tortonian Paratethys's and Protomediterranean sediments. Similar work in Greece has not been done in recent years and most species need revision. In this research, we will be using gastropods of the Conidae family from Crete (Tortonian deposits) for the identification of species, with the help of their color patterns under ultraviolet rays.

**Methods & Results:** This method, which consists a non-destructive treatment of samples (impregnation in sodium hypochlorite), is particularly useful in species that do not present many diagnostic characters, as it helps in uncovering their color patterns, and consists a good example for an easier and more accurate discrimination between gastropod species as well. Results from similar studies show that this technique is reliable for the description and differentiation of species. A good example would be *Kalloconus neumayri*, a species, hard to identify without observing the residual color patterns of the shell, but visually different from other samples, because of its distinguishable color pattern. Also, Miocene Conidae are great paleoenvironmental indicators, as they were abundant during that period. For this reason, the variety of Conidae in the studied areas can be indicative of the influence of the environment on their habitat, reveal potential connecting populations of Paratethys and Protomediterranean, as well as indicate migration of species through time from North to South. Their color patterns exhibit a lot of variation, thus the method used is very helpful for their taxonomic characterization.

**Conclusions:** From over 120 samples, at least 15 species of Conus have been identified using UV light. Samples, that were considered as one species, present different color patterns under UV light. Revising the gastropod species from Late Miocene deposits of Crete, will help us create a database of the species encountered and compare them with similar occurrences of Miocene's Paratethys.

**OCEANOGRAPHIC AND CLIMATE VARIABILITY OF MIS 19 INTERGLACIAL COMPLEX AT THE ATLANTIC-MEDITERRANEAN GATEWAY**

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**Objectives:** Determining the history of climate change occurred during Marine Isotope Stage (MIS) 19, an interglacial spanning 790-760 ka and relevant for the parallelism with the current interglacial in terms of Earth orbital parameters. An in-depth study of the magnitude and frequency of the main features of MIS 19 is also expected to better understand the physical mechanisms that triggered the Early-Middle Pleistocene Transition (EMPT: 1.4-0.4 Ma), a broad-scale watershed between the 41-ka and the 100-ka glacial-interglacial mode. Another goal is to describe the differential response of terrestrial and marine ecosystems to a common climate forcing.

**Methods & Results:** We selected ninety-three sediment samples from 209.77 to 200.57 meters composite depth (mcd) of the ODP core 976 (Alboran Sea, Western Mediterranean), covering the interval between late MIS 20 and late MIS 19 at a mean time resolution of ~500 years. In each sample we carried out analyses of the palynological (pollen and dinocysts) and calcareous plankton (nannofossils and foraminifera) content as well as stable isotope measurements ( $\delta^{18}\text{O}$ ). The Mediterranean/sub-Mediterranean forest taxa exhibit higher abundances during periods of lighter  $\delta^{18}\text{O}$  (both interglacials and interstadials), when also warm-water dinocysts and calcareous plankton taxa show larger abundances. Cooler periods (including late MIS 20 and several cold spells accompanying the MIS 19-18 transition) are marked by the expansion of steppes and semi-desert vegetation belts, as well as by the incursion of polar-water planktonic taxa. Peculiar pollen signals also describe variations at both precessional and millennial time-scales, highlighting the sensitivity of western Mediterranean areas to a wide-scale of climate change.

**Conclusions:** The integrated study of the isotope and biotic components of deep-sea sediments reveals the pattern of the Earth climate dynamics during the EMPT. The succession of climate changes constrained by the chronological framework improves the correlation between the Mediterranean and North Atlantic climate dynamics. This also represents a powerful tool to model the time/spatial gradients of regional to global climate processes.

**SEA LEVEL CHANGE VS RIVER INPUT: LATE QUATERNARY BENTHIC MICROFAUNA OF THE CENTRAL AEGEAN SEMI-ENCLOSED SHELF BASINS**

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**Introduction:** This research concerns the Upper Pleistocene to Holocene benthic microfaunal record (benthic foraminifera and ostracods) of the central Aegean shallow and semi-enclosed marine basins and particularly those of South Evoikos and Saronikos Gulfs.

**Objectives:** The study aims to estimate the impact of sea level fluctuations and river input on the shelf benthic microfauna, during the post last glacial maximum period, as well as to reconstruct the palaeoenvironmental and palaeobathymetric history of the two Gulfs, based on the micropalaeontological evidence.

**Methods:** Two sediment cores (DEH 1 and DEH 5), drilled from the South Evoikos Gulf, and two (SAR 36 and SAR 39) from the Saronikos Gulf middle shelf, were subjected into a high-resolution benthic microfaunal analysis. The continental shelf is particularly affected by environmental perturbations and so it is an ideal target for paleoenvironmental studies. Statistical and Multivariate analyses were conducted, including the estimation of several biodiversity indices (Dominance, Shannon-Wiener, Fisher- $\alpha$ ) and Q-mode hierarchical cluster analyses.

**Results:** Radiocarbon dating showed that the sedimentary record approximately covers the last 20,000yrs. Benthic microfaunal assemblages were taxonomically assessed and associated with specific biofacies. During the Upper Pleistocene and up to the Early Holocene, the biodiversity of both Gulfs was poor, indicating the low-stand of sea level. At this stage, the river influence is evident in the case of South Evoikos Gulf, whereas in Saronikos Gulf, sea level seems to be the main factor that defines the biofacies. During the Holocene, the micropalaeontological record follows the sea level rise, which is gradual into the South Evoikos Gulf and abrupt into the Saronikos Gulf. River input continues to affect the benthic microfauna of South Evoikos Gulf, while Saronikos Gulf is entirely marine.

**Conclusions:** The comparative study of the two Gulfs successfully revealed the Late Quaternary sea level rise in the Central Aegean shelf basins, compatible with that of the entire Aegean and the Mediterranean Sea. Benthic microfaunal assemblages efficiently detected the degree of river influence on the shelf palaeoenvironments, allowing the discrimination of several characteristic biofacies.

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STRATIGRAPHIC RESEARCH OF THE LOWER PANNONIAN (UPPER MIOCENE) OF THE  
TRANSYLVANIAN BASIN (ROMANIA): NEW BIOSTRATIGRAPHIC AND AUTHIGENIC  $^{10}\text{Be}/^9\text{Be}$   
ISOTOPIC DATA

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**Objectives:** During the Late Miocene, an enormous and long-lived lake – Lake Pannon – with rich endemic fauna covered most of the intra-Carpathian realm. Today, the Pannonian sediments occur in a more or less contiguous area in the central, southwestern and eastern part of the Transylvanian Basin (TB), which is a compressional back-arc basin. After the deposition of these sediments, exhumation and erosion started due to tectonic inversion, therefore the average thickness of the Pannonian sequence is only 300 m. The estimated age of these deposits is between 11.6 and 9.0 Ma. In the lack of a detailed and comprehensive treatise on the Pannonian fossils of the area, the accurate biostratigraphic resolution of this ca. 2.5 million years has not been developed so far. The widely outcropping Early Pannonian deposits in the TB offer an excellent opportunity for a modern investigation of the fauna and for exploring the changes that occurred at the beginning of the Pannonian. The rocks of similar age and their fauna are deeply buried in the Pannonian Basin (PB) – where a thick Pannonian sequence (4-5 km) preserved – and are mostly known from boreholes. The main aim of our study was a taxonomical revision and the increase of the biostratigraphic resolution of the Early Pannonian sediments of the TB.

**Methods & Results:** Taxonomic determination and revision of Pannonian brackish-water gastropods and bivalves were carried out from 72 localities. The material came from our own collection (12 localities) and from collections of the Geological and Geophysical Institute of Hungary (59 localities), the Hungarian Natural History Museum, Budapest (6 localities), and the Palaeontological Collection of the Department of Palaeontology of the Eötvös Loránd University (2 localities). Altogether 3124 specimens were determined so far, representing 17 genera and 56 species. There are 75 mollusc taxa in the material, including 2 probably new species.

Based on faunal composition and sedimentological characteristics of the localities, shallow-water (littoral) and deep-water (sublittoral and profundal) associations were separated. The shallow-water outcrops (15 localities) are mainly on the basin-margin, while the deep-water ones (56 localities) are rather located in the central part of the basin. We found just one fauna containing *Congerina czjzeki* – a characteristic species of sublittoral assemblages – at the locality of Lopadea Veche. Authigenic  $^{10}\text{Be}/^9\text{Be}$  isotopic dating method was also applied on 7 samples from 4 localities.

**Conclusions:** The tentative results were combined with the biostratigraphic data, thus in case of the deep-water sediments, 2 biozones and 3 subzones („*Lymnocardium*” *praeponticum* – *Gyraulus vrapceanus* assemblage zone and *Congerina banatica* assemblage zone with *Velutinopsis velutina*, *Undulotheca nobilis* and *U. rotundata* lineage subzones) were established. We hypothesize that 9.5-9 million years ago the TB became isolated from the PB, as suggested by the appearance of new endemic taxa, and evolved as an independent lake. With further collection of molluscs, investigation of the microfauna, magnetostratigraphic and further isotopic measurements, our objective is to develop the stratigraphic resolution of Lake Pannon deposits.

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**UNDERSTANDING THE DYNAMICS OF A SEMI-ENCLOSED MARINE ENVIRONMENT AS  
INFERRED FROM THE BENTHIC MICROFAUNA OF SARONIKOS GULF, EASTERN  
MEDITERRANEAN, DURING THE LAST 20,000 YRS**

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**Objectives:** This study aims to reconstruct the Late Quaternary palaeoenvironmental and palaeoceanographic evolution of Saronikos Gulf (W-Central Aegean), by means of the benthic microfaunal (foraminifera and ostracods).

**Methods & Results:** A 260-cm long sediment core (SAR 39) was recovered from Saronikos Gulf middle shelf, at 140m water depth. The micropalaeontological and statistical analysis was carried out on 50 samples, collected all along the core. The sedimentary record covers more than 16935±50 cal. yrs BP (radiocarbon dating at 196-198cm of the core).

Three main benthic foraminiferal assemblages and two ostracod assemblages alternate along the core.

The benthic foraminiferal fauna revealed:

- A well-oxygenated and well-vegetated mesohaline shallow marine assemblage, consisting of *Elphidium* spp., accompanied by *Ammonia tepida*, dominates from the bottom to about 70 cm of the core. This assemblage can be further divided into: the *Elphidium* spp., *Ammonia tepida* assemblage, where *Elphidium* spp. and *Ammonia tepida* are dominant and the diversity is very low and the *Elphidium* spp. increased diversity assemblage, where *Elphidium* spp. dominates, but the diversity is slightly higher and additional species groups are present.
- From 70 cm to 50 cm, *Bolivina* spp., *Bulimina* spp., *Cassidulina* spp. and *Hyalinea balthica* are indicative of a periodical oxygen-stressed environment, due to high organic fluxes at the seafloor, in an outer shelf environment.
- From 50 m to the top of the core, the assemblage of *Uvigerina* spp., *Bulimina* spp., *Bolivina* spp., *Cassidulina* spp., *Hyalinea balthica*, *Textularia agglutinans* introduces an upper circallitoral environment, under eutrophic conditions. At the last 10 cm of the core, *Uvigerina* spp. relative abundance is slightly decreased and the presence of *Bulimina* spp., *Hyalinea balthica* and *Bigenerina nodoraria* grows, suggesting lower circallitoral conditions.

The ostracod fauna revealed:

- A mesohaline/polyhaline shallow marine assemblage, mainly with *Leptocythere* species (*L. bacescoi*, *Leptocythere* sp. cf. *L. multipunctata*) and *Callistocythere crispata*, accompanied by *Xestoleberis decipiens* and *Paradoxostoma* spp. is dominant for the largest part of the core (from 260 to about 50cm). The distribution of *Leptocythere* spp. presents an opposite trend to the distribution of phytophilus taxa as *X. decipiens*, probably indicating substrate changes. The diversity indices present the lower values from 260 to 120 cm, while from 120 to 45cm, they present a clear increase.
- At the upper part (from about 45cm to the top of the core) a deeper marine assemblage prevails, mainly with *Acanthocythereis hystrix*, *Pterygocythereis jonesii*, *Bosquetina dentata* and *C. crispata*, and the diversity indices present their higher values.

**Conclusion:** The integrated data collected from the benthic microfauna finally allowed the discrimination of the successive palaeoenvironments, developed in Saronikos Gulf, during the Late Quaternary. Both benthic foraminifera and ostracod assemblages are indicative for an Upper Pleistocene to Holocene relative abrupt transition from a shallow marine mesohaline environment to a fully marine open sea environment. An incidence of dysoxic conditions, at the Mid-Holocene, was also detected.

**THE BRAIN OF CATS AND CAT-LIKE PREDATORS**

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**Objectives:** 'False sabertoothed cats' (Nimravidae) were specialized predators of the Late Eocene-Oligocene with a cat-like appearance. Though phylogenetically unrelated to the true cats (Felidae), their craniodental anatomy was superficially very cat-like. Their brain, on the other hand, was rather different than that of Felidae. The aim of this contribution is to compare the specialization of their brain anatomy.

**Methods:** This study is based on the endocranial casts of the Len Radinsky collection (now in the Field Museum of Natural History). The endocasts were scanned with a NextEngine 3D laser scanner and the acquired scans were used for calculating the brain volume and surface area of the exposed cerebral cortex. The superficially exposed gyri were digitized using an Immersion MicroScribe 3D point digitizer and their length was used as an indication of the degree of cortical folding. This approach was followed because there is a very good correlation between the degree of cortical folding and the relative length of the gyri that are exposed on the outer surface of the hemispheres.

**Results:** Nimravids had in the Oligocene the same relative brain size with the living felids. Furthermore, their cortical folding was rather advanced compared to that of any other Palaeogene carnivore. Nevertheless, their cortical folding is rather simple when compared to that of Felidae. The brain of true cats was more fissurated already at their earliest representatives. The Late Oligocene-Early Miocene *Proailurus* had a brain similar to that of some modern viverrids. During their evolutionary history, felids increased their cortical surface from *Proailurus* to *Pseudailurus* and then to the Miocene forms. The Late Miocene *Barbourofelis*, a genus that is sometimes included within the nimravids, had a brain that was almost the same as that of the Oligocene forms and thus, far behind any Miocene felid.

**Conclusions:** Despite their craniodental similarity, nimravids and felids have differences in their brain anatomy. In particular, Nimravidae had a cerebral cortex which was considerable less convoluted than that of Felidae.

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THE FIRST RECORD OF A VILLAFRANCHIAN SMALL CERVID “*CROIZETOCEROS*”  
FROM TURKEY

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**Objectives:** The northwest-southeast trending Burdur basin was formed as a result of NW-SE directed crustal extension in control of the northwest dipping main fault to the east of the basin margin. The late Miocene-Quaternary fill of the basin outcrops along a NE-SW trending depression c.a. 10 km wide between Burdur and Tefenni. The unit comprises a central basinal succession with a volcanic intercalation to the northeast. The basin-fill succession is subdivided into Çendik, Akdere and Günalan members in ascending stratigraphic order; the latter is subdivided into lower and upper Gölcük members. The Çendik and Günalan members are dominated by fluvial sediments that laterally pass into alluvial-fan deposits. Whereas the Akdere member represent the central basin area dominated by the sediments of lacustrine setting.

**Methods & Results:** The Neogene Burdur Formation is diachronous and becomes progressively younger to the southwest, where a considerable thickness of the succession is Pleistocene in age. The central basinal succession of lacustrine Akdere member contains abundant low-diversity freshwater ostracode fauna ranging from lower Pliocene to upper Pliocene – lower Pleistocene times (Bering, 1971; Price, 1989). Karaman (1986) states that palynomorphs from lignite horizons within the Burdur formation indicates a Pliocene age. Ostracode-bearing horizons of the Burdur Formation sampled by Price (1989) indicate a Pontian age (i.e. latest Miocene), but questioned that this age estimate is speculative because of facies dependency and longevity of the Neogene freshwater ostracode species in Turkey. More recently Tunoğlu & Bayhan (1996) has determined the ostracod bearing lacustrine horizons of lacustrine Akdere member as Pliocene in age and interpreted the palaeoecology of the lake as freshwater with volcanic hydrothermal input..

The cervid fossil, a lower m2 of *Croizetoceros* sp. discovered in the marsh-swamp deposits between fluvial Çendik and lacustrine Akdere members. The age of fossil bearing marsh-swamp deposits are in well accordance with the lacustrine expansion stage of the coeval basins of Eşen, Çameli, Baklan and Acıgöl around Burdur basin.

**Conclusions:** *Croizetoceros* is a cervid genus with an uncertain systematical position as a direct relationship with any representative of the subfamily Cervinae has been discussed lately. It has numerous records from the Late Miocene to Early Pleistocene localities of Western and SE Europe. The most abundant taxa that belongs to *Croizetoceros* is *C. romanus* which has a wide distribution during Early-Middle Villafranchian in Europe. The total of seven chrono-subspecies of *C. romanus* were recognized from France: *C. ramosus ramosus* (MN 16; Perrier-Etouaires, Vialette), *C. r. medius* (MN 17, Saint-Vallier, Pardines) and *C. r. minor* (MNQ 18, Seneze, Le Coupet); from Spain: *C. r. villaroyensis* (MN16, Villaroya, Huelago), *C. r. pueblensis* (MN 17, La Puebla de Valverde) and *C. r. fonelensis* (MNQ 18, Fonelas). There are also limited records from Poland (MN 16, Rębielice Królewskie) and Slovakia (MN 16, Hajnáčka). Better records from Greece were collected from Early-Middle Villafranchian localities of Volax., Sesklo, Millia while the Gerakarou specimen was recognized under the sub-species, *C. r. gerakarensis*. From biometric viewpoint, the Burdur lower molar (m2) falls within the metric range of *Croizetoceros ramosus* m2s, and closer to those of Les Étouaires and Millia m2 measurements. This is the first record of a small-sized cervid from Villafranchian localities of Turkey and also the first record of this European common taxa. In the light of this cervid record, further studied will reveal a better picture of Burdur fauna.

**FROM PARATETHYS TO DANUBE CATCHMENT: HOW AND WHEN THE NEOGENE DEEP MARINE BASINS IN CENTRAL AND SOUTHEAST EUROPE WERE CONVERTED INTO FLUVIAL PLAINS**

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The Miocene marine basins of Central and Southeast Europe, once comprising the Paratethys Sea, were gradually filled with sediments during the Neogene and were replaced by the Danube catchment area and thus the sediment transport system of the modern Danube. Seismic data show that these several hundred meter deep basins were filled by lateral accretion of river-transported sediments, appearing as clinoform sets in seismic profiles. By mapping and dating these clinoform sets, it is possible to reconstruct the paleogeographic changes and to understand the role that the Danube sedimentary system played in the silting up of the Paratethys. In this paper we define the Danube as a river that drains the North Alpine Foreland Basin and charges into the nearest standing water to the east.

In the North Alpine Foreland Basin, large-scale, eastward prograding clinoforms are present within the Eggenburgian Hall Formation. By the Ottnangian, the deep-water environment ceased to exist in the NAFB. The Eggenburgian sedimentary system cannot be regarded as a direct forerunner of the Danube, because during the following Middle Miocene, the NAFB drained towards the west, into the Mediterranean.

The Vienna basin sedimentary architecture includes Badenian clinoforms prograding towards the east, and fed by sediments from the Alps and from the Bohemian Massive. The drainage of the NAFB, however, was towards the west at the same time, thus the Vienna basin clinoforms cannot be attributed to the sediment transport system of the Danube either. The early Late Miocene shallow-water pebbly deltas of the Vienna basin (Hollabrunn-Mistelbach Fm), on the other hand, does indicate the formation of the eastward sediment transport of the incipient Danube.

In the Kisalföld/Danube basin of the Pannonian Basin System, regional clinoform sets appear in the Pannonian Stage. They are slightly younger than the pebbly deltas in the Vienna basin, and prograde towards the SE. They were fed from the Alps and Western Carpathians, and can be considered as a product of the Danube and its tributaries.

Much of the Central Pannonian Basin was filled by a sediment transport system that „overspilled” the sill of the Transdanubian Range on its way from NW to SE. The age of this system is late Late Miocene and Early Pliocene. It reached as far to the south as the Sava Basin and the Banat region of Romania and Serbia.

In the Dacian basin, the clinoforms also prograded from west to east in the westernmost extremity of the basin, but east to west and north to south directions prevail further to the east. These directions indicate Carpathian provenance of the sediments. Their age is Meotian – Pontian, corresponding to the latest Miocene, i.e. they are coeval with the clinoforms of the Pannonian basin. The Dacian basin clinoforms thus cannot be attributed to the sedimentary system of the Danube.

The present-day Danube has been building clinothemes in the margin of the Black Sea shelf since the Pliocene.

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THE ENDEMIC LACUSTRINE GASTROPOD GENUS *MICROMELANIA* BRUSINA 1874 IN NW HUNGARY

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The extinct hydrobiid snail genus *Micromelania* lived in the Paratethyan basins and possibly in adjacent lacustrine environments during the Neogene. The genus probably originated in Lake Pannon, where it was endemic during the early Late Miocene. Several dozens of *Micromelania* species have been described from the littoral, sandy deposits of the brackish Lake Pannon in Austria, Hungary, Croatia, Serbia and Romania during the late 19th and early 20th century. They usually occur together with dreissenids and cardiids of marine and brackish origin, suggesting a brackish rather than purely freshwater paleoenvironment, and with a variety of herbivorous snails, indicating a habitat in the zone of rooted vegetation within the lake.

We conducted a taxonomic revision of the *Micromelania* species that occur in surface outcrops in NW Hungary. Our material came from 23 outcrops. In addition to our own collections, we examined specimens from the collections of the Geological and Geophysical Institute, Budapest, the Hungarian Natural History Museum, Budapest, and the Bakony Natural History Museum, Zirc. Some materials from SW Hungary and from foreign localities were also utilized for the revision; the kind support of the Natural History Museum, Vienna and the Croatian Natural History Museum, Zagreb is acknowledged herein.

In the investigated area, we distinguished 10 species: *Micromelania cerithiopsis* Brusina, „*M.*” *laevis* (Fuchs), *M. menisi* Brusina, *M. sandrii* Brusina, *M. striata* Gorjanović-Kramberger, *M. coelata* Brusina, *M. fuchsiana* Brusina, *M. gracilis* Brusina, *M. subula* (Fuchs), *M. letochae* (Fuchs). Two of the 10 species, *M. subula* and *M. menisi* have their type locality within our study area (Tihany and Kúp, respectively). We established that *M. scobina* Brusina is a synonym of *M. cerithiopsis*, *M. freyeri* Brusina is a synonym of „*M.*” *laevis*, whereas *M. cylindrica* Lőrenthey and „*Pyrgula*” *radici* Pavlović are synonyms of *M. fuchsiana*.

The geographical distribution of the *Micromelania* species within the study area suggests that some of the species may have a restricted stratigraphic span, whereas others seem to have had much longer time span and thus wider geographical distribution. The most common species is „*M.*” *laevis*, which shows a slight but consistent morphological change through its long time span. The assignement of this species to *Micromelania*, however, is considered dubious and requires further support.

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**HOLOCENE VARIABILITY IN OCEAN AND ATMOSPHERIC CONDITIONS IN THE WESTERN MEDITERRANEAN SEA AND ATLANTIC TELE-CONNECTIONS**

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Marine and atmosphere patterns in the western Mediterranean Sea are explored in base to a high-resolution multiproxy study from the marine sediment core ALB-02 from the Alboran Sea. XRF core scanner-record base don Zr is used as indicator rainfall changes over land and sea surface temperatures (SST) have been obtained through Mg/Ca ratio measured in the planktonic foraminifera *Globigerina bulloides* measured on the planktonic foraminifera *Globigerina bulloides*. Both marine and terrestrial source proxies are combined to identify those similar and different patterns along the Holocene. In base to our results, the early-Holocene display the warmest temperatures and the more humid conditions during the Holocene. Mid-Holocene is characterised by a transition towards the coldest temperatures and driest conditions established in the late-Holocene. However, the high-resolution data allow us to observe centennial-scale oscillations in both proxies. Early-Holocene display a good parallelism between warm periods with an aridity increase, while during the late-Holocene warm periods become linked with humidity increases. The mid-Holocene (6 to 4 cal. kyr BP) appears as a transition period between these two described patterns. These records are compared with isotopic records of benthic foraminifera from the Cantabric Shell, and other Atlantic records, suggesting a connection between humidity changes over Iberia and major reorganization in the circulation patterns of the North Atlantic Ocean. The last 4kyr appear as a particularly climatically instable within the Holocene, Mediterranean variability is compared with a new speleothem from the Cantabrian range and we propose a link between this variability and the arrival of Atlantic fronts over the north of Iberia. These results are discussed in the framework of independent marine and terrestrial pollen records and flooding reconstruction from the region providing a compressive regional picture. Moreover this comparison provides a further insight in the rapid climate variability of our current interglacial period.

**BIOGEOGRAPHIC RELATIONSHIPS OF EARLY MIOCENE FLORAS OF TURKEY**

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**Objectives:** To date, no biogeographic investigation of Neogene floras of Turkey is available. In this paper, I assess biogeographic relationships of early and early middle Miocene macrofloras of Turkey in order to better understand plant geographic (and possibly palaeoecological) links of Anatolia during this time.

**Methods & Results:** A database including a revised taxonomy for all known Turkish macrofossil (mainly leaf) sites and a current revision of western Mediterranean coeval floras along with an analysis of published floras across western Eurasia and Central Asia form the basis for the biogeographic evaluation. In this paper, I focus on biogeographic relationships with roughly coeval floras. In a forthcoming paper I will investigate relationships with modern distribution patterns. Biogeographic patterns of the Miocene of Anatolia are manifold: Most taxa are widespread N hemispheric elements. Further, a great part of species migrated from Asia into Europe during the (late) Paleogene and reached Anatolia during the early Miocene (e.g. *Acer* spp., *Ailanthus*, *Chaneya*, *Fagus*, *Paliurus*, *Quercus* Group Ilex). Fewer taxa might have been in Anatolia before they migrated to Europe (*Ilex mioidipyrena*, *Mahonia grimmii*, *Smilax miohavanensis*, *Vauquelinia* sp. nov.). Some of these elements might turn out to be Mediterranean disjuncts when the rich southeastern French Chattian and Aquitanian floras originally described by Saporta will have been revised. This pattern including eastern and western Mediterranean disjunctions has previously been shown for an extinct group of cycads, for *Berberis*, and is possibly also true for *Dracaena*. Overall, at this point, Turkish and Greek floras are more similar to Central European early and middle Miocene floras than to western Mediterranean ones.

**Conclusions:** Assessing biogeographic relationships of plant fossil assemblages at the genus and infrageneric levels is in its early steps but will have important implications for assessing broad-scale palaeoecological patterns. This has recently been demonstrated for a group of evergreen oaks (*Quercus* Group Ilex). Furthermore, combining these data with data from vertebrate palaeontologists will have important implications for understanding the establishment of biome boundaries in the early Neogene.

**CRUSTAL DEFORMATION AND FAULT MODEL OF THE 2017 GULPINAR EARTHQUAKE SEQUENCE (BIGA PENINSULA, NE AEGEAN REGION): SEISMOLOGICAL AND INSAR EVIDENCE**

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**Objectives:** we study the shallow earthquake sequence onshore Biga Peninsula (NW Turkey, NE Aegean region) that occurred during February-April of 2017 near the village of Gulpinar in order to map crustal deformation and locate the seismic fault.

**Methods and Results:** we use seismological data (parametric data and Moment Tensor solutions from NOA and KOERI catalogues) and InSAR interferograms (Sentinel-1 satellites) to identify the east-west striking seismic fault and to refine its geometry and kinematics using inversion techniques. The catalog earthquakes were relocated with the HypoDD software and the use of a local velocity model. The spatial distribution of relocated events shows the activation of one fault with a total length of about 12 km. A stress inversion using 20 focal mechanisms ( $M > 3.6$ ; NOA solutions) indicates that faulting accommodates a N196°E crustal extension.

**Conclusions:** A south-dipping fault is not retrievable from InSAR but it is clear from seismology and the aftershocks distribution. Despite the moderate magnitudes of the main events ( $5.0 < M < 5.2$ ) there is clear surface deformation (maximum 8 cm along descending LOS), which is well visible with InSAR because of the shallow depth of the four main events (6-8 km) and the good coherence of the signal phase.



**TECTONO-SEDIMENTARY EVOLUTION AND GEODYNAMIC SETTING OF THE CORINTH RIFT, GREECE**

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The onshore central Corinth rift (CR) contains a >3 km thick syn-rift succession deposited in 5-15 km wide tilt blocks; all now inactive, uplifted and deeply incised. It records upward-deepening from fluvial to lake margin conditions and finally to sub-lacustrine turbidite channel and lobe complexes. Deep water lake conditions were established over most of the rift by 3.6 Ma, the lake closing to the west. Traced over the wider rift, such activity defined the first of two phases of tectono-sedimentary development. This Rift 1 (5.0-3.6 to 2.2-1.8 Ma) developed as a 30 km-wide zone of distributed normal faulting, the lake fed by 4 major N- to NE-flowing, antecedent drainages along the southern rift flank. These sourced an axial fluvial system, Gilbert fan deltas and deep lacustrine turbidite channel and lobe complexes. Onset of Rift 2 (2.2-1.8 to 0.0 Ma) involved a 30 km northward shift in the locus of rifting. In the west, major giant Gilbert deltas built into a deepening lake depocentre in the hanging wall of the newly-developing southern border fault system. Footwall and regional uplift progressively destroyed Lake Corinth, producing a staircase of deltaic and, eventually, shallow marine terraces descending from >1000 m to present-day sea level.

The evolution of the CR can be attributed to the combination of two major tectonic controls, i.e. the role of major strike-slip/transform faults that cut the overriding plate and the influence of the subducting African slab and rollback of subduction. A series of sub-parallel dextral strike-slip faults, such as the NE-SW-striking Kefalonia and Patras faults in the west, are associated with clockwise block rotation and N-S extension on E-W-striking normal faults in central Greece. Observations from the Rift 2 phase of the CR broadly support such a model, with pronounced migration of fault activity, self-organisation and strain localisation along co-linear border faults; and increased fault interactions. This, when viewed in a geodynamic context, could be explained by enhanced strain in a zone of interaction between dextral strike-slip faulting in the Patras rift and N-S extension within the CR. However, while the highest N-S geodetic extension rates are observed in the west, the largest fault displacements within Rift Phase 2 are located in the central part of the rift (and during Rift Phase 1 the locus of extension was to the east of the rift). These data could suggest that the interaction between dextral strike-slip deformation in the Patras rift to the west and the CR may be a relatively young phenomenon, occurring over the last c. 0.8 Ma. Overall, high extension rates across the CR are related to the Peloponnese block moving southwards away from slower moving Central Greece and over the Hellenic subduction zone. Regional uplift of Pliocene/early Pleistocene lacustrine fan deltas that are >30 km distant from any Pleistocene/Holocene active faults has been on-going for at least 1 Ma. The most plausible dynamic for regional uplift is that arising from buoyancy of the western part to the shallow-dipping African that underlies the central and eastern rift.

**MEGARA BASIN: A POST LAST GLACIAL MAXIMUM “CARBONATE FACTORY”**

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**Aims:** This research aims to investigate the Late Quaternary palaeoceanographic evolution of the Megara basin (NW Saronikos Gulf, W-Central Aegean), as evidenced by the sedimentary record and the contained microfauna. The main objective of the study is to evaluate the impact of the post-LGM sea level change, on the sedimentary palaeo-conditions. Other factors are also considered as possible to affect the sedimentation.

**Methods:** The studied 260cm-long core SAR 39 was recovered from the NW Saronikos Gulf shelf, at 140m water depth. The core was logged and scanned for magnetic susceptibility (MS). Carbonate contents were continuously determined, at 1-2cm resolution and selected samples were studied about their XRD bulk and carbonate mineralogy. SEM was also employed and an AMS radiocarbon dating was conducted at 196-198cm. Foraminiferal analyses followed standard micropalaeontological laboratory and statistical techniques.

**Results:** The studied sedimentary record covers more than  $16,935 \pm 50$  ka. The total  $\text{CaCO}_3$  content is positively correlated with aragonite. Aragonite precipitates present a typical fine-grained needle-structure (1-5 $\mu\text{m}$  size). XRD analyses point out two distinct aragonite-dominated sequences: a first one from the bottom to 192cm of the core, where aragonite presents a gradual decrease from 70 to 55wt% and a second one, from 182 to 88cm, where aragonite ranges between 74-90wt%. Both sequences correspond to the end of Pleistocene. Over the last 88cm, aragonite content displays an abrupt decrease, reaching 7wt%, at the top of the core, while both MS and terrigenous minerals increase. Prior to this point, MS values are very weak. Foraminiferal analysis indicates: a Pre-Holocene low-diversity shallow marine fauna, dominated by relatively stenohaline taxa, typical of well-oxygenate waters. This faunal composition possibly corresponds to a landlocked marine basin, disconnected from the open sea or significant river discharges. During the Early Holocene, the microfauna is enriched by fully marine species, suggesting the reconnection with the open sea. At the Mid-Holocene, an incident of dysoxic conditions is observed, based on the relatively high abundance of tolerant to low-oxygenation taxa.

**Conclusions:** During the time interval between LGM and Late Glacial-Holocene transition, Megara Basin was a landlocked marine embayment. The dominant mineral was aragonite, with an average content of 60 wt%. This percentage is relatively high, considering the moderate sea temperatures recorded in East Mediterranean, during that period. After a rapid enhancement of aragonite production, the average aragonite content reached 90 wt%. All along the core no other evaporitic minerals were detected, excluding evaporation as the main control factor of the depositional conditions. The abundance of the mineral aragonite indicates that this unique carbonate factory survived until Early Holocene, when the reconnection with the open sea was established. Comparative results are also suggested by the study of several other cores, retrieved from both internal (Megara basin) and external Saronikos Gulf.

**PLIOCENE-MIDDLE PLEISTOCENE PLANKTONIC FORAMINIFERA RECORD AND  
PALEOENVIRONMENTAL RECONSTRUCTION OF CYPRUS ISLAND (EASTERN  
MEDITERRANEAN)**

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**Objectives:** A study to record all the biostratigraphical events of the Pliocene to Middle Pleistocene Nicosia Formation was carried out on two selected sections, in order to reconstruct the paleoenvironmental evolution of the island of Cyprus in the easternmost part of the Mediterranean Sea.

**Methods & Results:** The two studied sections of Essovouyes-Exovouyes and MP7 borehole are located on the margins of the Central Mesaoria basin with the Larnaka and Pafos basins respectively, from both sides of the Troodos Ophiolite Complex. The 90 m thick Essovouyes-Exovouyes section is consisted of pinkish and brown marls, brownish organic-rich finely laminated sapropelitic layers alternating with grey homogeneous marls, yellow to brownish marls, yellowish sandy marls, marly sands and calcarenites. The MP7 core borehole consists of 130 m thick of greyish white marls, pinkish marls, grey marls, yellow marls, and calcarenites. The qualitative and quantitative analyses of the planktonic foraminiferal assemblages revealed the presence of 13 and 18 bioevents in Essovouyes-Exovouyes section and MP7 borehole respectively. These eighteen (in total) astronomically dated planktonic foraminiferal bioevents were used to constrain an age model through linear interpolation covering the time intervals 5.22-2.0 Ma and 5.33-0.899 Ma for Essovouyes-Exovouyes section and MP7 borehole respectively. Within this robust biostratigraphical framework, and because the bioevents are related to palaeoenvironmental changes, these events used to unravel the paleoenvironmental evolution of the two studied areas. In this sense planktonic foraminifera are important palaeoecologic and palaeoclimatologic indicators and their records provide significant insights into the complex dynamics of the studied basin of the eastern Mediterranean Sea. Correlation between the paleoclimatic and the sea surface environmental parameters with the three main factors of the principal component analysis (PCA-1, PCA-2 and PCA-3) performed on both studied sections, showed that the most important factors affecting the marine environments of the two areas were the surface primary productivity (SSP) for the Essovouyes-Exovouyes section and the sea surface temperature (SST) for the MP7 borehole.

**Conclusions:** The sediments of both sites clearly show the gradual uplift of Cyprus, from the upper slope to the infralittoral zone, into which were deposited the lower marls and the calcarenites respectively.

**WHAT KAVAK DERE (ANKARA) LATE MIOCENE MAMMALS BRING TO THE KNOWLEDGE OF MAMMALIAN EVOLUTION IN ANATOLIA?**

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**Objectives:** The mammal locality of Kavak Dere (KD) is situated in the Kazan Neogene Basin at some 50 km NW of Ankara. It yielded a diverse and well-documented Late Miocene mammalian fauna, without being, however, subject of detailed analyses. The knowledge dealing this fauna is sparse, and incomplete. The main aim of this study is to present a complete view of its diversity, its age and its environment.

**Methods & Results:** In the Kazan Basin, the pioneering research of Fikret Ozansoy in the 1950s led to the discovery of a number of mammal localities, including KD, whose age ranges from the Middle Miocene to the latest Pliocene. Indeed, in this basin fluvio-lacustrine deposits of the Sinap Formation cover large areas and are rich in Neogene vertebrate fossils. Ozansoy studied the large mammals of some localities whose faunas appeared to him to be "original", while he left aside the so-called "Pikermian" faunas which seemed to him rather classical. The KD fauna was part of the second category. However, in his various publications Ozansoy listed 13 species of mammals found in this locality. Later, other teams carried out excavations in various localities of the Sinap Formation, including KD, and recently International Sinap Project (1989-1995) investigated stratigraphy, sedimentology and palaeontology of the Sinap Formation, and carried out the magnetostratigraphy of several sections, including that of KD. These studies showed that the fossiliferous level of KD is included in massive mudstones with paleosol features such as root traces, burrows, and carbonate nodules. These mudstones were laid down in flood plain deposits. The magnetostratigraphic results correlated the KD fossiliferous horizon with C4r.1r, i.e., c. 8.2 Ma.

Mammalian fossils from KD are at present dispersed in several collections in Ankara (MTA and Ankara University), Izmir (Natural History Museum of Aegean University), Germany (Munich and Hannover), Switzerland (Zurich) and France (Natural History Museum, Paris). The latter collection is left by Ozansoy in late 1950s and includes interesting specimens that are the subject of the present study. It includes cranial and postcranial remains of a large hipparionine *Hippotherium brachypus*, and a chalicotheriid *Ancylotherium pentelici* represented by some upper jaw fragments, both species characteristic of Turolian biome from Iran to the Balkans. The large scavenger and bone-cracker hyaenids are represented in particular with a new subspecies of *Adcrocuta eximia*, which has dentition more gracile and sharper than that of *A. eximia* from Pikermi, and a large deinotherid represented by some postcranial remains.

**Conclusions:** The KD fauna is typical for the Pikermian biome, but some species display primitive features of their group. Its composition indicates open forest woodland because of the dominance of grazer and browser taxa as previously suggested by phytolith studies.

HIGH RESOLUTION STRATIGRAPHY OF THE MESSINIAN/ZANCLEAN BOUNDARY AT THE CUEVAS DEL ALMANZORA SECTION (VERA BASIN, SOUTH-EASTERN SPAIN)

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**Objectives:** A multidisciplinary study using planktonic foraminifera, ostracods, mineralogical contents and stable isotopes ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ) was carried out across the Messinian/Zanclean boundary at the Cuevas del Almanzora section (Vera basin, South-eastern Spain) in order to reconstruct the paleoenvironmental changes that occurred from the end of the Messinian salinity crisis to the early Pliocene reflooding of the Mediterranean sea.

**Methods and Results:** The studied section is 23.70 m thick and it is composed by two segments distant laterally by a few meters. The first segment (I), 5.3 m thick, is composed by homogeneous grey marls, whereas the second segment (II) is 18.70 m thick and partially overlaps the first segment. A total of 126 samples were collected throughout the section.

In the Messinian sediments, mollusks, typical of brackish to lacustrine conditions, were found together with ostracods and benthic foraminifera (*Ammonia tepida*, *Haynesina germanica* and *millioids*). The ostracod fauna is mainly characterized by the presence of Paratethyan species *Loxocorniculina djafarovi*, *Euxinocythere praeabaquana*, *Amnicythere propinqua*, *A. litica*, *A. subcaspia*, *A. accicularia*, *Loxoconcha eichwaldi* and *Zalanyella venusta*. The presence of the nominal taxon (*Loxocorniculina djafarovi*) allows to refer this segment to the homonym biozone. In these layers stable isotopes exhibit negative values typical of brackish waters.

A large variation in the foraminiferal assemblages and the increase of stable isotope compositions characterize the sedimentary layer considered as the base of Pliocene. Planktonic foraminifera show that the Cuevas del Almanzora section contains a typical assemblage of the lowermost part of MPI 1 biozone (Zanclean) with the typical acme zone of *Sphaeroidinellopsis* that occurs between cycles 2 and 6 of the MPI 1 biozone in the reference section of Eraclea Minoa. The ostracod fauna is mainly dominated by the presence of genera *Argilloecia buntonia*, *Bytocipris*, *Costa*, *Cytherella*, *Henryhowella*, *Krithe*, *Parakrithe*, and, typical of normal marine conditions. Two peaks of *Neogloboquadrina acostaensis* senestral coiling permit an accurate correlation with the coeval core section of ODP Site 975. In the Zanclean interval, 6 lithological cycles, well marked by stable isotopes oscillations, permit to correlate the studied interval to Laskar astronomical solution. The Pliocene sedimentary deposits correspond to the first 6 precessional cycles (5.332-5.21 Ma). From cycle 1 to cycle 3 of MPI 1 biozone, marine benthic foraminifera and ostracods repopulated the Mediterranean sea. In fact in cycle 1, the first specimens of *Epistominella exigua* and bolivinids were followed in cycles 2 and 3 by *Oridorsalis stellatus*, *Cassidulina subglobosa*, *Uvigerina peregrina* and *Gyroidinoides* spp.. The first occurrence of *Siphonina reticulata* was recognized in the uppermost part of *Sphaeroidinellopsis* spp. acme zone (cycle 5) with an age of 5.22 Ma. Since *S. reticulata* disappeared from the Mediterranean sea in lower Messinian at 7.16 Ma, its reappearance in cycle 5 of MPI 1 biozone indicates the return to a good ventilation of bottom waters, also testified by positive  $\delta^{13}\text{C}$  values.

**Conclusions:** The return to normal marine conditions after the Messinian Salinity Crisis in the Mediterranean sea appears synchronous between the western Vera basin (Cuevas del Almanzora section) and the Central Sicilian Basin (Eraclea Minoa section). Differently, the re-oxygenation of bottom waters developed diachronously from the western to the eastern part of the Mediterranean sea.

**NEW NEOGENE BRACHIOPOD RECORDS FROM THE MEDITERRANEAN (MALTA AND ITALY)**

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Brachiopods are not dominant but regular members of Neogene benthic assemblages, and their investigation has a long history both in the Mediterranean and the Central Paratethys. During the last decades, brachiopod research activity was more intensive in Paratethyan areas. However, recently diverse Mediterranean brachiopod faunas were studied mainly from Malta and Italy.

In Malta extensive new materials were studied from three different sources (Michael Gatt's private collection in Rabat; Pierre Moissette's collection in Hungarian Natural History Museum, Budapest; Arie Janssen's collection in Naturalis Biodiversity Center, Leiden; altogether about 2800 specimens). Additionally to the nine species of brachiopods already recorded in previously published works (*Aphelesia bipartita*, *Terebratula terebratula*, *Maltaia maltensis*, *Gryphus minor*, *Terebratulina retusa*, *Megathiris detruncata*, *Joania cordata*, *Megerlia truncata*, *Lacazella adamsi*), a further ten species are being added (*Novocrania anomala*, *Aphelesia margineplicata*, *Cryptopora lovisati*, *Terebratula maugerii*, *Gryphus sphenoides*, *Argyrotheca bitnerae*, *A. cuneata*, *Platidia anomioides*, *Dallina septigera*, *Megerlia eusticta*). A new *Aphelesia* species was also recorded. Stratigraphic distribution of the identified species within the Maltese Oligocene-Miocene strata was investigated in detail. Brachiopods were found in all Oligo-Miocene formations of Malta, but they are most common and diverse in the Upper Coralline Limestone.

A small Middle Miocene (Langhian) brachiopod fauna was found in Naturalis Collection (Leiden) from Sicily, collected by Arie Janssen, which has evolutionary and palaeogeographical significance. Only 16 specimens are available, from which five is *Terebratulina retusa*, while the other 11 specimens belong to three different species of cementing thecideid brachiopods. Until now, superfamily Thecideoidea was represented in the Mediterranean only by *Lacazella* (family Thecideidae) both in fossil and recent assemblages. Family Thecidellinidae is unknown from Mediterranean, and has also very limited occurrence in the Central Paratethys (*Minutella*, Middle Miocene, Bulgaria). The small fauna from Máucini (Sicily) contains a *Lacazella* species (*L. adamsi*), and a probably new *Thecidellina* species. The third form also belongs to Thecidellinidae, but represents not only a new species, but a new genus, too.

A very limited Late Miocene (Tortonian) brachiopoda fauna was earlier published from Tetti Borelli (North Italy) in 2010 on the basis of Naturalis Collection in Leiden (26 specimens, 6 species). Recently a new, diverse collection arrived to Naturalis from this locality (Roest collection) which contains also a more numerous brachiopod materials (200 specimens, 9-10 species). Additionally to some rare taxa, an interesting and surprising form was also recognized. The outer morphology of the three pedicle valves are similar to *Megathiris*, however, internally there are 2-3 strong and wavy septa on both sides of the small median septum, which are until now unknown in family Megathiridae. The official description of this new megathiridid genus is obstructed by the absence of brachial valves of the new form; therefore, any available brachiopod material from Tetti Borelli would be welcomed.

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**NEW STRATIGRAPHIC DATA TO DEFINE THE VOLUME AND BOUNDARIES OF THE REGIONAL UNITS OF EASTERN PARATETHYS (KONKIAN, SARMATIAN, MAEOTIAN, PONTIAN)**

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**Objectives:** The stratotypes of the regional stages of the Neogene stratigraphic scale of the Eastern Paratethys were proposed in the relatively shallow basins where the stratigraphic successions are generally incomplete. For the modernization of the Middle Miocene Neogene stratigraphic scale we need to study more complete successions from the deep settings with integration of new methods.

**Methods & Results:** Our stratigraphic framework, based on a combination of high-resolution palaeontological and paleomagnetic data.

**Konkian regiostage.** The Karaganian/Konkian boundary is dated at 13.4 Ma. Konkian regiostage subdivided into three units and correspond to the certain stages of development of the basin - Kartvelian, Sartaganian and Veselyankian. According to paleomagnetic data, three units are correlated well with the Badenian (Kosovian) of Central Paratethys.

**Sarmatian regiostage.** The Konkian/Sarmatian boundary is dated at 12.65 Ma.

Diatoms were the most informative group for the correlation of the Upper Sarmatian with open basins. Within the *Achnantes brevipes* regional zone there is an appearance of the oceanic species: *Thalassiosira burckliana* (LO-7.9 Ma), *Th. grunowii* (LO-7.8 Ma), and *Th. antiqua* (FO-7.7 Ma). The position of the Sarmatian /Maeotian boundary remains controversial. Faunistically dated by the mollusks Maeotian deposits begin with bioherms. However, 10 m and 35 m lower in clays, characterized only by the diatoms of *Achnanthes brevipes*, there are erosion boundaries, the lower of which are very significant in paleomagnetic data.

**Maeotian regiostage** is subdivided into Lower Maeotian with the marine euryhaline fauna and the Upper Maeotian, mainly with *Congerina*. Upper Maeotian is characterized by periodic invasions of marine waters with a richer microfauna and phytoplankton. These levels have foraminiferal assemblages with predominance of species of marine genera *Discorbis* and *Cassidulina*. The presence of *Thalassiosira maeotica* (Lower Maeotian) and *Cymatosira savtchenkoi* (tops of the Lower and Upper Maeotian) and oceanic marker species in the complexes of regional diatoms allowed the direct correlation with the Messinian and the *Nitzschia miocenica* and *Thalassiosira convexa* zones (subzone A of the tropical oceanic zonal scale). According to diatom data, the Maeotian marine invasion began about 8-7.9 Ma. The wider transgression was in Late Maeotian - the beginning of the Pontian and belongs to the Early Messinian — to pre-evaporate deposits and lower part of lower evaporate deposits.

**The Pontian regiostage** begins with the appearance of brackish-water endemic Pannonian and Aegean origin in mollusks, ostracods, the complex with *Caspidinium rugosum* - *Galeacysta etrusca*, as part of organic phytoplankton. The age of the base of the Pontian according to zonal diatom species is estimated in the range from 6.2 to 5.9 Ma, and according to paleomagnetic data - about 6.1 Ma. The boundary with the Azov layers of the Kimmerian according to paleomagnetic data is slightly older than the end of the chron C3r.

**Conclusions:** The conducted biostratigraphic and paleomagnetic studies showed that the reference sections of the Taman Peninsula can be proposed as faciostratotypes for the Konkian, Sarmatian, Maeotian and Pontian and the points of its boundaries (except for the Sarmatian/Maeotian boundary, where the contact is erosive) and may well correspond to the modern requirements that are used in the study of Global Standard-stratotype Section and Points (GSSP).

**INVESTIGATION OF THE MIDDLE MIOCENE MEDITERRANEAN ICHTHYOFAUNA AND PALAEOENVIRONMENTAL REPRESENTATIONS ON CYPRUS ISLAND (ALASSA, LEMESOS)**

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**Objectives:** The fish otolith assemblages identified in the Serravallian sediments of Alassa section (Limassol, Cyprus) were analyzed in order to define the paleoenvironmental conditions in the study area during the Serravallian age.

**Methods & Results:** 5 samples, weighting approximately 30 Kg each, were collected along the Alassa section. All sediment samples were diluted in tap water overnight, and were sieved through 250 µm diameter mesh sieve, while the otoliths and foraminifera were handpicked under a stereoscope. The palaeobathymetric estimation method of Nolf & Brzobohaty (1994) was applied and the assemblages were further analyzed palaeoecologically on the basis of present-day ecological information of the identified taxa. To reinforce palaeobathymetric estimation, a micropalaeontological analysis was employed, based on the collected foraminifera. More specifically, the oceanity index (Gibson 1989) was used to define palaeodepth. The 426 studied otolith specimens (sample 1) belong to the following 9 taxa: A) Myctophiformes: *Diaphus befralai* Brzobohaty and Nolf, 2000, *Diaphus cavallonis* Brzobohaty and Nolf, 2000, *Ceratoscopelus maderensis* (Lowe, 1839), *Benthosema suborbitale* (Gilbert, 1913), *Myctophum* cf. *fitchi* Schwarzhans, 1979, *Diaphus* sp.1 and *Diaphus* sp.2. B) Gadiformes: *Bregmaceros* sp. Tompson, 1840, C) Stomiiformes: Phosichthyidae.

**Conclusions:** From the stratigraphic range of the accompanied Foraminifera the age of the studied sample is estimated as Lower to Middle Serravallian. The fish assemblages consist mainly of pelagic and mesopelagic taxa, thus can be considered typical of a continental slope environment of depths >500 m. *Bregmaceros* sp. is the most abundant species in Alassa. The existence of such tropical species, not found in the Mediterranean today, indicates a warmer climate during the Middle Miocene in the eastern Mediterranean.

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**NEW PALYNOLOGICAL DATA ON THE CONTINENTAL ENVIRONMENT AND MARINE ENVIRONMENT OF THE SOUTHERN CORRIDOR RIFAIN (RHARB BASIN, NORTHERN MOROCCO) AT THE MIOCENE-PLIOCENE BOUNDARY.**

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During its evolution from the Lower Miocene to the upper Pliocene, the western Mediterranean has experienced several and crucial geodynamic and eustatic events. The messinian salinity crisis is one of the main Neogene paleogeographic events in the Mediterranean Sea.

The return of water in the Mediterranean basin after the mesinian salinity crisis through the Strait of Gibraltar indicates an important stage in the Mediterranean Sea story. The Mio-Pliocene sedimentary deposits recorded environmental and climatic conditions, which marked the rifain corridor during this epoch.

In the Mediterranean, there is a gap more or less important to the passage Miocene-Pliocene. This gap is of variable duration according to the sequences; it seems relatively short in the sequence of Sicile. Currently, the only known site with no hiatus is the BouRegreg Valley located at the western end of the Mediterranean region on the Atlantic coast. It is, however, a sequence located near the South rifain furrow that allowed exchanges between the North Atlantic and the Mediterranean area (Van der laan et al.,(2006)).

According to Van der laan et al., (2006) the flooding of the Mediterranean to the Miocene-Pliocene boundary (in the wake of messinian salinity crisis) is not associated with a high glacio-eustatic level of the sea, but with tectonic causes.

The knowledge on the vegetation and climate to the passage of the Miocene-Pliocene South furrow rifain are rare. The only study that currently exists (Warny, (1999)) shows that the section of BouRegreg is poor in pollen. In order to obtain information on the marine and continental environment during the Miocene-Pliocene transition. a preliminary palynological study was conducted on two geological sections (l'Oulja A, and l'Oulja B), located in the Gharb basin.

The biostratigraphical analysis based on planktonic foraminifera of the Miocene-Pliocene transition from the studied sections reveals the succession of five biostratigraphic events well correlated with the scale of reference of Lourens and al. (2004). These biostratigraphic events allowed dating precisely these sedimentary deposits.

The dinoflagellate cyst's assemblage, spores and pollen show that the continental contributions dominate the marine contributions. The abundance of neritic dinoflagellate cyst's associations and the rarity of oceanic taxa explain that the deposit environment was epicontinental neritic with fluvial contributions. Similarly, these assemblages indicate that surface waters are warm.

The Mio-Pliocene flora is represented by elements currently living in China and Europe beside the Mediterranean elements.

The vegetal landscape is open-dominated by herbaceous plants colonizing the low-lying altitude, while trees take hold in average altitude. The climate is subtropical hot and xeric in low plain.

**Keywords:** Palynology, Rifian corridor, Miocene / Pliocene boundary, continental environment, marine environment.

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**HOW GOOD A RECORD OF THE LATE MIOCENE WESTERN MEDITERRANEAN IS THE SORBAS BASIN SUCCESSION?**

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The Abad Marls are the well-exposed, pre-Messinian Salinity Crisis succession that was deposited in the Sorbas Basin, SE Spain. These sediments have been intensively studied and astronomically tuned. Consequently, the succession is used extensively in cross-Mediterranean correlation where it is commonly used to illustrate the behaviour of the Western Mediterranean during the Late Miocene. Here we present a new sub-precessional Sr isotope dataset from the Abad Marls and a biomarker dataset that spans both the Abad Marls and the overlying Primary Lower Gypsum. These data demonstrate that, despite the small precessional fluctuation in Western Mediterranean precipitation, the well-developed lithological cyclicity visible in the Abad Marls does not result from local run-off or changes in local climatic conditions, but from changes in exchange between the Western Mediterranean and Sorbas basins. Combining these two geochemical datasets with previous faunal data also shows that while Sorbas salinity was driven by that of the Western Mediterranean, Sorbas had an amplified salinity response, a positive hydrologic budget and lithological cyclicity out of phase with the Western Mediterranean's. We therefore conclude that while the Sorbas Basin can provide insights into the physical properties of the Western Mediterranean during the Late Miocene, the sedimentary record of the two basins is likely to be distinctly different.

MICROPALAEONTOLOGICAL ASSEMBLAGES AND INDEX FORAMINIFERA AROUND THE KARPATIAN/BADENIAN (BURDIGALIAN/LANGHIAN) BOUNDARY ON THE ALPINE-CARPATIAN JUNCTION

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**Introduction:** Study area includes the Danube, Vienna and Novohrad - Noograd Basins situated at the Alpine–Carpathian–Pannonian junction. They represents a region of the Central Paratethys which was strongly influenced by orogenic processes and climatic changes during the Early to Middle Miocene. The study discusses possible gateways assuming two-way circulations where the surface and deep waters can be exchanged between the Mediterranean, Central Paratethys and the Eastern Paratethys. We study the influence of this change in planktic and benthic foraminiferal assemblages and the stratigraphical constrains.

**Objectives:** We would like to discuss the standard stratigraphy which has been commonly used for the Miocene Central Paratethys, which is in contradiction to the standard basin model. So how can we trace the boundary in connection to water masses changes? What are the spatiotemporal attributes of this boundary?

**Methods & Results:** To identify the stratigraphic and depositional model, profiles focused on the Karpatian/Badenian boundary within the northern Central Paratethys were studied. High resolution biostratigraphy (calcareous nannoplankton, planktic foraminifera), paleoecology and sedimentological analyses were performed. Calcareous nannoplankton, foraminifera, organic-walled dinoflagellata and pollen assemblages from different sites (wells and outcrops) that may yield the Karpatian/Badenian boundary are presented here: Špačince-5, Nová Vieska-1 wells (Danube Basin), Príbelce, Trenč, Hámor, and Čebovce (Novohrad-Nógrád Basin) and Cerová Lieskové outcrops (Vienna Basin). The reconstruction of the marine paleoenvironment in selected time intervals additionally included a number of published datasets from the Western Carpathians and adjacent areas. Moreover taphonomic changes of foraminiferal assemblages were identified and evaluated.

**Conclusions:** The estuarine circulation can be interpreted based on identified taxa which can be connected to upwelling in several basins of the Central Paratethys (Late Burdigalian – Early Langhian; ~17–15 Ma). The gateway towards the east was closed, while the trans-Dinaride marine connection opened toward the west in the southern realm of the Central Paratethys. During the rest of Langhian (~15–13.5 Ma) the area was flooded and reached the maximal extent. In front of the uplifting Western Carpathians the Carpathian Foredeep depocentres show a shift of subsidence from the west to east. Aridification led to a salinity increase in the surface water and anti-estuarine circulation regime of this semi-closed sea started to communicate with the global ocean across the trans-Dinaride gateway. During the Early Serravallian (13.8-12.6 Ma) the partial isolation of this semi closed basin led to low oxic conditions in the entire Central Paratethys, however an occasional open circulation regime with the Eastern Paratethys (or Mediterranean) is expected. In the Late Serravallian (12.5–11.5 (11.6) Ma), the water masses from the Eastern Paratethys entered the semi-closed basin again. An estuarine circulation supported the water exchange with the eastern back-arc basins domain. This regime is assumed for a short period of time. Uplift of the Western Carpathian mountain chain can be the reason of fluctuations in humidity during this climatic period. This study was supported by grants: APVV-16-0121, APVV-15-0575, APVV-14-0118, APVV-0099-11, VEGA 1/0559/17. Our gratitude goes to the Nafta petroleum company.

**GEOLOGICAL MAP AND TEKTONIC MAP OF AIGION AREA "AIGION SHEET"  
(N. PELOPONESSUS, GREECE)**

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The geological and tectonic map of the region covered by the AIGION sheet of the Hellenic Army Geographical Service (H.A.G.S.) 1:50,000 scale topographic map of Greece is presented. It regards the greater region of Aegialia and Kalavrita. The geological mapping was carried out in 1:20.000 scale, however, serving the aims of the presentation, the map is presented in 1:50.000 scale. The geological mapping of the region of AIGION sheet was conducted during stratigraphic, tectonic, and paleogeographic (post-alpine formations) studies.

Stratigraphic columns of the alpine and post-alpine formations of the area are also presented as well as geological cross-sections in 1:20.000 scale. From the geological mapping, it resulted that the geological formations comprising the area of AIGION sheet are alpine and post-alpine.

Alpine formations: Phyllite-Quartzite Unit (Arna), Tripolis Unit and Pindos Unit.

Post-alpine formations: The post-alpine formations occupy the largest part of AIGION sheet area. They include mainly fluvio-torrential, terrestrial, lacustrine and lagoonal deposits.

These deposits are developed and distributed in a WNW-ESE general direction. They occur mostly within three basins, which correspond to tectonic grabens orientated parallel to the Corinth Gulf. The three basins in the study area are: The Kalavryta basin at the southern part, the Valta basin at the central part and the Western Paleo-Corinth Gulf basin at the northern part.

Other Pleistocene deposits: Breccias of Ksirokampos at Chelmos. talus deposits of the fan-deltas, red weathering mantle, Pleistocene fluvial terraces and Glacial deposits.

Holocene deposits.: Holocene deposits occur in many areas of the AIGION sheet. They are

Holocene alluvial fan deposits, which extend along the coastal zone of Aigialia, fluvial

terraces, talus and talus cones, and alluvial plains of sands and gravel inside the valleys of rivers and torrents.

The study area based on its fault tectonics is composed of two 1<sup>st</sup> order fault blocks, that of Helmos and Corinth Gulf. The Corinth Gulf block is composed by four 2<sup>nd</sup> order fault blocks that in their turn are composed of smaller scale 3<sup>rd</sup> and 4<sup>th</sup> order fault blocks, each one of them including a horst and graben structure. The 1<sup>st</sup> and 2<sup>nd</sup> order fault blocks and bounded by 4 fault zones of WNW-ESE trend and sinistral oblique-normal kinematics. Moreover, 6 fault zones of smaller scale were identified with dextral oblique-normal kinematics, five of which follow a NNW-SSE trend and one only follow a NNE-SSW trend. These zones define horst and graben structures both in alpine and post-alpine sediments.

The tectonic data of the area are indicative of a domino type structure that has developed in a WNW – ESE direction and has been tilted towards the S. Furthermore, it is multiply transversely faulted and dextrally offset. The fault kinematics indicates that the region is under a composite field of deformation, with a dominating extensional stress field.

**PALEOCLIMATIC RECONSTRUCTION FROM MARINE RECORDS OF CENTRAL AND WESTERN MEDITERRANEAN AREA OVER LAST FIVE MILLENNIA USING PLANKTONIC FORAMINIFERA**

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**Objectives:** Planktonic foraminifera have been used to reconstruct the climate evolution of the last five millennia from marine sediment cores of western and central Mediterranean Sea.

**Methods and Results:** We provide the comparison between planktonic foraminiferal paleoclimatic curves obtained from different environmental areas of Mediterranean basin: i) western Sicily Channel (core water depth 475 mbsf); ii) Minorca Basin (core water depth 2117 mbsf); iii) north Tyrrhenian Sea (core water depth 87.2 mbsf) and iv) central Tyrrhenian Sea (core water depth 93 mbsf). These results are compared with paleoclimatic curves from extra-Mediterranean marine areas to evaluate the geographical extent of the recognised climatic variability.

**Conclusions:**

The planktonic foraminiferal paleoclimatic curves document an overall warm and stable climatic condition from 3500 BCE to 750 BCE, corresponding to low amplitude oscillation in  $\Delta 14C$  residual and to a period where NAO index does not show particular trend and/or main oscillation. From 750 BCE to ca. 250 BCE, the Mediterranean and extra-Mediterranean paleoclimatic curves document a transition-cooling phase, which becomes consistent at ca. 250 BCE, in correspondence of the sharp global cooling related to Homeric solar minimum. This short time interval (750 BCE - ca. 250 BCE) corresponds to the well-known Sterno-Etrussia excursion in terrestrial magnetic field.

The global cooling over the last two millennia, related to the decrease in insolation, is documented by the parallelism of all planktonic foraminiferal paleoclimatic curves, showing an isochronous response of Mediterranean and extra-Mediterranean planktonic foraminifera. This long-term cooling trend results parallel to a progressive trend vs negative anomaly in  $\Delta 14C$  residual as well as parallel to the shift of NAO index trend toward positive values and reach the maximum cooling during the Little Ice Age at ca. 1800 CE (Maunder Minimum). At ca. 550 CE the planktonic foraminiferal paleoclimate curves show a further cooling phase, which age corresponds to the Late Antique Little Ice Age (LALIA), considered as an additional environmental factor contributing to the establishment important change in human culture. At 1800 CE, the paleoclimatic curves show a turnover vs the modern warm climate condition.

This comparison will provide a more complete high-resolution picture about the climate changes in the Mediterranean region and the validity of planktonic foraminifera as tool for global paleoclimate reconstruction over the last five millennia.

We acknowledge financial support from the Italian Project of Strategic Interest NEXTDATA (<http://www.nextdataport.it>) "A national system for recovery, storage, accessibility and dissemination of environmental and climatic data from mountain and marine areas"

FLUID TRANSPORT AND MINERALIZATION CONTROLLED BY THE WESTERN CYCLADIC  
DETACHMENT SYSTEM IN NORTHERN AND CENTRAL HYMITTOS MT. (ATTICA, GREECE)

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**Objectives:** In the present paper we examine the characteristics of detachment fault system related mineralization in northern and central Hymittos mt. (Attica, Greece), along different structural levels that are accompanied by brittle and/or brittle-ductile deformation. The mineralized parts of the low-angle faults are associated with extensive Fe-hydroxide impregnations and zones of intense dolomitization and silicification.

**Methods and Results:** The northern and central Hymittos area comprise greenschist-facies metamorphosed rocks that were exhumed at shallow crustal levels in the late Miocene through a series of low-angle normal faults (LANFs) with top to SSW sense of shear that belong to the Western Cycladic Detachment System (WCDS). Small oxidized Pb-Zn and Fe-ore deposits that are accommodated by these low-angle normal faults are well expressed at Ag. Ioannis Kynigos, Glyka Nera (northern) and Sesi (central). The individual ore deposits are hosted by mylonitized marble at the interface with hanging wall lithologies. All these three sites have been subject to small scale exploration in the recent past. At Ag. Ioannis Kynigos (northern Hymittos) mine Pb (-Cu) sulphide mineralization is identified and described for the first time. The ore is exposed in underground mining caves developed along a zone of intercalations of mylonitic marbles and mica-schists in the main branch of the detachment. Scanning Electron Microscope (SEM)/EDS analyses and microscopic study of the ore structures showed that the main sulfide is galena associated with Ag-Cu-Sb sulfosalts and subordinate covellite. The ore is developed in thin veins and fills small cavities of dissolution of the carbonate host. Subsequent oxidation of the primary sulphide ore resulted in the formation of secondary lead carbonate and sulfate minerals and an extensive Fe-oxidation zone within the brecciated carbonate host rock. At Glyka Nera (northern Hymittos), Agios Elefterios mine, the greater part of mineralization is oxidized to smithsonite (calamine), hydrozincite, anglesite, cerussite. The thickness of the ore bearing zone is 1.5-2.5 meters and the Zn content ranges 1 - 2.4 %. It occurs mainly as ~EW sub-vertical veins following sub-vertical normal faults. The hypogene primary ore (Zn and Pb sulfides) is not exposed at surface. At Sesi (central Hymittos) iron-oxide/hydroxide mineralization is developed in a cataclastic zone a few meters thick (2-3m), forming thin rusty black encrustations and larger zones of alteration with a reddish to yellow brown hue. The iron-ore deposit consists of hematite that is extensively replaced by goethite and trace amounts of sulfides and barite. Goethite appears with the typical colloidal forms within voids showing typical open-space filling type microstructures.

**Conclusions:** Based on microstructural evidence, SEM/EDS and bulk ore chemical analyses the types of mineralization corroborate a hydrothermal metasomatic deposition along the Hymittos brittle and brittle-ductile detachment low-angle faults sharing significant similarities to the Lavrion deposit.

**GROWING EVIDENCE ON MID-MIOCENE (BADENIAN) EVAPORITES INSIDE THE CARPATHIAN ARC IN HUNGARY – POSSIBLE IMPLICATIONS FOR GLOBAL CLIMATE CHANGE AND PARATETHYS SALINITY**

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**Objective:** Exploration for oil and gas resulted in finding evaporites unexpected in the Soltvadkert Trough, Hungarian Great Plain, that led to studies on the depositional environment, distribution and age of these evaporites.

**Methods & Results:** There is a growing evidence of evaporite occurrences in Hungary. The correlation to Badenian Salinity Crises (BSC, 13.8 Ma, Middle Miocene) was first established in the Soltvadkert Trough by nannoplankton and foraminifera biostratigraphy. Numerous other boreholes were found since transecting evaporites in data depository. Previously, evaporitic basins were supposed to be found exclusively outside the Carpathian Arc, but we assume evaporite formation in the entire Central Paratethys during BSC. Different scenarios are suggested for what subsequently happened to these evaporites to explain their presence or absence in the geological record. Where evaporites are present, scenario A suggests preservation in subsiding, deep basins overlain by younger sediments protecting the evaporites from reworking e.g. Soltvadkert area based on seismics. Where evaporites are absent, scenario B suggests recycling of these evaporites during Late Badenian and Sarmatian.

**Conclusions:** Scenario B gives a hypothetical explanation for the recorded occurrence of Sarmatian hyper- or normal salinity (e.g. “the myth of the brackish Sarmatian Sea” by Piller & Harzhauser) providing the source of salts from recycling the BSC evaporite. Introducing the idea of reworking BSC salts, a Sarmatian Sea of variable salinity in both space and time from brackish to hypersaline becomes more conceivable. Altogether, these scenarios suggest a much larger amount of evaporites locked up in the Central Paratethys during BSC than previously thought, probably contributing to the step-like nature of cooling of the Mid Miocene Climate Transition, the coeval Mi3b.

**MULTIPHASE DEFORMATION HISTORY OF PAIKON AND TZENA TERRANES (AXIOS ZONE, CENTRAL MACEDONIA, GREECE).**

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**Objectives:** Paikon and Tzena terranes are situated in the centre part of the Axios zone, between Almopia and Paionia ophiolitic belts. Several questions remained unanswered about the structural evolution of those terranes. Whether they form a single tectonostratigraphic terrane or they consist two discrete terranes with different deformation history is one of those questions. Thus, we try here to reconstruct the evolution of deformation of Paikon and Tzena terranes, from Jurassic till recent times, emphasizing the Neogene-Quaternary rejuvenation of inherited structures.

**Methods:** For this purpose, we carried out geological mapping and detailed structural investigations, as well as thorough study of geological contacts, combined with all available geochronological and stratigraphic data. Shear criteria were used in order to study the geometry and kinematics of deformation.

**Results:** Tectonostratigraphic data show that Paikon and Tzena terranes consist of similar tectonostratigraphic units and both have undergone the same multiphase deformation from Mid-Jurassic to recent times (D1-D6). Shortening alternated with extension, while the deformation conditions evolved from ductile (D1 to D3, Jurassic until Cretaceous) to brittle (D4 to D6, Tertiary until now). Compressional events are related to ophiolite obduction, nappe stacking, crustal thickening and terrane accretion, while extensional ones are related to orogenic collapse, crustal thinning, terrane dispersion and basin formation. Therefore, Paikon and Tzena terranes formed by terrane accretion, consist a complicated tectonic nappe pile, including obducted ophiolites rooted in the Axios ocean and travelled westwards from their initial place. This tectonic nappe pile evolved finally into a multiple tectonic window that formed due to successive compressional and extensional events from Jurassic to Tertiary time. The final exhumation of Paikon and Tzena tectonostratigraphic units occurred during the Oligocene – Miocene extensional event in brittle conditions (D5). During Miocene – Pliocene, the D6 extensional event caused faulting, overprinting all the previously structures. D6 structures include high-angle normal, dip-slip to oblique faults, as well as strike-slip faults. A very important D6 fault is the ENE-WSW striking and SSE dipping Aridea fault zone, which is considered to be originally a dextral strike-slip fault, reactivated during the Pliocene – Quaternary until recent as a normal dip-slip fault. This fault separates Tzena from Paikon terrane, forming the Neogene to Quaternary Notia-Periklia depression and leading to post-accretional terrane dispersion.

**Conclusions:** Paikon and Tzena terranes are tectonostratigraphically identical. They formed by terrane accretion, consisting a tectonic nappe pile evolved finally into a multiple tectonic window. Their final arrangement into two terranes separated from Notia-Periklia basin is due to post-accretional terrane dispersion (D6, Miocene to recent).

**Keywords:** accretion, dispersion, tectonostratigraphic terrane, tectonic nappe, strike-slip and normal fault, Neogene deformation.



**DETRITAL ZIRCON AND APATITE CONSTRAINTS ON DEPOSITIONAL AGES, SEDIMENTATION RATES AND PROVENANCE: PLIOCENE PRODUCTIVE SERIES, SOUTH CASPIAN BASIN, AZERBAIJAN**

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**Objectives:** We used detrital zircon U/Pb geochronology and apatite (U–Th–Sm)/He thermochronology to better constrain depositional ages and sedimentation rates for the Pliocene Productive Series in Azerbaijan.

**Methods and Results.** U/Pb analysis of 1378 detrital zircon grains and (U–Th–Sm)/He analysis of 57 apatite grains – from Kirmaky Valley and Yasamal Valley onshore sections, Absheron Peninsula – yielded two distinct sub-populations: 'young' Neogene grains; and 'old' Mesozoic, Paleozoic and Proterozoic/Archean grains. The large numbers of Neogene age grains (around 10% of all grain ages) provided a new absolute age constraint on the maximum depositional age of the Lower Productive Series of 4.0 Myr. These 'young' Neogene zircon grains most likely originated from volcanic ash falls sourced from the Lesser Caucasus or Talesh Mountains.

Two scenarios are presented for the age of the Lower Productive Series: (1) using only zircon grain U/Pb dating, and (2) using both zircon U/Pb and apatite (U–Th–Sm)/He detrital thermochronology.

**Conclusions:** These new age constraints for the Lower Productive series gave much faster sedimentation rates than previously estimated: 1.3 km/Myr in the South Caspian Basin margin outcrops and up to 3.9 km/Myr in the basin centre. The older group of detrital zircon grains constituted the majority of grains in all sample sets (~80%). These older ages are inferred to reflect the provenance of the Productive Series sediment. This sediment is interpreted to have been derived from the Proterozoic/Archean crystalline basement rocks of the Russian platform, Proterozoic/Paleozoic rocks of the Ural Mountains, and Mesozoic sedimentary rocks of the Greater Caucasus. This sediment was likely supplied from northerly sourced drainage that emptied into the South Caspian Basin.

Our analyses also demonstrated that the Productive Series detrital zircon grain age distributions are similar to those of Modern Volga sediments and Jurassic sandstones in the Greater Caucasus.

**SEA LEVEL AND SEASHORE LINE CHANGES: CASE STUDIES IN W, CRETE, W.  
PELOPONNESUS AND CHALKIDIKI PENINSULA, DURING LATE HOLOCENE. GREECE**

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Sea-level changes during the last 18,000 years is a combination of eustatic, isostatic and tectonic contributions. In an effort to minimize the tectonic contributions, our study of sea-level changes in western Crete, w. Peloponnesus and Chalkidiki Peninsula, within historical times is focused on geological-stratigraphic criteria, remote sensing data and GIS techniques and radiocarbon dating of coastal sedimentological formations.

According to sea-level curve, the rapid increase of sea level concluded prior to 5.5 ka and was followed by a slow steady rise at a rate of 0.9 mm/a up to its present stage. Next decades the sea level is predicted to be higher than the present level, the rates of this value are realised in the next few decades and can be attributed not only geological activity but mainly to human-induced global climatic change.

Geomorphological survey along the western coasts of Crete western Peloponnesus and Ierissos Chalkidiki peninsula revealed widespread evidence of uplifted and submerged tidal notches, different phases of beachrock formation, and many relics of ancient coastal constructions. About 1.6 ka BP, when the sea level was at  $-1.25 \pm 0.05$  m. The western tectonic block of the Crete island uplifted by  $9.15 \pm 0.20$  m in its westernmost extremity and by 2.00 m approximately in its eastern boundary. Along the coasts of the studied areas, the younger phase of the submerged beachrocks was identified and measured at the studied areas, together with the submerged tidal notches and archaeological remains.

According to the Greek legislation (2971/2001) as "Old seashore" is defined the land zone resulted from the coastline movement toward the sea caused by natural change or technical work. It is determined by the current line of seashore and the limit of old seashore. In order to map out the line of the old seashore mainly the following four geological factors affecting the formation of coastal area and seashore are checked out:

- A) changes of sea level due to climatic periodicity
- B) geotectonic land movements resulted from fault activity
- G) land and sea interaction
- D) effects from human activity.

For the determination of old seashore the following actions take place:

Study of the Greek and international bibliography concerning the geology of the wider area, focusing on the tectonic movements and the relevant changes of sea level.

Mapping of the coastal region focusing on the spatial determination of streams and recording of the results caused by waves and winds as well as by any anthropogenic activity influencing the alternation of deposition-erosion.

Excavations take place in selected sites, where sediment and, if present, water sampling are carried out. Grain and microscopic sediments, micropalaeontological, volcanoclastic analyses as well as AMS dating, water chemical analysis are performed, in order to determine the physical – chemical characteristics of the sediments and their stratigraphy.

Study of the existing air photos usually covering the period 1945 up to today.

The methods and results of the definition of old seashore carried out in the Prefectures of Chania, Rethymno in Crete Island, at western Peloponnesus and Chalkidiki Peninsula are presented in this paper.

TEMPORAL CHANGES OF ENVIRONMENTAL IMPACT IN THE MARINE COASTAL ZONE OF A FORMER MINING AREA DETECTED BY MEANS OF BENTHIC FORAMINIFERA

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**Objectives:** Due to their hard shell and small size, benthic foraminifera leave a sedimentary record and may be recovered in marine core sediments with high numbers, where they register the effects of environmental changes. Assemblages of sediments deposited under pre-impacted conditions may be regarded as representative of the *in-situ* ecological reference conditions, which may be compared with more recent conditions in order to highlight possible environmental degradation due to anthropogenic impact. The Sulcis Iglesiente mining district (west Sardinia, Italy) was involved, between 1850s and 1990s, in intensive mining which strongly impacted the mainland and the coast, but processes of weathering from mine tailings still affect the area. Core SI69 was collected at 13 m water depth in front of the mouth of Rio Guttu, a stream crossing the mine area, and was investigated for grain size, metal and trace elements and benthic foraminifera in order to reconstruct the historical metal contribution due to anthropogenic activity and recognize the related ecological response of foraminifera.

**Methods & Results:** A group of strongly correlated elements (Ba, Cd, Cu, Hg, Mn, Pb and Zn) showed a typical profile along core depth, characterized by low steady concentrations in the lower part of the core and increased values, particularly for Cd and Zn, in the upper 20 cm. This pattern is attributable to anthropogenic enrichment. Because the whole core is mainly constituted by sand (>96%), it may be assumed that changes of metal concentrations along depth are entirely attributable to changes in metal contribution. Canonical Correspondence Analysis was applied to recognize the effects metals on the foraminiferal assemblage. The elements affected by anthropogenic enrichment showed positive correlation with *Ammonia parkinsoniana*, *Buccella granulata* and *Peneroplis pertusus* and negative correlation with *Ammonia beccarii* and *Lobatula lobatula*. Also the Foraminiferal Number (FN: number of specimens / gram of dry sediment) was negatively correlated to the anthropogenically enriched elements. Other species demonstrated to be indifferent to metal contamination as well as species diversity. Although two species, *Rosalina bradyi* and *Buccella granulata* were found abundant in the whole core, two distinct ecozone were recognizable: ecozone A (0-20 cm), characterized by contaminated sediments and low-density foraminiferal assemblage, with prevailing *Ammonia parkinsoniana*, *Buccella granulata* and *Peneroplis pertusus*; ecozone B (20-260 cm), characterized by uncontaminated sediments and high-density foraminiferal assemblages with more abundant *Ammonia beccarii* and *Lobatula lobatula*.

**Conclusion:** This study recognized, in the upper 20 cm of core, an anthropogenic enrichment mainly for Cd, and Zn, attributable to extensive mining and also weathering of mine waste deposits. Although foraminiferal assemblages do not show major changes along core depth, and high species diversity would suggest, in general, a good environmental status through time, the comparison of assemblages from the contaminated upper core interval (ecozone A) with reference conditions of the pre impacted interval (ecozone B) reveals that heavy metal contamination determined change of assemblage composition and great decrease of foraminiferal density. Consequently, a comprehensive degradation of the ecological status referable to mining activity was recognized in this study.

**THE JUNE 12, 2017 M6.3 LESVOS OFFSHORE EARTHQUAKE SEQUENCE (AEGEAN SEA, GREECE): FAULT MODEL AND STRESS ANALYSIS FROM SEISMIC AND GEODETIC OBSERVATIONS**

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**Objectives:** we present seismic and geodetic data analysis of the shallow, normal-faulting earthquake sequence offshore Lesvos (Aegean Sea, Greece) that was initiated by the June 12, 2017 M6.3 earthquake.

**Methods and Results:** We use seismological data (relocated events and Moment Tensor solutions from NOA and KOERI catalogues) to identify the ESE-WNW striking seismic fault and to refine its geometry and kinematics using inversion techniques. Despite the large magnitude of the mainshock (M6.3), the surface deformation is not visible with InSAR because of the offshore occurrence of the earthquake. However, cm-size co-seismic horizontal offsets were recorded by the continuous GPS stations (of two private networks) operating at both Lesvos and Chios islands. In Sentinel co-seismic interferograms (C-band) we see no co-seismic displacements within  $\pm 0.3$ - $0.5$  fringe ( $\pm 10$ mm). There are two local InSAR displacement patterns close to Plomari, possibly attributed to slope instabilities, which require further investigation. Lack of signal coherence was detected in the area of village Vrissa, that was heavily damaged by the earthquake.

**Conclusions:** The spatial distribution of relocated events shows the activation of one fault with a total length of about 20 km, at depths 5-15 km. The fault-dip direction is not retrievable from GPS/InSAR but a south-dip is inferred from the aftershocks distribution and sea-bottom geomorphology. The absence of visible InSAR signal is consistent with the slip-model predictions, based on the GPS models.

BENTHIC FORAMINIFERAL RECORD OF PALEOENVIRONMENTAL CHANGES IN THE LANGHIAN  
ST. PETER'S POOL SECTION (MALTA ISLAND)

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**Objectives:** Benthic foraminiferal assemblages were analyzed in order to reconstruct oxygen and productivity main changes at the sea-floor during the Langhian interval in St. Peter's Pool Section (South eastern Malta Island).

**Methods and Results:** Quantitative analysis of benthic foraminifera was carried out on a dataset of 139 samples. For each sample the fraction > 125 µm was divided with a microsampler to obtain unbiased aliquot with about 200-300 benthic foraminifera. Relative taxa abundance, expressed as percentage of the total number of benthic foraminifera per sample, was calculated. To illustrate the changes in oxygen contents at the sea-floor we applied and compared the Oxygen Index (OI) of Schmiiedl et al. (2003) [(HO/(HO+LO)+DIV)\*0.5; HO=relative abundance of high oxygen indicators and LO=relative abundance of low oxygen indicators deep infaunal] and the Oxygen Transfer Function of Kouwenhoven and van der Zwaan (2006) [Oxygen content µMol/L= 7,9602+5,95 (% oxyphilic taxa)]. The abundances curves of four selected benthic species identify four main intervals, also highlighted by oxygen content estimates at the sea-floor.

Interval A (0 - 7 m): increasing trend of the oxic species *Siphonina reticulata* and decreasing trend of *Cibicidoides dutemplei-subhaidingerii*, oxic species with little tolerance of oxygen deficiency. Occurrence of the high productivity species *Uvigerina peregrina* and dysoxic species *Bolivina spathulata*.

Interval B (7 - 10 m): gradual decreasing trend of *S. reticulata* and two peaks of *C. dutemplei-subhaidingerii* of 47% (7.63 m) and 48% (9.69 m); increasing trend of both *U. peregrina* and *B. spathulata*.

Interval C (10 - 12 m): decreasing trend of *S. reticulata* and *C. dutemplei-subhaidingerii*; significant increasing trend of *U. peregrina* and *B. spathulata*, and significant peak of *Melonis barleeanum*, a species controlled more by cold temperature than by food supply.

Interval D (12 - 31 m): increasing trend of *C. dutemplei-subhaidingerii* from the base to the top of the interval and of *S. reticulata* up to about 24 m; decreasing trend of *U. peregrina* and positive and negative peaks of *B. spathulata*.

**Conclusions:** The most important factors that control benthic foraminiferal distribution throughout the St. Peter's Pool section are mainly oxygenation and food supply, but also temperature of bottom sea waters. The benthic foraminiferal assemblages suggest alternating relatively more oligotrophic and oxic conditions (Intervals A and D) and more trophic (high productivity Intervals B and C) and cooler conditions (Interval C) at the seafloor.

**PALAEOENVIRONMENTAL EVOLUTION OF AKROPOTAMOS AREA (STRYMON BASIN, NORTHERN GREECE) DURING LATE MESSINIAN BASED ON BENTHIC FAUNAL ASSEMBLAGES**

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**Introduction:** The Strymon Neogene Basin (Northern Greece) is one of the extensional basins that were developed in the early–middle Miocene over the southern part of the northern Aegean along NE-SW and NW-SE trending faults. Akropotamos area exposes a clastic sequence with gypsum intercalations, which is dated in the Messinian and it is located in the southeastern part of the Strymon Basin.

**Objectives:** Purpose of this research is to collect palaeoecological evidence from ostracod, benthic foraminiferal and mollusk assemblages in order to reconstruct the palaeoenvironmental history of Akropotamos area during Late Messinian.

**Methods & Results:** 61 samples were obtained from four sections of Akropotamos area, but only 19 samples bear palaeontological content. A total of 32 ostracod species referable to 23 genera were identified. The qualitative and semi-quantitative ostracod analysis indicated characteristic differences in the composition of the ostracod assemblages along the studied sections. The preservation of benthic foraminifers is generally moderate to poor in most samples. The mollusk fauna is relatively diverse, composed of bivalves and a few gastropods, annelids, and echinoids. Paratethyan ostracod and mollusk species are present in several samples.

Generally, at the lower part of the sections the benthic assemblages reflect a shallow marine environment as they are consisted mainly of the ostracod taxa *Loxocauda* aff. *L. decipiens*, *Xestoleberis* spp., *Paradoxostoma* sp., *P. turbida*, *Callistocythere excanaliculata* and the benthic foraminifers *Valvulineria complanata*, *Rosalina globularis*, *Cibicides lobatulus*, *Ammonia beccarii*. The mollusks are represented by *Serpula* spp. reefs, small ostreids and rare *Chlamys multistriata*. Upwards, assemblages initially present a mixed character with the presence of marine and brackish taxa and eventually, brackish mesohaline to oligohaline taxa prevail. Finally, the ostracod faunas are dominated by *Cyprideis agrigentina* and *Loxoconcha muelleri*, both species common during the lower Lago Mare interval. Foraminifers are rare, mainly represented by *Porosonion granosum*, *Ammonia beccarii* and *Bolivina seminuda*. Mollusks are represented by juvenile thin-shelled sessile bivalves. The composition of these assemblages indicates a low mesohaline environment with short-term dysoxic facies.

**Conclusions:** The distribution and composition of the benthic faunal assemblages allowed the discrimination of eight stages in the environmental evolution of Akropotamos area. Overall, a gradual transition is recorded from a shallow infralittoral well-vegetated marine environment to a sheltered lagoonal environment with salinity fluctuations due to the communication with the sea and/or freshwater input.

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**ASTRONOMICAL TUNING OF THE BLACK SEA PONTIAN**

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**Objectives:** The Messinian Salinity Crisis (MSC) of the Mediterranean is the greatest event in the Miocene related to dramatic paleoenvironmental changes and deposition of evaporites. Most researchers assume that the Black Sea Pontian partially or entirely corresponds to the MSC interval. We present the results of high-resolution cyclostratigraphic analysis of all the substages of the Black Sea Pontian designated at the Zheleznyi Rog section (Taman Peninsula).

**Methods & Results:** The Pontian sediments at Zheleznyi Rog were investigated by cyclostratigraphic methods using the magnetic-susceptibility rocks and statistical techniques. Magnetic susceptibility was measured with a "KM-7" magnetic susceptibility metre with a sensitivity of  $10^{-6}$  SI units (GF Instruments, Brno, Czech Republic). In total, 2,145 measurements of the magnetic susceptibility of Maeotian/Pontian and Pontian Rocks were obtained with an average vertical spacing of 7 cm. The magnetic susceptibility (MS) of the transition Maeotian/Pontian rocks ranges widely with values from 0.016 to  $0.937 \times 10^{-3}$  SI units. In the studied interval, a 145-m-long sedimentary sequence, spectral analysis revealed statistically significant signals with 6.1-8.2m and 3.0-4.0m wavelength. These signals correspond to the obliquity and precession cycles, respectively. Astronomical tuning of the Pontian sedimentary record at the Zheleznyi Rog confirms that the Pontian began at ~6.1 Ma. The estimated ages of base and the top of Portafarian in the Zheleznyi Rog section are ~5.65 Ma and ~5.45 Ma, respectively. The Novorossian /Portafarian boundary is marked by a hiatus of ~150-160kyr. The top of the Bosphorian dates at ~5.27 Ma. During the Pontian, and at the end of the Maeotian, the average sedimentation rate varied from 13.5 to 19.5 cm/kyr/

**Conclusions:** This study correlates the main steps of Messinian Salinity Crisis (MSC) of the Mediterranean to the Black Sea Pontian record.

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**THE EARLIEST MODERN TESTUDINIDAE: A NEW *TESTUDO SENSU STRICTO* FROM THE LATE MIOCENE (VALLESIAN) OF GREECE**

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We report on the earliest modern *Testudo* from the late Miocene (Vallesian, MN 10) of the hominoid locality, Ravin de la Pluie (RPI), Greece. The material corresponds to a small nearly complete carapace owning a well distinct hypo-xiphiplastral hinge, which supports the *sensu stricto* generic assignment. This new terrestrial testudinid specimen is characterized by original features (a tectiform narrow-elongated shell shape with a pentagonal pygal and a long, posteriorly elevated, lenticular and rounded dorsal epiplastral lip), with regard to other Mediterranean known hinged forms and allowing the erection of the new taxon *Testudo hellenica*, close phylogenetically to two Greek species, the extant *T. marginata* and the fossil *T. marmorum* (Turolian, 7 Ma). This record ties the first appearance of the genus *Testudo sensu stricto* to a minimum age of 10-9 Ma.



TERTIARY GREEK PETRIFIED PALMS

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**Objectives:** A more systematic approach to the study of fossil wood in Greece could lead to a more advanced knowledge of the evolution of the Cainozoic flora in the Aegean region to date and a more accurate reconstruction of paleoclimate.

**Methods & Results:** It must be specified that the study was realized on a previously selected material as belonging to palm structures, representing 100 specimens, in total 290 thin sections. By the study of this material 5 form-species of *Palmoxylon* have been identified, 3 forms of *Rhizopalmoxyton* and 1 form of *Palmocaulon* as it follows: *Palmoxylon daemnoropsoides* (UNGER, 1845), *P. chamaeropsoides* n. sp., *P. coryphoides* n. sp., *Palmoxylon sabaloides* GREGUSS, 1969, *P. trachycarpoides* n. sp., *P. phoenicoides* HOFMANN, 1944, *Rhizopalmoxyton daemnoropsoides* n. sp. *R. phoenicoides* n. sp., *Rhizopalmoxyton* sp. (aff. *Corypha*), *Palmocaulon* sp. (aff. *Phoenix*).

**Conclusions:** Greece it's a Haven of Cainozoic petrified forests, known in the insular part as well as in the continental one. Even if the evolution of the Cainozoic Flora in this large region is generally known, a paleoxylotomical study of an important collection of petrified Palm woods started now could bring a new image of its floral composition in Aegean region. Our impression is that during the Cainozoic time, these regions were forested lands, the present day situation having, most probably, an anthropogenic explanation. In this respect, taking into account the vegetal fossil associations already described in this region, we can imagine Mixed Mesophytic Forests living under tropical to warm temperate paleoclimate strongly influenced by the presence of the Tethys (Mediterranean) Sea in the neighborhood. Beside Conifers, there is a rich association of arboreal Dicotyledons (as Laurales, Fabales, Myrtales) and Monocots (Arecales). The samples of Palm petrified wood representing the stem structure or from the basal part or other plant parts, comes from Lesvos, Limnos, Evros, Kastoria from Late Oligocene to Early Miocene, also from Peloponnese which could be Plio-Pleistocene.

**BIOGEOGRAPHIC RELATIONSHIPS OF GREEK FLORAS FROM THE LATE OLIGOCENE  
TO THE PLIOCENE**

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**Objectives:** Modern accounts on establishing biogeographic relationships of western Eurasian late Oligocene and Neogene floras do not exist. Recently (Hoek Ostende et al., 2015 *Palaeobio. Palaeoenv.* DOI 10.1007/s12549-015-0199-7), vertebrate palaeontologists investigated such patterns for the early Miocene (MN4) localities of the Kimi-Aliveri basin. The aim of this paper is to assess biogeographic relationships of Greece floras spanning the time period late Oligocene to Pliocene. We establish biogeographic relationships for fossil-taxa encountered in the macrofossil record with modern families, genera, and infrageneric taxa. In a forthcoming paper, we will assess biogeographic relationships to coeval floras across Eurasia.

**Methods & Results:** We use a database compiled during recent work (Velitzelos et al., 2014 *Rev. Palaeobot. Palynol.* <http://dx.doi.org/10.1016/j.revpalbo.2014.02.006>) and investigate biogeographic patterns at family, genus, and species level. For families, the great majority shows a tropical-N temperate modern distribution suggesting that niche evolution and biome crossings happened at the family level. At the genus level, a more distinctive N temperate pattern emerges. A few extinct genera belong to (extinct) western Eurasian lineages of families with a modern subtropical-tropical distribution (e.g. the cycad "*Encephalartos*"). At the species level, again, most taxa belong to modern N temperate groups (*Acer*, *Alnus*, *Betula*, *Fagus*, *Quercus*) that are entirely absent from the tropics. A few fossil-species (e.g. *Smilax miohavanensis*) represent the only Old World representatives of clades that are today found in the subtropics and tropics of the Americas. Similar patterns are seen (at the genus level) when investigating the palynological record.

**Conclusions:** By the late Oligocene, a distinctive N temperate floristic component had become established in Greece. While horizontal N hemispheric migrations are indicated by the fossil record, crossing to and from Africa appears not to have occurred for the main woody elements. Hence, biome boundaries may have been established since the late Oligocene.



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