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**24-28 June 2024, Montpellier, France**

**Book of abstracts**





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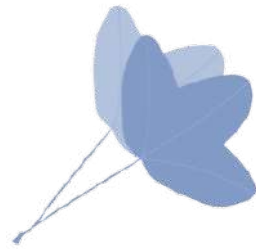
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**SESSION 1**  
**DINOFLAGELLATE CYST RESEARCH**







**KEYNOTE**

**Dinoflagellate evolution: fossil evidence and integration with  
molecular phylogenetic data**

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The first detailed phylogenetically based classification of dinoflagellates, incorporating both fossil and extant forms, was published in 1993. At the time very little if any molecular-phylogenetic data were available, and so the classification was based almost entirely on morphology and anatomy. The 1993 scheme emphasized tabulation (in the broad sense including amphiesmal-vesicle arrangement) as one of the main criteria. The scheme reflected that most fossil and modern dinoflagellates could be classified under a relatively few tabulation types: for example the gonyaulacoid–peridinioid type, and that some of these types have deep fossil roots. Although incomplete, the dinoflagellate fossil record reveals critical evidence, such as the occurrence of now-extinct groups, including the order Nannoceratopsales (a “missing link” between Dinophysales and taxa with a gonyaulacoid–peridinioid tabulation type) and the peridiniacean subfamily Wetzelielloideae. Also evident is that some groups were once far more common and diverse than they are today, for example the family Cladopyxidaceae. Also significant is the fact that patterns in the dinoflagellate fossil record can lead to important insights, such as the notion that dinoflagellates underwent a fundamental evolutionary radiation in the early Mesozoic, an interpretation now supported by the molecular evidence. As the molecular evidence has evolved, it has broadly supported the phylogenetic interpretations based on the 1993 scheme, but the latter has needed some readjustments along the way. Currently, the molecular evidence supports most clades interpreted from the 1993 scheme, for example the coherence of the order Gonyaulacales and its suborders. However, the sequence of branching indicated in the 1993 scheme is not always clearly supported by the molecular data. We look for insights into dinoflagellate evolution by comparing schemes developed from morphological and molecular evidence. Another important topic involves dinoflagellate “prehistory”: obviously dinoflagellates have a history prior to their early Mesozoic radiation, but the extent to which that history is observable from the fossil record — for example the role, if any, of acritarchs — has been controversial. The biogeochemical record is an important source of information for resolving this issue. Thus, although the incompleteness of the dinoflagellate fossil record is sometimes bemoaned, we should celebrate that the group does have a significant representation in the rocks, and also the power of combining different lines of evidence in unravelling the group’s evolutionary history.

**Keywords:** dinoflagellates; evolution; fossil record; molecular phylogenetics; classification; tabulation types.



POSTER

**Palynological investigation from Late Cretaceous-Paleogene  
in the Middle Atlas basin (Morocco)**

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In the context of a multidisciplinary project encompassing stratigraphic, chemostratigraphic, and paleontological studies, our objective is to elucidate the faunal and floristic turnover that occurred during the Cretaceous-Paleogene transition in the Moroccan Middle Atlas region. This area offers a significant potential for investigating the impact of sea-level, climate change, and tectonics over depositional environments across the K-Pg boundary in the Northwestern African margin. In this context, we present our results of a palynological analysis carried out in the southeastern flank of the Oudiksou syncline.

The Achlouj section previously yielded charophytes and vertebrate remains suggesting that the lower marine El Koubbat Formation and upper marine to continental Irbzer Formation span the Maastrichtian-Paleocene interval. A quantitative analysis of 51 samples from this section revealed rare palynomorphs, except in the stratigraphic interval covering the top of the El Koubbat Fm. and the base of the Irbzer Fm. This interval yielded a rich and well-preserved dinoflagellate cyst assemblage, with abundant *Areoligeraceae*. The association is composed of the following taxa: *Areoligera senonensis*, *Areoligera coronata*, *Areoligera medusittiformis*, *Glaphyrocysta ordinata*, *Glaphyrocysta vicina* and *Circulodinium distinctum*. The marker taxa contained in this association suggest a late Maastrichtian age.

The organic residues from the marine part of the section (the El Koubbat Fm. and the base of the Irbzer Fm.) indicate an increased dominance of phytoclasts, which suggests a proximal continental shelf depositional environment with fluctuations from a marginal basin environment. The high level of amorphous organic matter in some levels suggests a transition from anoxic-dysoxic conditions to oxic conditions in the interval between the uppermost part of the El Koubbat Fm. and the lowermost part of the Irbzer Fm.

**Keywords:** palynology; dinoflagellate cyst; biostratigraphy; K-Pg transition; Middle Atlas; Morocco.



POSTER

**Palynological characterization of the Barremian-Aptian transition in the Gorgo a Cerbara section (Northern Apennines, Central Italy): new elements of correlation with other key Tethyan sections**

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The Gorgo a Cerbara section (Umbria-Marche Basin, Northern Apennines, Central Italy) was formerly proposed as a GSSP candidate for defining the base of the Aptian stage, at the base of the magnetic chron M0r (Erba, 1996). The re-examination of the ammonite fauna occurring within the M0r revealed that the base of the Aptian Stage, as proposed by Erba (1996), is close to the base of the Martelites sarasini Zone of Barremian age (Frau et al., 2018). Based on these results and on the C isotopic record, an alternative position for the base of the Aptian could be represented by the negative C-isotope spike marking the Oceanic Anoxic Event 1a (OAE1a - Selli level, marker-bed in the Umbria-Marche Apennines), (Weissert and Erba, 2023).

Previous palynological studies of the Gorgo a Cerbara section provided valuable palynostratigraphic information on the Barremian-Aptian transition, allowing comparisons with other Tethyan key sections (e.g. Cismon, Southern Alps, Italy; Unida and Patruno, 2015). Recently, a new palynological investigation was carried out in Gorgo a Cerbara, focusing on a 5.5 m thick interval spanning the uppermost Maiolica Formation to the lower part of Marne a Fucoidi Formation, including the Selli level.

The palynological assemblages recorded from the interval below the base of the Selli level show a remarkable affinity with the Barremian historical stratotype in the Angles section (Southeast France; De Renéville and Raynaud, 1981). They are dominated by the presence of common *Druggidium deflandrei*, *Cassiculosphaeridia reticulata* and *Pterodinium* spp.. The species *D. deflandrei* is very common from the Barremian of the Tethyan domain, ranging, with rare occurrences, in the lowermost part of the Aptian (it is more common in the Aptian of the Boreal domain, Drugg and Habib, 1988; Harding, 1990). *Odontochitina operculata*, *Prolixosphaeridium parvispinum* and the angiosperm pollen *Afropollis* sp. are also recorded below the Selli level, which is consistent with their lowest stratigraphic occurrences within the late Barremian (Torricelli, 2000; in-house TotalEnergies database). The acritarch *Pinocchiodinium erbae* is recorded a few centimeters below the base of CM0r. This species was previously recorded by Torricelli (2000) in the Cismon section (Belluno Basin, Southern Alps, Italy) from the top of CM0r (up to the Selli level). This study points to an earlier appearance of *P. erbae*, likely dateable to the latest Barremian (Buratti et al., 2023).

The Selli level is characterized by the last occurrence of *Rhynchodiniopsis aptiana*, which is not younger than lowermost Aptian in the Tethyan Realm (Torricelli, 2000). This event seems to be present in the same lower Aptian stratigraphic level in the Cismon section. The species *Afropollis* cf. *jardinus* is also recorded within the Selli level, which is consistent with its lowermost stratigraphic occurrence in the early Aptian (e.g. Doyle et al., 1982; Torricelli, 2001).



**Keywords:** palynology; Cretaceous; Aptian; Barremian; OAE1a; Italy; Tethys.

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POSTER

**Barremian—Aptian (Early Cretaceous) dinoflagellate cysts from the Scotian Margin, offshore eastern Canada**

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The Scotian Margin is located in offshore Nova Scotia, Atlantic Canada, and includes a well-developed succession of Mesozoic strata that accumulated during the opening of the North Atlantic Ocean following the breakup of Pangea. Biostratigraphic studies of Mesozoic–Cenozoic strata along the Scotian Margin began in the early 1970s and focused on zonation schemes for each fossil group. Subsequent work, however, has emphasized an event-stratigraphic approach, combining palynologic with micropaleontologic and nannofossil events, as well logs and seismic horizons. Extensive taxonomic treatment of Late Cretaceous and Cenozoic palynomorphs from the Scotian Margin were also undertaken, but did not extend to the Triassic to Early Cretaceous interval. Thus, our present aim is to develop a detailed taxonomic review and a comprehensive event-stratigraphic scheme for this earlier interval of the Scotian Margin based mainly on palynology, integrated with macrofossil, nannofossil and sequence stratigraphic analyses. In our initial research, we are focusing on Lower Cretaceous conventional cores, including studies at the Panuke B-90 well.

Data from sedimentary facies, including macrofossil and ichnofossil assemblages, suggest that, up from the base of the section studied there is an initial, regressive transition from a shelfal (neritic) to a mainly estuarine-brackish setting. The regressive trend is followed by a transgressive trend through most of the Upper Member of the Missisauga Formation, culminating in a return to fully marine conditions near the base of the overlying Naskapi Member. The presence of the dinoflagellate cyst (dinocyst) species *Muderongia microperforata* and *Palaeoperidinium cretaceum*, considered tolerant to low-salinity waters, supports a brackish-estuarine setting in much of the Upper Member of the Missisauga Formation. However, the relatively abundant and rich dinocyst assemblages in specific intervals within this member indicate frequent fluctuations in and out of the estuarine complex, with intermittent connections with a fully marine environment.

The dinocyst assemblages and key bioevents recorded in this study suggest a Barremian age for the Upper Member of the Missisauga Formation in Panuke B-90. This includes the co-occurrence of *Odontochitina operculata* and *Tenua anaphrissa* at the base of the section, indicating a probable early Barremian age, and higher, the *Cerbia tabulata* abundance is a reliable bioevent for the late Barremian to early Aptian interval. The palynological data also confirm an early Aptian age for the overlying Naskapi Member of the Logan Canyon Formation, based on the presence at its base of the age-diagnostic ammonite *Deshayesites* sp.



Near the boundary between the Missisauga and Logan Canyon formations, the  $\delta^{13}\text{C}$  isotope ratio results show a negative carbon isotope excursion and subsequent recovery, which we interpret as the Cretaceous Oceanic Anoxic Event 1a (OAE1a, or Selli Event). At the onset of the event, dinocysts show a relatively high abundance and species richness; but this trend changes upwards, and at the top of the Selli Event both abundance and species richness decrease and *Cerbia tabulata* temporarily disappears. Based on the above results, our ongoing study of the Panuke B-90 conventional cores and coeval successions will contribute to a comprehensive event-stratigraphic framework for the Scotian Margin.

**Keywords:** dinoflagellate cysts; Early Cretaceous; paleoenvironments; Selli Event; Scotian Margin; stratigraphy.





TALK

**Palynostratigraphy from the Bathonian—early Callovian (Middle Jurassic) of Cabo Mondego, Lusitanian Basin, Portugal**

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Middle Jurassic strata are well developed in the Lusitanian Basin, especially at Cabo Mondego, located on the western-central coastal region of Portugal. Outcrops include those of the Cabo Mondego Formation, which comprises the entire Middle Jurassic succession, from uppermost Toarcian to the upper Callovian. Although the lower part of the Middle Jurassic succession has been comprehensively investigated, including the Global Boundary Stratotype Section and Point (GSSP) for the Bajocian stage and the Auxiliary Boundary Stratotype Section and Point (ASSP) for the Bathonian stage, the strata from uppermost lower Bathonian to upper Callovian lack detailed paleontological and biostratigraphical studies. To address this issue, we examined 45 productive samples for palynology from the Cabo Mondego section at Lage do Costado beach, spanning the early Bathonian *Procerites aurigerus* ammonite biozone to the early Callovian *Bullatimorphidites bullatus* ammonite biozone. We aim to document significant dinoflagellate cyst stratigraphical ranges and identify key bioevents, which would be fundamental for the age control of this part of the section.

In this study, we recorded typical Middle Jurassic palynomorph assemblages, with the araucariacean pollen *Araucariacites australis* and *Callialasporites* spp. being the dominant group. The pollen *Exesipollenites tumulus* and *Spheripollenites* spp. and the spores *Deltoidospora* spp., *Ischyosporites variegatus* and *Leptolepidites* spp. are also common. Among dinoflagellate cysts, the *Ellipsoidyctium-Valensiella* complex are the most abundant group, especially in the lower and middle part of the sections (early to late Bathonian). An exception occurs near the early/middle Bathonian boundary, where a significant *Ctenidodinium cornigerum* acme was identified, with this species attaining about 96% of the total palynomorph assemblage. Other common taxa present in this interval are: *Chytroeisphaeridia chytroeides*, *Ctenidodinium sellwoodii*, *Epiplosphaera* spp., *Gonyaulacysta adecta*, *Tubotuberella dangeardii* and *Valensiella ovulum*.

The dinoflagellate cyst diversity slightly increases in the Bathonian/Callovian transition, where the first occurrences of *Impletosphaeridium? varispinosum*, *Surculosphaeridium? vestitum*, the *Systematophora* complex and *Tubotuberella eisenackii* were recorded. Taxa such as *Endoscrinium acroferum*, *Meiourogonyaualax* spp., *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, and indeterminate complex chorate dinoflagellate cysts are also present in this upper part of the succession. These taxa are characteristic of Bathonian and Callovian ages, and *Impletosphaeridium? varispinosum* is a reliable early Callovian marker. The ranges and bioevents reported in this study support the early Bathonian to early Callovian age of the



succession at Lage do Costado beach and provide detailed biostratigraphical data for this part of the Cabo Mondego Formation.

**Keywords:** dinoflagellate cysts; miospores; biostratigraphy; bioevents; Middle Jurassic; Lusitanian Basin.



POSTER

**Dinoflagellate cysts from the Upper Cretaceous (Campanian-Maastrichtian)  
from The Naze Peninsula, James Ross Island, Antarctica**

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We present findings from a comprehensive examination of dinoflagellate cysts in outcrop samples sourced from the Snow Hill Island Formation (SHF) section in James Ross Island, Antarctica. The assemblages of dinoflagellate cysts are rich and predominantly feature gonyaulacoid taxa. The appearance of *Kallosphaeridium? helbyi* and *Chatangiella granulifera*, alongside the initial occurrence of *Pterodinium cretaceum*, suggests a likely late Campanian age (~76.4~72.1 Ma) for the lower strata. Conversely, the first appearance of *Manumiella bertodano* and the last appearance of *Odontochitina operculata*, *Xenascus ceratioides*, and *Stiphrosphaeridium anthophorum* indicate an early Maastrichtian (~72.1~70.0 Ma) age for the upper strata. When integrated with existing paleobotanical and palynological data, our results point to a medium-high continental and marine productivity characterized by temperate paleoclimate devoid of glaciers. Lithological and paleontological evidence suggests primarily inner neritic marine depositional environments. The prevalence of shales in the lower segment of the lower Maastrichtian interval hints at a slightly deeper setting. In contrast, the middle part of the lower Maastrichtian exhibits a shallower, transitional environment, as evidenced by the presence of theropod dinosaurs and decapod crustaceans.

**Keywords:** dinoflagellates cysts; biostratigraphy; paleoecology; Antarctic Peninsula; paleoproductivity.



TALK

## The Application of Dual Nomenclature in Organic-walled Dinoflagellate Cysts

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Dual nomenclature in dinoflagellates is supported under the current Nomenclatural Code for algae, fungi and plants (ICN) and allows a fossil-defined (usually cyst) species to bear a name other than that of its equivalent non-fossil species, as established for example by incubation experiments. Two names can then apply to the same cyst morphotype, reflecting the separate concepts and criteria used for fossil- and non-fossil taxa. The ICN explicitly distinguishes between fossil- and non-fossil taxa (diatoms excepted), recognising the fundamental differences in their underlying taxonomic concepts. Living organisms can be circumscribed potentially on the basis of their entire life history and genome, whereas fossils cannot. These concepts and this distinction form the basis for dual nomenclature. Fossil-species are normally and logically assigned to fossil-genera and non-fossil species to non-fossil genera, a practice that facilitates dual nomenclature, which operates at the species level. Ambiguities arise when binomials combine elements of fossil- with non-fossil taxa.

For example, the fossil-genus *Lingulodinium* is typified by the holotype of *Lingulodinium machaerophorum*, an extant fossil-species from the Miocene of Australia. The theca-defined non-fossil species equivalent to *Lingulodinium machaerophorum* is *Gonyaulax polyedra*. Dodge in 1989 emended *Lingulodinium* to include thecal characteristics and transferred *Gonyaulax polyedra* to it, as *Lingulodinium polyedra*. However, most fossil-defined species of *Lingulodinium* are extinct, their motile stage morphologies hence unknowable. The genus *Lingulodinium* is therefore returned to its fossil status, and the new non-fossil genus *Lingulaulax* Head et al. 2024a along with the new combinations *Lingulaulax polyedra* (von Stein 1883) Head et al. 2024a and *Lingulaulax milneri* (Murray & Whitting 1899) Head et al. 2024a have been proposed respectively.

The cyst-defined extant *Spiniferites elongatus* and *Spiniferites membranaceus* were emended to incorporate information on their motile stages, and transferred to the non-fossil genus *Gonyaulax*, as *Gonyaulax elongata* (Reid 1974) Ellegaard et al. 2003 and *Gonyaulax membranacea* (Rossignol 1964) Ellegaard et al. 2003. This unified approach to dinoflagellate nomenclature severs an important link with the Cretaceous-defined fossil-genus *Spiniferites*. Head et al. (2024b) applied dual nomenclature in returning these species to their previous assignments as *Spiniferites elongatus* and *Spiniferites membranaceus*. We then transferred *Pterosperma ovum* to the genus *Gonyaulax*, as *Gonyaulax ovum* (Gaarder 1954) Head et al. 2024b, to provide an equivalent non-fossil name for *Spiniferites elongatus*, even though both species are typified by a cyst. A distinctive motile stage obtained from published cultures started with cysts assignable to *Spiniferites membranaceus* allowed *Gonyaulax lewisiae* Head et al. 2024b to be proposed as its equivalent non-fossil species.



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**Keywords:** dinoflagellate cysts; dual nomenclature; *Lingulodinium*; *Lingulaulax*; *Spiniferites*; *Gonyaulax*.



TALK

**A new view of the phylogeny of thecate dinoflagellates**

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Understanding the relationships between different groups of organisms is essential for uncovering their evolutionary history and classifying them. In the case of the dinoflagellates, a group defined largely by vesicles in the cell cortex that often contain cellulose plates, different groups are morphologically defined based on their tabulation patterns. However, the relationships between these groups based on molecular data are still unclear. The first landmark phylogenomic study of dinoflagellates used an alignment of 180 genes to conclusively show that thecate dinoflagellates are monophyletic. But that study did not resolve the deep phylogeny of dinoflagellates. This is also the case in more recent phylogenomic studies.

We hypothesize that this lack of resolution may partially be explained by the relatively simple phylogenetic models, and smaller alignment lengths. Here, we assemble a dataset composed of 320 genes and analyze it in a Bayesian framework using the more complex CAT+GTR+G model.

We give a general overview of phylogenetic models, and present preliminary results from our phylogenomic analyses. In particular, we focus on the Symbiodiniaceae, the position of which has lacked consistent support in previous studies. By mapping morphological data onto the phylogeny, we propose how tabulation patterns may have evolved among the dinoflagellates.

**Keywords:** phylogenomics; molecular phylogenetics; evolution; dinoflagellates; tabulation.



TALK

**Dinocyst assemblages in MIS 6 and MIS5 of the Sea of Marmara (Turkey)  
and connections to adjacent seas**

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The Sea of Marmara (SoM) is the connection between the vast Black Sea-Caspian Sea basin (Pontocaspian) and the Global Ocean via the Mediterranean Sea. Its water levels and water conditions have widely varied over times. Combining two cores in the SoM and using organic-walled dinoflagellate cyst assemblages as the main proxy (combined with alkenones and benthic foraminifera), allow qualitatively reconstructing water conditions during Marine Isotopic Stages (MIS) 6 and 5, such as sea-surface salinity and oxygen level.

A clear main marine phase is illustrated in MIS 5e. A minor marine incursion occurred during MIS 5c, mostly supported by alkenone data. The rest of the record indicates brackish Pontocaspian conditions, with more *Spiniferites inaequalis* in MIS 6 and more *S. cruciformis* in the non-marine parts of MIS 5.

At the MIS 6/MIS 5 transition, an earlier initial marine flooding in the SoM (dinocyst assemblages) was highlighted in comparison to the Black Sea. The marine reconnection occurred at different moments as seen in the terrestrial vegetation reconstructed from pollen analysis linking the two seas.

**Keywords:** dinocysts; Sea of Marmara; palaeosalinities; sea level; last interglacial; penultimate glacial; pollen.



TALK

**Using infrared spectroscopy to understand the macromolecular taphonomy of organic-walled dinocysts: a phylogenetic perspective, and implications on dinocyst ecological functions and affinity studies of organic microfossils**

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Organic-walled resting cysts of dinoflagellates (dinocysts) are composed of dinosporin, a substance known to be compositionally different from other resistant (and commonly fossilizable) biomacromolecules such as sporopollenin (from pollen and spores), algaenan (from green algae) and lignin (from higher plants). Recently, infrared spectroscopic analyses of modern dinocysts have revealed a relatively broad variety of dinosporin types, some similar to cellulose ('transparent dinosporin'), others with additions of pigments, or aliphatic, aromatic, or proteinaceous compounds. As these cysts serve as protective capsules, the compositional variability of their cyst wall is likely related to the dinoflagellate's survival and proliferation in specific environments.

For this study, the spectroscopic dataset on modern cysts was extended to a wide variety of fossil taxa, as old as the Middle Triassic (i.e., temporally close to the earliest appearance of dinoflagellates in the fossil record). The resulting >500 spectra—recorded from individual specimens—revealed specific macromolecular changes and differential preservation behaviors in different dinosporin types during burial and diagenesis. Similar trends were also observed in a series of artificial thermal maturation experiments on modern cysts, these generally show (1) a progressive loss of functional groups (mainly due to the destruction of proteins and sugars) and associated relative increase of more stable aliphatic moieties, (2) a progressive increase in carbonyl groups (likely due to oxidative cross-linking of molecular oxygen with unsaturated lipids), and (3) the formation of (poly)aromatic moieties at higher thermal maturities (similar to those observed during thermal maturation of sporopollenin). Eumelanin pigments in typically brown





dinocysts (which are not exclusively formed by heterotrophic species) appeared to preserve well, even in early Cenozoic taxa. In fossil forms, the distinction between transparent, pigmented and aliphatic dinosporin is still possible, with the transparent type appearing to be most ancestral and generally restricted to gonyaulacoid, suessoid and cladopyxidoid cysts. Aliphatic (in peridinioid cysts) and pigmented types (in protoperidinioid cysts) make a later appearance in the fossil record. Within a specific compound class, subtle but systematic compositional variability can sometimes be observed at the genus level, highlighting the chemotaxonomical potential of the method. Aromatic and proteinaceous types were only identified in modern cysts. Based on the compositions and phylogenetic affinities of the different dinosporin types, possible ecological functions are hypothesized, such as the provision of protection against harmful UV-radiation and microbial attack.

The breadth of this study in terms of geological age and taxonomic variety allowed, for the first time, an assessment and better understanding of the macromolecular taphonomy of organic-walled dinocysts. A similar methodology was also applied to other fossilizable biomacromolecules such as sporopollenin and algaenan, the results showing that these compounds, after thermal maturation, can still be distinguished from dinosporin. These results are especially promising in light of spectroscopy-based biological affinity studies of acritarchs.

**Keywords:** dinoflagellates; cyst wall composition; infrared spectroscopy; molecular taphonomy; organic matter preservation; chemotaxonomy.



TALK

**An illustrated palynological zonation of the late Albian and Late Cretaceous succession of the Tano-Ivorian Basin (offshore Ghana)**

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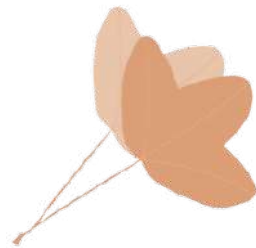
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Studies of cuttings from exploratory wells have led to a refined palynostratigraphic framework for the late Albian to Maastrichtian succession of the Tano-Ivorian Basin (offshore Ghana). The identification of highest and lowest occurrences, influxes and acmes of dinoflagellate cysts (dinocysts), pollen and spores, recurring in the same stratigraphic position and order in different borehole sections, cross-calibrated by calcareous nannofossils and foraminifers, resulted in a zonation scheme suitable for age control and correlation of late Albian and Late Cretaceous sequences along the transform margin of West Africa.

Despite good preservation, discrimination of dinocyst taxa is sometimes difficult because of morphological continua, *i.e.* intermediate forms between the end-members which fit descriptions of official taxa *sensu* Fensome et al. (2019). In such cases, the effort to give specific attribution to hundreds of specimens belonging to morphotypes which intergrade with each other, recovered from a multitude of samples routinely investigated in the context of industrial biostratigraphic studies, is apparently unsustainable. Moreover, it may be useless when the stratigraphic and paleoecological information in the available literature is not associated to distinct species but genera or supra-generic taxa. For these reasons, we often limit the taxonomic identification at generic level (for example *Dinogymnium* spp., *Xenascus* spp., *Oligosphaeridium* spp., etc.) or lump similar-looking species into groups (for example *Trithyrodinium* gr. *suspectum*, *Cleistosphaeridium* gr. *multifurcatum*) or use informally composite names (for example *Coronifera/Florentinia* group). This pragmatic approach to dinocyst analysis is supported by an extensive acquisition of photographic material that, duly annotated, guarantees consistency and repeatability of such informal taxonomic assignments and thus the correlability of datasets acquired over the years in different wells.

**Keywords:** dinoflagellate cysts; biostratigraphy; taxonomy; Late Cretaceous; Tano-Ivorian basin.

**SESSION 2**  
**CLIMATE RECONSTRUCTIONS**  
**AND MODEL SIMULATIONS**







KEYNOTE

**The Holocene *Cedrus* pollen record from Sierra Nevada (Southern Spain) as a proxy for millennial-scale climate variability and human impact in North Africa**

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In this study, we synthesized fossil pollen data from seven sites across the Sierra Nevada mountain range in southern Spain to examine how forests in the western Mediterranean area responded to millennial-scale climate changes and human influence during the Holocene. Our focus lies particularly on *Cedrus* pollen abundances, likely originating from Northern Africa and transported to the Sierra Nevada by wind. Despite *Cedrus* pollen receiving scant attention in Iberian Peninsula Holocene palynological records due to its low concentrations and African origin, our research aims to reconstruct its historical trajectory and understand its relationship with climate.

While *Cedrus* abundances typically remain below 1% in our studied pollen samples, comparison with North African (Moroccan) *Cedrus* pollen records reveals similar long- and short-term trends. Consequently, this record could serve as a proxy for tracking changes in this forest species in North Africa. Our analysis of the Sierra Nevada synthetic record indicates a notable increase in *Cedrus* pollen during the Middle and Late Holocene, closely correlated with declining summer insolation. This likely resulted in cooler annual temperatures in Northern Africa (Middle Atlas and Rif Mountains) and reduced summer evaporation, favoring the growth of this cool-adapted montane tree species and enhancing moisture availability during critical summer periods.

Furthermore, millennial-scale variability characterizes the Sierra Nevada *Cedrus* synthetic pollen record, with *Cedrus* abundance oscillations mirroring well-known climatic fluctuations that historically influenced cedar abundance and altitudinal distribution in montane regions of North Africa. This study underscores the importance of interdisciplinary research combining paleoecology, climatology, and historical ecology to unravel the complex interactions between climate, vegetation, and human activities, providing invaluable insights for informed forest management strategies in a changing world.

**Keywords:** *Cedrus*; Holocene; Climate; Sierra Nevada; Western Mediterranean; Windblown pollen.



POSTER

**Fungi in a Warmer World: Paleocological and Paleoclimatological implications of the Zhangpu Biota Funga, Southeastern China**

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Fungi play a crucial role in the ecology of all terrestrial biomes. It is therefore critical to understand the response of fungal assemblages (fungas) to climate change and incorporate them into climate models. The Miocene Climate Optimum (~18-13 Ma) is analogous to the projected repercussions of anthropogenic global warming. The middle Miocene (~14.7 Ma) Zhangpu Biota from the Fotan Formation of Southeastern China records a series of transitions from subtropical evergreen to tropical evergreen forests to tropical rainforests followed by re-emergence of drought-tolerant subtropical forests. Here, we present a record of fungus recovered from Fotan Formation sediments. Paleocological and Paleoclimatological interpretations were made using the nearest living relative method. The Zhangpu fungus contain primarily ubiquitous subtropical to tropical forest-associated saprophytic fungi, with overall high taxonomic diversity. Of note, *Arecophila* sp., a saprotroph associated with palms and humid subtropical to tropical rainforest conditions is present in the middle part of the section. To date, our results agree with pollen-indicated paleoclimate reconstructions.

**Keywords:** China; fungi; Miocene; Paleoclimate; Paleocology.



POSTER

**A Post Mid-Pleistocene Transition (MPT) Paleoenvironmental Record from the Southwest: Stoneman Lake, Arizona**

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Long continuous lake sediment cores provide enormous potential for interpreting vegetation and climate changes through time. In the American Southwest, long records are revolutionizing our understanding of the characteristics of glacials and interglacials, the extent and timing of megadroughts, and ecological processes such as fires. These important events of the past will most certainly occur in the future, and our ability to learn from them may be helpful for future climate scenarios. One site with potential to study all of these events and more is Stoneman Lake, whose basin is a circular depression formed by a collapse in late Tertiary volcanics. Although nearly dry in recent years, Stoneman Lake has during glacial times been a deep lake, alternating with a shallow wetland during interglacial times. In 2014 our team obtained a nearly 83 meter long record from two drill holes, and the sedimentology of these have been studied (Staley et al. 2021). In addition, the pollen from upper 10 m of the record, covering MIS 6 – 1, has also been published (Jiménez-Moreno et al. 2023). Here we report on characteristics – pollen, charcoal, sediments and hyperspectral scanning imaging (HIS) – of the earlier record, beginning in glacial MIS 16 (by ~676 ky) up to and including glacial MIS 6 (ending ~123 ky). Situated today at ~2048 m asl, on the ecotone between piñon (*Pinus edulis*) – juniper (*Juniperus*) woodland and ponderosa pine (*P. ponderosa*) forest, the site has frequently been sensitive to climate changes. In general, glacial stages have been dominated by tree pollen, particularly since MIS 14 (~563 – 524 ky), with increasing percentage with each successive glacial. Of these, *Pinus* has dominated. In addition, several glacial stages show elevated *Picea* pollen, suggesting 800 – 1000 m lowering of spruce trees during those times. Based on this, MIS 10 (~374 – 337 ky) may have been particularly cool, while MIS 8 (~300 – 243 ky) may have been particularly mild. Deeper glacial lake phases are most often noted by the increased abundance of pelagic alga *Pediastrum*. HIS, which traces lake productivity changes, also suggests higher productivity during glacials. By contrast, interglacial stages have been dominated more by pollen of shrubs and herbs, including grasses. Yet each interglacial was slightly different. Whereas MIS 13 (~524 – 478 ky) was dominated by pollen of Amaranthaceae (i.e. *Atriplex*), MIS 11 (~424 – 374) contained more grass, and in MIS 9 (~337 – 300 ky) it was Asteraceae. Charcoal is more abundant in interglacials than glacials, suggesting greater fire. Pollen of the shallow-water aquatic plant, *Myriophyllum*, dominates interglacials, and HIS suggests interglacial are characterized by low productivity.



These differences suggest that the Stoneman Lake has the unique potential to illuminate long term climate change in an arid region of the Southwest where little information previously occurred.

**Keywords:** Mid-Pleistocene Transition; pollen; charcoal; hyperspectral scanning; Arizona.





TALK

**The spread of aridity in Southwestern Mediterranean at 39 ka BP: linking vegetation, climate dynamics and humans during Heinrich Stadial 4**

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During the last glacial period, the Mediterranean region has demonstrated high sensitivity to sub-millennial climate changes evidenced in paleoclimatic records from Greenland and the North Atlantic. The Heinrich stadial 4 (HS4) around 39 ka BP was described as one of the most notable arid events, marked in southern Europe by the rapid spread of semi-desert vegetation. The Leg 161 ODP 976 core, located in the Alboran Sea about 110 km east of Gibraltar Strait, has provided continuous insights into the dynamics of marine and terrestrial ecosystems along the last glacial period.

A high-resolution pollen analysis of the ODP 976 core (about 90 years as an average time resolution) between 41 and 35 ka BP allowed us to reconstruct the vegetation changes before, during and after the HS4, including Dansgaard-Oeschger 8 and Greenland Stadial 8. Climate changes are also reconstructed from these pollen data. A multi-method approach has been tested here to reconstruct abrupt changes and to provide climate estimates of annual and seasonal temperatures and precipitations. The methods applied are the Modern Analogue Technique (MAT), Weighted Averaging Partial Least Squares regression (WA-PLS), and recent machine learning methods as Random Forest (RF) and Boosted Regression Trees (BRT). Results show that a strong decrease in temperature and precipitation during the HS4 is well identified by all four methods, albeit with varying magnitudes of reconstructed changes. Notably, results highlight the role of the winter season, which agrees well with previous studies and model simulations. Our study also reveals substantial shifts in the hydroclimatic seasonality regime, with a strong decrease in winter precipitation during HS4 associated with the expansion of semi-desert vegetation at regional scales. These results have been compared with available climate reconstructions from the Western Mediterranean (Padul) and the Iberian Margin (MD95-2042, MD95-2043); bringing light on the spatial expression of HS4 aridity and the interplay between Mediterranean and Atlantic influences on sub-millennial climate oscillations in the region.

In conclusion, we show the importance of using a multimethod approach to improve pollen-inferred climate reconstructions, to provide more reliable estimates and to discuss the amplitudes and trends of climate changes. This study enhances our understanding of the environmental and climatic variability experienced by human populations in Mediterranean Europe during the key period of transition from the Middle to Upper Palaeolithic.

**Keywords:** Pollen-inferred climate reconstructions; vegetation dynamics; sub-orbital changes; Heinrich stadial 4; Middle to Upper Paleolithic Transition.



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**POSTER**

**Running Lapse: Palaeoaltitude estimates from pollen-based climate reconstructions**

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Eroding landscapes, such as mountains and their elevations, can be challenging to reconstruct in the geological record. However, from a past climates perspective, the geographical distribution and altitude of orography is a critical boundary condition in modelling studies. Here we present a novel means to determine palaeoaltitude from probability density function climate reconstructions that are derived from pollen. As pollen in a lowland depositional setting is typically a mixed assemblage of local and regional taxa, some probability density function derived climate reconstructions can be multi-modal in distribution – likely reflecting multiple sources. During global reconstruction of Miocene climates, we came across a number of bimodal distributions that were typically from regions with mountainous topography. Here we show that by splitting these bimodal assemblages into their lowland (warmer) and upland (cooler) groups, and by then applying lapse rates it is possible to derive a palaeoaltitude. We have also validated the technique with modern surface samples.

**Keywords:** Modern; Miocene; palaeoclimate; palaeoaltitude; pollen source.



POSTER

**Quantitative pollen-based climate reconstructions  
for the southern forest zone of European Russia**

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This study aims to reconstruct Holocene paleoclimate parameters (T<sub>jul</sub>, T<sub>ann</sub>, T<sub>jan</sub>, and P<sub>ann</sub>) for the southern forest zone of European Russia. Reconstructions are based on the Modern Analogue Technique (MAT), applied to pollen data from peat sediments in one Moscow site and four Smolensk Region sites. The analysis spans the entire Holocene for the Moscow region and the Late Holocene (the last 4 200 years) for the Smolensk Region.

We utilized a specially designed calibration dataset primarily sourced from the European Modern Pollen Database (EMPD). This dataset was curated by selecting all surface spectra from sites located between 5° and 60° E and 45° and 80° N. All taxa were standardized to ensure homogeneity in taxonomic composition, comprising a total of 1500 samples from EMPD, supplemented by 120 unpublished surface pollen spectra from Central Russia collected by one of the study's authors. This dataset underwent rigorous cross-validation and homogenization to reduce local variations in pollen spectra and enhance its predictive accuracy.

The dataset was tested on five fossil pollen sequences from the Moscow and Smolensk regions in Western Russia using a weighted averaging partial least squares (WA-PLS) approach. The most extensive paleoclimate reconstruction, focusing on the Moscow Region center, spans 11 000 years and captures major Holocene climatic events. The paleoclimate reconstructions of the Smolensk Region are confined to the Late Holocene but provide detailed insights into climatic parameters over the last 4 200 years.

**Keywords:** pollen; climate reconstruction; European Russia; modern analogue technique.



POSTER

**Temperate to tropical palaeoclimates on the northwest margin of Europe during the middle Cenozoic (~34—16 Ma)**

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Palaeoclimate reconstruction of the Oligocene to early Miocene (33.9—15.97 Ma) allows us to better understand the climate dynamics of an earth system with similar pCO<sub>2</sub> levels, palaeogeography, and Antarctic ice, to present-day. Previous studies suggested that late Oligocene sea-surface temperature in the North Atlantic increased whereas corresponding pCO<sub>2</sub> levels declined from 700—300 ppm. The recent IPCC AR6 report identified the Miocene as an interval of interest, and that reconstructing and understanding its climate dynamics has implications for better understanding 21st century anthropogenic climate change. This study focuses on the British Isles, which provides a unique perspective on terrestrial climate, as the regional conditions are influenced by the heat outputs of the North Sea and the Atlantic Ocean. While many onshore and offshore records of Oligocene to early Miocene palaeovegetation exist across the British Isles, no previous attempts to reconstruct the palaeoclimate of these warmer and wetter-than-present intervals have been made. Through applying the Bayesian probability-density-function-based reconstruction model, Climate REconstruction SofTware (CREST), on the nearest living relatives of listed fossil taxa from secondary sources, we present the first Oligocene to early Miocene palaeoclimatic record of the northwest edge of Europe. We also present a new method of assigning Köppen-Geiger climate classifications, which we applied to our reconstructions.

Our study suggests Oligocene to early Miocene palaeoclimates were mostly warmer than present, given that reconstructed Köppen-Geiger classifications ranged from a temperate, warm-summer signal with no overall dry season (Cfb) to that of a tropical rainforest climate (Af), the latter climate type's appearance in our Chattian records being paced by orbitally forced long eccentricity (400-kyr) pulses. Seasonal Köppen-Geiger classifications (Cwb) were driven by precessional (26-kyr) forcing. All early Miocene reconstructions were assigned a temperate palaeoclimate with no dry season and warm summers. Our reconstruction of the Mochras borehole revealed large, rapid declines in Mean Annual Temperature which may suggest the presence of sediment deposited over the Oligocene to Miocene Transition. This may be the first instance of this boundary being recorded in northwest European strata.

**Keywords:** Cenozoic; British Isles; palaeobotany; palaeoclimate; palynology; Köppen-Geiger.



POSTER

**Holocene Pollen and Spores from the Lake Izabal Basin in Guatemala:  
Paleoecological and Paleoclimatic interpretations**

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The sedimentary record of tropical America has shown that, in the region, vegetation composition and structure have been variable during the Quaternary. Variability of temperature and moisture availability have been the main climatic drivers of vegetation turnover in the region. Here, we infer climatic and anthropogenic forcings based on two pollen records that comprise the Holocene in Lake Izabal, Guatemalan lowlands. The location of Lake Izabal in eastern Guatemala allows us to understand vegetation response to moisture fluctuations in one of the wettest regions in Central America. The rich and diverse pollen assemblages recovered reveal vegetation turnover patterns that involve taxa from evergreen, deciduous, montane, herbaceous, and aquatic floras in response to climatic variability and human impacts. Vegetation changes highlight an overall decreasing trend in the abundance of forest taxa, as opposed to the overall increasing trend of disturbance associated taxa, implying a progressively sparser forest cover through the Holocene.

Additionally, mean annual temperature (MAT) and mean annual precipitation (MAP) were inferred by combining models of the environmental distribution of modern taxa with palynological evidence. Millennial-scale trends in MAT and MAP appear to be controlled by insolation and the latitudinal migration of the Intertropical Convergence Zone during the Holocene, whereas centennial to lower scale changes appear to be influenced by other factors, including ecological dynamics, the probable existence of disjointed populations, and human influence. Syntheses of results suggest that millennial vegetation trends in the southern wetter Maya lowlands align with results in the drier Maya areas, while centennial scale changes appear to be more affected by local factors. Insights from this work contribute to our understanding of Holocene vegetation dynamics in a predominantly wet area where the Mayans once lived.

**Keywords:** Guatemala; Holocene; pollen; paleoclimatology; Lake Izabal.



TALK

**Miocene fungal diversity from the western Amazonas, Perú: paleoecologic and paleoclimatic inferences**

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Fungi provide essential ecosystem services, ranging from primary decomposition through nutrient cycling, symbiotic interactions, and both pestilence and disease control. Fungal communities, or fungus, are sensitive to changes in temperature, humidity, and nutrient availability. While the Fungi in a Warmer World team has made progress in elucidating ecosystem services of Miocene fungus during periods of past climate change, there remain many regions worldwide that are understudied. One such region is the Amazonas of Peru and Brazil. Existing palynological studies have either ignored fungi or identified them only using form-names, which does not permit their use in delimiting fungus. The sediments from the Peruvian western Amazonas spanning the Miocene Climate Optimum present a unique opportunity to unravel the paleoenvironmental changes that occurred in the context of changing climate and orogenic uplift. Palynological re-study reveals a rich fungal assemblage suggesting good preservation and high diversity. The samples are dominated by cosmopolitan amero spores but also contain taxa indicative of tropical wetland ecosystems. We further enhance the understanding of tropical fungal paleoecology, providing new insights to refine existing reconstructions for continental to marginal marine forested areas.

**Keywords:** Peru; fungi; paleoecology; paleoclimatology; Amazonas.



TALK

**Preliminary palynological results from IODP Expedition 401: A proxy for the Mediterranean-Atlantic gateway evolution**

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Mediterranean-Atlantic oceanic exchange exhibits one of the largest dense saline water outflows of the global ocean. As this plume is thought to be a critical driver of Atlantic Ocean circulation patterns, the transport of water between the Mediterranean Sea and the Atlantic Ocean potentially has great implications for global thermohaline circulation and atmospheric carbon cycling. The evolution of the exchange, from the initiation of the overflow of Mediterranean Outflow Water (MOW) to the establishment of its modern configuration, can therefore significantly impact these processes. IODP Expedition 401 (December 2023 to February 2024) recovered a nearly complete late Miocene to early Pliocene sedimentary record of the evolution by drilling successions on either side of the Gibraltar Strait. Here, we present the first results from a new palynological research project to be conducted on 145 samples collected from this expedition to evaluate sea-surface conditions (dinoflagellate cysts) and the type of vegetation (pollen and spores) that covered the area adjacent to the drilling paleo-location. The purpose is to provide a detailed chronology of any observed vegetation and environmental changes throughout the late Miocene to early Pliocene. Preliminary results indicate well preserved organic material with identifiable pollen, spores, and dinoflagellate cysts. Palynology will provide data key to answering expedition-specific questions regarding paleoclimate reconstructions and various environmental parameters including mean annual temperature and mean annual precipitation. Quantification of these environmental parameters has the potential to refine our understanding of the nature of the Mediterranean-Atlantic gateway evolution. Various causes of the gateway changes between the Mediterranean Sea and the Atlantic have been suggested including the local tectonic activity, global climate (e.g., enhanced evaporation), and eustatic changes driven by variations in Antarctic sea ice volume. In addition to serving as a paleoclimate proxy, this work along with calcareous nannofossil analysis will provide a biostratigraphic zonation necessary for the age constraint of the record. Studying regional events such as the evolution of the Mediterranean-Atlantic gateway exchange will help us to understand and characterize their impact on global-scale processes such as ocean circulation patterns, heat transport, and changes in sea ice volume.

**Keywords:** International Ocean Discovery Program; Mediterranean; Mio-Pliocene; paleoclimate; pollen; spores; dinoflagellate cysts.



TALK

**Late Miocene floras from the Peruvian coastal desert**

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The coastal xeric ecosystems face a significant threat under the current global warming trend. The late Miocene, characterized by warm climates and comparable pCO<sub>2</sub> values (~400–600 ppm), presents an opportunity to understand future warming scenarios for dry coastal ecosystems. In this study, we present the first-known late Miocene paleobotanical record from the Peruvian coast, where arid environments have been in place since at least the late Neogene, thus providing limited and rare sedimentary opportunities for preserving the continental fossil record. This scarcity makes it challenging to formulate hypotheses regarding the evolution of dry and xeric biomes.

Recalibrated leaf-based precipitation estimates indicate that coastal rainfall values were 5 to 10 times higher than today, while significantly wetter conditions compared to the present existed on the western slopes during the austral summer. The combined paleobotanical record reveals a diverse community dominated by elements typical of modern dry forests rather than desert-like habitats, including a mixture of lowland and Andean wooded taxa. These findings suggest a substantial shift in the ecosystem that allowed the development of a greener woodland landscape along the central Peruvian coastal region during the warmth of the late Miocene. Although the sources of extra humidity remain uncertain, warmer sea surface temperatures in the eastern Pacific and local convection may have contributed to the additional moisture. Moreover, intensified or even a permanent El-Niño state during the warmer late Miocene could have potentially served as an additional moisture source. Regardless of the mechanism, our results provide compelling evidence of reduced aridity, leading to a greening of the coastal Peruvian desert and large-scale biome and landscape changes in response to the Miocene greenhouse climate.

**Keywords:** Western Pacific Desert; coastal floras; dry forest; Pisco Basin.





TALK

**Out of Africa: fungal assemblages across the MCO in Nigeria and Kenya**

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The Fungi in a Warmer World project is delineating the utility of fungi as global proxies for paleoecology and paleoclimate across the Miocene Climate Optimum (MCO). These studies are permitting the identification of global fungal guild changes associated with climate-driven environmental changes. Africa is the last continent to be examined, and unlike other studied regions, published studies of fungi across the MCO do not exist. This omission is due in part to the scarcity of correct-age rocks and sediments. Two palynology study-sites with documented abundant fungi have been located: the Agbada Formation in the Kolo Creek Oilfield in the Niger Delta region of Nigeria and sediments from lacustrine deposits in the northern Lokichar and Kerio Valley basins in Kenya. Here, we present the first documented fungal assemblages across the MCO and compare documented changes in assemblage composition from wet environments on either side of the continent.

**Keywords:** fungi; Miocene; Africa; Niger Delta; Lokichar Valley; Kerio Valley.



TALK

**Contrasted climate patterns during the Holocene in the central Mediterranean inferred from pollen data**

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In the central Mediterranean region, many studies suggest that the Holocene is characterized by longitudinal and latitudinal complex and different climatic trends. This particularity in the regional climate system has been highlighted by multiple proxies showing contrasting trends of climate variations. Chironomid temperature-based reconstructions indicate the presence of a thermal optimum in Italy (10,000 – 7,000 cal. BP), contradicting the pollen-inferred quantification of Northern Europe. Those discrepancies point to the need for further investigation concerning the Holocene climate of the Mediterranean region. To date, various studies have attempted to quantify the climate signal through different approaches without being able to propose a consistent climate reconstruction between proxies and sites.

In this context, and within the frame of the ANR project AUTUMN-LAMBS, a multi-proxy method (brGDGTs and pollen) has been developed to quantify the Holocene climate in the central Mediterranean through a regional approach using multiple sites in Southern France, Italy and Greece. We show here the results mainly based on pollen data, which is based on a collection of multiple sites, extracted from international pollen databases (NEOTOMA or European Pollen Database). The pollen-inferred climate is quantified by a multi-method approach, using four different methods (MAT, WA-PLS, BRT and RF) and three modern pollen databases (regional and global).

This study highlights the existence of strong inter-regional differences in the Holocene climate in the central Mediterranean. The results show that not all of the northern Mediterranean basin is marked by a Holocene thermal optimum and that there is strong spatial variability. Central Italy seems to show the presence of a thermal optimum, but this pattern is not observed in the rest of the Mediterranean basin, particularly in Greece and southern Italy.



Southern France and northern Italy show more variable climatic patterns, where altitude seems to play a particular role. Seasonality also appears to be an important aspect of the Mediterranean climate, and its study enables us to highlight different climatic dynamics and gain a better understanding of the particular characteristics of the Holocene climate in this region.

**Keywords:** paleoclimate reconstruction; pollen; transfer functions; northern Mediterranean; Holocene.



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POSTER

**Pollen GALORE: GlobAL mOdeRn pollEn dataset and evaluation of crestr  
Bayesian climate reconstructions**

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Here we present a new global dataset of 21,500 modern pollen samples synthesized from published literature. The samples have had their taxonomy standardized, uncertain identifications removed, species-level diagnoses converted to genus, and genera of Poaceae aggregated to the family level. These data treatment stages enable the dataset to be treated like a pre-Quaternary palynology dataset. The dataset comprises 2310 taxa with 426,480 occurrences. Here we use it to determine how well the crestr technique reconstructs modern climate. This is then used to evaluate the reliability of pre-Quaternary palaeoclimate reconstructions.

**Keywords:** modern; Miocene; palaeoclimate; palynology; data.



POSTER

**Assessing large-scale ecological responses to climatic change of the Central Mediterranean area during the late Holocene**

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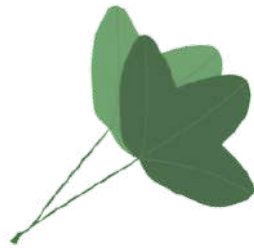
This PhD project is focused on the investigation of the paleoclimatic changes and its deriving mechanism across the Central Mediterranean area from a marine sedimentary record in Gulf of Gaeta, Italy. The geographic location and the semi-enclosed geometrical configuration of this area make it a vulnerable and sensitive region to modern and past climate changes, as well as the high sedimentation rate which makes it a prime location to save the paleo climatic traces. A chemo-palynological proxy is applied to reconstruct the paleo solar irradiance. Specifically, ultraviolet radiation B which acts as a biotic stressor and has the capacity to affect the eco and environmental systems. Ultimately, our project seeks to develop a comprehensive time-based image spanning the late Holocene and can accurately depict the interaction between the ecosystem and climate change.

**Keywords:** paleoclimate reconstruction; central Mediterranean; chemo-palynology; ultraviolet radiation.



**SESSION 3**

**HUMAN-ENVIRONMENTAL INTERACTIONS  
AND VEGETATION CHANGE**









**KEYNOTE**

**Human mobility & cultural contact in the shaping of southern California landscapes: MeSCAL project**

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The California coast is a worldwide biodiversity hotspot, with an estimated 20% of its flora comprising non-native species. It has also been a cultural crossroads, with a long and rich history of prehistoric and colonial migration, contact and settlement, which have played a significant role in the shaping of cultural landscapes. The MeSCAL project (2022-2026), funded by the French National Research Agency, investigates the role that past cultural interactions and human mobility have played in shaping the landscapes of southern California over the last 4000 years. The main objectives are to analyse the spatial distribution of land uses and plants following prehistoric migrations and colonial processes, and to assess their impact on native flora, wetlands and soils.

MeSCAL brings together an international team and combines 1) multi-proxy palaeoenvironmental analyses, i.e. pollen, non-pollen palynomorphs, fire history analysis, diatoms, sedimentology - in continental wetland and marine records providing local and regional information on vegetation and land-use change; 2) calibration of fossil palynological datasets with modern analogues of vegetation and land-use; 3) archaeobotanical analyses providing information on past plant consumption and use; and 4) comparison of palaeoenvironmental results with archaeo-historical and ethnographic datasets. We combine the study of coastal areas in San Diego city and the Santa Barbara-Ventura region with nearby mountain hinterland areas in Kern and Los Angeles Counties. This transect of records will make it possible to assess differences in landscape change between coastal areas under direct colonial control and inland areas with less colonial influence, which may have served as refuges for indigenous populations and landscape. We will present palaeoenvironmental results obtained so far, which show the response of Mediterranean vegetation and wetlands to coupled climate change and prehistoric and colonial management during the last 4 ky, and archaeopalynological results from archaeological cave sites, which show the continued use of native plant resources such as *Datura* and *Lomatium* ssp. by historical Chumash inland communities before and after colonial contact.

**Keywords:** transported cultural landscapes; multi-proxy palaeoenvironmental analyses; southern California, late Holocene.



POSTER

**Alessandro Lagoon and MESCAL: an unusual 1500-year record of vegetation and land-use change from southern California**

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Alessandro Lagoon is a small wetland in southern California, adjacent to the Pacific Ocean. The study of the Alessandro paleoenvironmental record is part of the MESCAL Project – “Mobility & cultural contact in the shaping of southern California landscapes” – and is one of a series of small wetlands situated at some proximity to Spanish Missions established by Franciscan fathers in the 18<sup>th</sup> and 19<sup>th</sup> centuries. San Buenaventura Mission, situated along the Ventura River, is located ~7.5 km north of Alessandro Lagoon. The Lagoon, positioned near the mouth of both the Ventura and Santa Clara Rivers where they empty into the Pacific Ocean, is currently within San Buenaventura State Beach of Ventura, California. Today, the wetland is primarily a freshwater marsh, but periodically receives marine incursions at particularly high tides. A single sediment core was extracted from the purported deepest part of the basin in November 2022. Approximately 95 cm of sand – essentially barren of pollen but containing marine shells – is overlain by ~140 cm of organic muds, with some sandy layers. A series of pollen and charcoal samples have been analyzed from the upper muds to reconstruct the former vegetation and landscape activities that occurred around the Lagoon. All of the pollen samples occur within sediments deposited since ~1100 CE. Pollen early in the record is dominated by *Pinus* and *Amaranthaceae*, with sage scrub pollen as well. The occurrence of dinocysts and vesicular-arbuscular fungi suggest deposition from both marine and freshwater sources. Shortly thereafter, sage scrub pollen types (*Asteraceae*, *Artemisia*, *Eriogonum*, *Rhamnus*, with amaranths increase. This assemblage is immediately before the introduction of *Erodium* pollen, a marker that dates to the mid-16<sup>th</sup> century along the southern California coast. By this time, the dominant pollen types include *Baccharis pilularis*, a common coastal shrub today. Sage scrub pollen types dominate until the 1870s when *Eucalyptus* tree pollen increases after the local introduction of that tree. Marine incursions prior to this period are shown by periodic increases in *Ruppia* and dinocysts, and include one horizon tentatively assigned to the 1812 tsunami that struck the coast. Also noted is the potential Atmospheric River (AR) event of 1861-2. The 20<sup>th</sup> century witnessed an increase in local exotic trees (*Cupressaceae*, *Pinus*, *Juglans*, *Fraxinus*, *Rutaceae*), and a freshening of the marsh, being dominated by *Scirpus* and *Typha/Sparganium* pollen, perhaps facilitated by the construction of a major freeway adjacent to the marsh.



**Keywords:** southern California; land-use; paleofire; introduced taxa; tsunami; Atmospheric River  
**TALK**

## **Holocene vegetation, fire, climate dynamics and human impact in the Upper Orkhon Valley of the Khangai Mountains, Mongolia**

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The Upper Orkhon Valley, located in the Khangai Mountains of Central Mongolia, is mainly covered by a forest-steppe ecosystem. This is an interesting area to study because its vegetation dynamics might have been influenced by climatic and anthropogenic drivers. This study investigates the dynamics of vegetation (pollen), human activity (pollen and NPP) and fire activity (macro-charcoal) from a lacustrine sediment core from lake Shireet Naiman Nuur, covering the last 7400 cal. yr BP. The results of the pollen analysis showed a continual and constant decline of tree species in favour of the development of grasslands. Fire activity was more intense (high peak magnitude) during the mid Holocene, while it became more frequent but less intense from 5000 cal. yr BP onwards, when herbaceous taxa became more present. The NPP analysis suggest that the study site was free of human activity from 7400 to 3500 cal. yr BP, whereas the traces of the development of human societies that took place in the Orkhon Valley, such as pastoralism and grazing activities, have been demonstrated by the increase in coprophilous fungi and the Poaceae Cerealia-type pollen around 3200 cal. yr BP, although its impact seems to have remained low.

**Keywords:** forest-steppe ecosystems; pollen; NPP; charcoal.



TALK

**Early-Middle Pleistocene Transition vegetation and climate in the western Mediterranean: insights into hominin occupation in western Europe**

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Between 1.4 and 0.4 million years ago (Ma), a shift in climate cycles occurs with the transition from obliquity-driven 41 ka cycles to eccentricity-driven 100 ka cycles. This period is known as the Early-Middle Pleistocene Transition (EMPT), and coincided with the appearance of Early Hominins in Western Europe. Prehistoric sites such as Sima del Elefante, Fuente Nueva 3 (Spain), and Pirro Nord (Italy), dating back to 1.4 to 1.2 Ma, provide evidence of this hominin occupations which took place later than in Asia (2 Ma) and in the Caucasus (1.8 Ma). Understanding the climate and vegetation changes during the EMPT is crucial to better understand this temporal discrepancy. Our study is based on palynological analyses from Leg 161 ODP Site 976 in the Alboran Sea, south of the Iberian Peninsula. This marine sequence is a rare continuous record for this time period in the Mediterranean, and complements terrestrial records from Tenaghi Philippon in Greece and Lake Ohrid in the Balkans. New ODP976 pollen data covering Marine Isotope Stage (MIS) 35-31 (1.141 – 1.062 Ma) and MIS 22-21 (0.9 - 0.814 Ma) expands our understanding of the Early Pleistocene Mediterranean environment, combined with previous studies on MIS 20-19 (0.814 – 0.761 Ma) and MIS 30-23 (1.141-0.9 Ma). The pollen analysis is used to reconstruct vegetation changes through eight glacial and nine interglacial periods, offering a detailed view of the environmental dynamics. Results highlight the transitional phases between glacial and interglacial conditions, characterized by rapid and distinct vegetation shifts. The data are compared with key sequences from the Eastern Mediterranean. Finally, we provide a new environmental and climatic framework to discuss mobility, technical and subsistence behaviours of Early Hominins in the Western Mediterranean.

**Keywords:** palynology; marine core; Early-Middle Pleistocene Transition; Paleoenvironment and palaeoclimate; vegetation; West Mediterranean.



POSTER

## A high-resolution analysis of vegetation dynamics during the Pleistocene-Holocene transition in South-West Nova Scotia, Canada

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Pollen analysis of an 8-meter core from the junction of Mersey River with Kejimikujik Lake (Nova Scotia, Canada) allowed for a detailed reconstruction of vegetation dynamics for the period starting 14 thousand years ago. Peopling of the region occurred close to that time, and the core provided an opportunity for the analysis of landscape resources available to local populations and their dynamics through time. Both the river and the lake were important for the indigenous communities, the river acting as a cultural arteria that connected two shores of the peninsula, and the lake serving as seasonal grounds. The stratigraphic sequence includes lacustrine and alluvial sediments, peat layers and immature soils, indicating that the site acted as a lake during high water stands and as a river floodplain during low stands. A remarkably high rate of sedimentation during the Late Pleistocene/Early Holocene transition created conditions for the reconstruction of plant taxa arrival to the area with a resolution of several years.

In the Allerod, the pollen spectra were dominated by Myricaceae (*Myrica* and *Comptonia*), *Betula* (both the dwarf and tree forms), and Ericaceae, with a smaller proportion of *Pinus*, *Alnus*, *Salix* sp., and a considerable proportion of herbs. During the Younger Dryas cooling (12800 and 12500 cal. yrs. BP), the percentage of all tree taxa drastically decreased, giving a rise to Poaceae, *Artemisia*, and other herbs characteristic of cold steppes. Among AP are *Salix* sp. and *Betula* that is represented solely by a dwarf birch. Solitary pollen of *Picea* is of *P. glauca*. The end of the Younger Dryas is marked by the increase in *Betula* (a tree form) and Myricaceae, while the percentage of herbs remains high. The Pleistocene-Holocene transition (11500-11000 cal yrs. BP) was marked by the drastic change of the entire pollen spectrum that occurred within two decades. The dominance of shrubs is replaced by *Picea* (*mariana/rubens* type) that arrives with an array of other arboreal taxa, such as *Pinus*, *Quercus*, and *Larix*; *Larix* is recorded in considerable numbers only in this transition zone. In the early Holocene (10500 cal yrs. BP), *Picea* forests are abruptly replaced by the communities of *Pinus*, *Betula*, and *Quercus*; the change coincided with a peak in microcharcoal. Aquatic taxa, such as *Nymphaea* and *Nuphar* appear in the spectra during this period. Around 8200 cal. yrs. BP, *Tsuga* arrives along with *Fagus* and *Fraxinus*; *Osmunda* become a part of the spectrum, and a share of *Alnus* is increasing.

The pollen analysis was complemented by the analysis of macrofossils that allowed to confirm a local presence of some taxa recorded in the pollen spectra. An example is finding *Abies* macrofossils in Allerod deposits. *Isoetes* macro- and microspores are present in most layers, peaking conspicuously during the Pleistocene-Holocene transition. Some layers contained microdebitage that allowed to put archaeological occupations of the shoreline into a context of contemporaneous climate, landscapes, vegetation, and available resources.

**Keywords:** Nova Scotia; Kejimikujik; Pleistocene-Holocene transition; pollen.



**POSTER**

**Holocene paleoenvironmental dynamics in the Ilha Grande, Brazil,  
assessed by terrestrial and marine microfossils**

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Ilha Grande is a Brazilian island that has a high vegetal biodiversity with a well- documented prehistoric human occupation but few paleoenvironmental studies. In view of this, multiproxy analysis of lagoonal sediments including radiocarbon dating were carried out on a 139 cm-long continental sediment core. The aim of our study was to recognise and explain regional environmental dynamics during the late Holocene (~5200 cal yr BP). The palynomorphs indicate the continuous presence of ombrophilous forest under humid conditions during the last Holocene sea-level highstand, after 5200 cal yr BP. The ombrophilous forest, the main vegetation in the Ilha Grande remained constant throughout the sediment core and was directly influenced by the South American Monsoon System (SASM) system while abrupt changes in the vegetal assemblages were not observed. A phase of low palynomorph concentrations was followed by a marked increase in palynomorph accumulation and diversity which may be linked to the subsequent drop of the sea-level. Dinoflagellate cysts showed a higher accumulation at the base of the sediment core. The low deposition of terrestrial palynomorphs and a high accumulation of dinoflagellate cysts observed at the base of sediment core LS02, dated at 5200 - 4600 cal yr BP, confirm the Holocene sea-level highstand at approximately this age. The high accumulation of charcoal particles identified between approximately 3700 and 3000 cal years BP might indicate human activity related to the long-lasting bonfires continuously maintained by the inhabitants of the archaeological site of Ilhote do Leste.

**Keywords:** Ilha Grande bay; marine palynomorphs; continental palynomorphs; charcoal; Brazil.



**TALK**

**5500 year old Neolithic lake shore villages and pile dwellings in Austria revisited – daily life revealed by palynology and palaeoethnobotany**

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More than 20 Neolithic and Bronze Age lake shore villages are known for Lake Mondsee and Lake Attersee in the UNESCO world heritage Salzkammergut area (Central Austria). This allows testing hypotheses on past environmental changes, agricultural sustainability, as well as on livestock and prehistorical human action. The palynological, palaeoecological, palaeoethnobotanical, and archaeological research performed during the last 8 years resulted in detailed glimpses about the past landscape management by Neolithic societies of the so-called Mondsee Culture. The research of more than 10 Bachelor-, Master- and PhD-students, as well as several post-doctoral researchers and esteemed University colleagues, from disciplines such as geology, sedimentology, X-ray fluorescence spectroscopy (XRF), and sedDNA, did highlight changes in according flora, vegetation, landscape and lake ecosystems through prehistorical times. The studied cultural layers of the lake shore villages are hereby preserved due to their current position more two meters below the today's lake levels, which in turn reveals that the Neolithic lake levels were for a long time at least 2 m lower than today.

**Keywords:** Neolithic; palynology; palaeoethnobotany; archaeology; lake-level change; past forest management.



TALK

**Human-environment interactions in the Bolivian Amazon: evidence from the wetlands of the Llanos de Mojos**

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Throughout history past populations have altered their natural environments through acts of manipulation, which have been inferred through palaeoenvironmental records. Emerging studies from Amazonia have shifted the understanding of how much this manipulation, or 'domestication', has impacted the environment. Evidence includes the discovery of earthworks, agroforestry, wetland management, and the cultivation of economically useful crops. Many of these studies have focused on the impact of these human- environment interactions on terrestrial environments, with few investigating the impact on aquatic environments (such as wetlands), particularly in relation to the impact on ecology and hydrology. One region where it is possible to study the impact of these interactions is the Llanos de Mojos, Bolivia.

The Mojos is a 135,000km<sup>2</sup> sub-basin of the Bolivian Amazon, with a strong seasonal flood cycle and a vegetation mosaic of forests, savannas, and both permanent and seasonal wetlands. Pre-Columbian earthworks (such as raised fields, forest islands, weirs) have been identified throughout the Mojos and are evidence of landscape domestication, with one hypothesised function being for hydrological control. Within the Mojos lies the Quinato Wetland, a permanent wetland situated within a ca. 320km long palaeoriver channel surrounded by the aforementioned earthworks. Previous investigations of two sites identified similar patterns of change for both sites: with pollen suggesting a switch from dry/seasonally dry conditions to the establishment of wetlands. Evidence also showed that fire and flooding occurred at both sites, however all identified changes occurred at different temporal periods, despite the sites only being 22km apart. Evidence suggests that past societies controlled floodwaters by constructing earthworks, such as weirs, and therefore influence the local vegetation and hydrology through this act of domestication.

This study will build upon existing knowledge by conducting new palaeoecological analysis of these two existing records, whilst also analysing two new records using a multiproxy approach of charcoal, diatoms, pollen, and geochemical analyses. This study aims to explore the idea that wetland domestication resulted in management of aquatic resources, such as fish, and also influenced local hydrology and ecology. Initial results support previous conclusions that past inhabitants created and managed both their terrestrial and aquatic environments concurrently through earthwork construction. The results will highlight the importance of studying these human-environment interactions in tropical regions, as this allows us to increase our understanding of how past environments were influenced by the societies that inhabited them, whilst also uncovering the legacy impact on modern day terrestrial and aquatic environments.

**Keywords:** human-environment interactions; domestication; Bolivia; Amazon; Holocene; wetlands.





POSTER

**A palynological reappraisal/reconstruction of mining in the Erzgebirge from the beginning of the Bronze Age to modern times**

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As part of the ongoing Interreg project ArcheoTin, a palynological analysis of three bogs in the Erzgebirge is being carried out. These investigations are taking place in the archaeological context of Bronze Age tin mining in the Erzgebirge.

Under the leadership of the State Office for Archaeology of Saxony, together with six partner institutions from the Czech Republic and Bavaria (LMU Munich, Institute for Pre- and Protohistoric Archaeology and Provincial Roman Archaeology), tin mining from the beginning of the Bronze Age to the modern period is being systematically researched in the ArcheoTin project. Tin is an essential raw material component for the alloying of bronze in the Prehistory and early History of Europe and was part of the formation of far-reaching trade networks and elites. Only a few geological formations in Europe and the Near East offer access to tin ores, including Cornwall/Devon, Brittany and the Erzgebirge. Until now, prehistoric tin mining was only documented for southwest England, with no direct evidence for the Erzgebirge. Only recent excavations of tin soap relics have provided evidence of mining since the beginning of the Bronze Age.

With the help of palynology, XRF- Core scanning, geochemical analyses und radiocarbon dates the gaps in archaeological evidence are to be closed. In three bogs, the human impact and the intensity of use in the hostile agricultural environment will be demonstrated. In addition, all bog cores will be subjected to a metal analysis in order to prove the mining and processing process in the tin soaps. The first results and date correlation will be presented from this ongoing project.

Examined sites: the Georgenfelder Hochmoor is located on the German-Czech border, approx. 45 kilometers south of Dresden, at an altitude of 875 NN. It covers an area of 11 hectares and is a nature reserve. The proximity to Schellerhau plays an important role here. Tin soap relics with archaeological evidence of Bronze Age tin mining can be found there. The moor in the Schellerhau offers a direct location to the archaeological sites. It is located 8 km from the Czech border. Initial surveys have also revealed excellent pollen preservation and the preservation of the Bronze Age period. The Little Crane Lake (Czech: Malé jeřábí jezero) is located on German and Czech territory at an altitude of 930 meters above sea level. The peat body is approx. 6 meters deep. The pollen preservation is very good. The bog is located near the Sauschwemme, where there is evidence of Late Bronze Age tin mining.

**Keywords:** palynology; archaeology; XRF- core scanning; geochemical analyses; radiocarbon dates; Bronze Age.



POSTER

**Unveiling Holocene paleoenvironment and human Interactions:  
Sozopol Harbor, Black Sea Coast, Bulgaria**

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In a region rich with cultural significance, the Black Sea serves as a connection between Europe and Asia. Bulgaria's underwater archaeological research, tracing back to the 1970s, has unveiled prehistoric sites along the Black Sea Coast. These discoveries include substantial village settlements dating back to the Eneolithic and Early Bronze Age eras, nestled in shallow waters (<10 m), offering remarkable preservation of wooden structures and invaluable insights into ancient diets, economies, and ecology through palynological analyses.

Within Sozopol harbor on the southern Bulgarian Black Sea coast, submerged prehistoric settlements provide crucial insights into early human habitation and regional ecological dynamics. Recent field campaigns have yielded samples from cultural layers for comprehensive analysis, including pollen, spores, dinoflagellate cysts, non-pollen palynomorphs, and acritarchs. The preliminary results from the last campaign in 2023, shed new light on the vegetation surrounding the settlements during the Chalcolithic and Early Bronze Age periods.

Palynological analysis reveals a landscape characterized by mixed-oak forests, Mediterranean elements like *Carpinus orientalis*, and continental species such as *Quercus cerris* and *robur*-type, *Carpinus betulus*, *Fagus* sp., and evergreen shrubs like *Ilex aquifolium*. Noteworthy taxa like *Ulmus minor*, *Carpinus betulus*, *Alnus* sp., and woody vines like *Hedera helix* indicate the presence of "Longoz" forests in the region. The prevalence of *Pinus* sp. and *Abies* sp. pollen grains suggests long-distance transportation from nearby mountainous regions.

Fluctuations in primary and secondary anthropogenic indicators, alongside arboreal pollen sums, hint at settlement activities related to pastureland, grazing, and agriculture. Identifiable pollen grains from cultivated cereals and secondary anthropogenic indicators like *Polygonum aviculare*, *Plantago lanceolata*, *Sanguisorba minor*, *Filipendula* sp., and *Centaurea jacea*-type indicate open woodlands, meadows, and pastures. Marine dinoflagellate cysts like *Lingulodinium machaerophorum*, *Spiniferites* sp., and acritarchs such as *Cymatiospaera globulosa*, coupled with pollen from aquatic species like *Typha/Sparganium*, Cyperaceae, and *Myriophyllum* sp., imply sea level fluctuations between the 5<sup>th</sup> and 3<sup>rd</sup> millennia.

This study's reconstruction of past vegetation and environmental changes enhances our understanding of the historical landscape on the Black Sea Coast, underscoring the importance of interdisciplinary research in elucidating our ecological heritage.

**Keywords:** paleoecology; Black Sea; Sozopol harbor; Chalcolithic; Bronze Age; pile-dwelling settlement.



TALK

## Multi-millennial modeling of North-western France vegetation

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In North-western France, the Massif Armorican, historically less prone to wildfires due to its climate and vegetation, is projected to experience significantly increased fire risks in the coming decades. This risk is exacerbated by pastoral decline, leading to the development of heathland, fuel accumulation and thus fire spread, especially in military training areas prone to ignition. The exceptional fire activity during the summer of 2022, which saw over 3800 hectares of vegetation burned in Brittany, supports these predictions. While wildfires may promote plant diversity in some regions, their impact on historically less fire-affected areas like Brittany remains unknown. Hence, understanding the long-term vegetation dynamics is crucial for anticipating potential changes in these ecosystems in the context of climate change.

Palynology is the most commonly used method for reconstructing past plant biodiversity. However, representing plant biodiversity through pollen is challenging due to variations in pollen production and dispersion among species. The Landscape Reconstruction Algorithm (LRA), incorporating models like REVEALS and LOVE, offers a promising approach to vegetation reconstruction based on pollen data, while effectively reducing biases caused by the complex pollen-vegetation relationship. These models have been tested and validated in various regions, including southern Sweden, and will be used to reconstruct past plant biodiversity in Brittany. Reconstruction will use pollen data from the Armorican database, containing pollen records from 60 well dated sites studied throughout the Armorican Massif. Various diversity indices are used showing an increase in plant richness over the last two millennia, mainly due to traditional human activities. A decline in this diversity can be observed in the records over the last few centuries due to pastoral decline, agricultural intensification and the possible increased frequency of fires.

This presentation will provide an overview of the initial findings of this project, which aims in the long term to reconstruct the history of fires, human activities, vegetation dynamics during the late Holocene in Armorica, and to model vegetation and fire hazard.

**Keywords:** Holocene; biodiversity; north-western France; palynology; Landscape Reconstruction Algorithm (LRA).



TALK

**4000 years of landscape change in southern California. Paleoecological analysis of marine core MD02-2503, Santa Barbara Basin**

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The landscape of Southern California (SoCal) has been shaped by climatic and anthropogenic dynamics for thousands of years. For example, ENSO dynamics have played a major role in the vegetation evolution, as the frequency of El Niño regulates the precipitation regime, one of the main limiting factors for the Mediterranean vegetation. On the other hand, human migration, cultural interactions and colonization processes during the Late Holocene have had a remarkable impact on vegetation composition, structure and distribution. This is particularly evident in the last ~250 years, following the introduction of agropastoral practices and urban development in coastal areas. However, the spatial extent of human-induced Late Holocene landscape change in SoCal remains poorly characterized, as does the response of the vegetation to the climatic changes during this period.

We present the palaeoecological results obtained in the Santa Barbara coastal region as part of the MeSCAL project, which aims to analyze the landscape change as a result of natural dynamics and/or prehistoric and colonial migrations, settlements and cultural interactions over the past 4000 years. High temporal resolution pollen, non-pollen palynomorphs, and microcharcoal analyses were conducted in the marine core MD02-2503 from the Santa Barbara Basin, to analyze regional vegetation change and fire dynamics. We could measure the spatial extent of the anthropic impact on the landscape by comparing the obtained regional data with local palaeoenvironmental reconstructions conducted in nearby small wetlands on the mainland coast and the northern Channel Islands, as well as with archaeo-historical datasets. Native management fires have left their mark on the landscape at a local and regional scale in the Santa Barbara Basin, and were reduced when the population declined.

The results obtained have also highlighted the Santa Barbara Basin vegetation resilience and its response to the different climatic and environmental changes during the Late Holocene. Despite the seasonality of the Mediterranean climate or the characteristic extreme regular events, vegetation proved to be sensitive to certain climatic changes. The 4.2 ka BP event or the Medieval Climate Anomaly has caused many shifts in the composition and structure of the landscape. Understanding these mechanisms and how species have adapted in the past could be essential to facing future scenarios under the current climate uncertainty.

This study provides a regional framework to gauge the spatial extent of long-term climatic and anthropogenic impact on landscape change in the Santa Barbara coastal region and offers new insights for the future management and conservation of this threatened biodiversity hotspot in Southern California.

**Keywords:** Santa Barbara Basin; marine core; ENSO; landscape change; prehistoric fires; colonization.



TALK

**Prehistoric landscape changes in the Montezuma Well area (Verde Valley, Arizona) through pollen, non-pollen palynomorphs and charcoal analysis**

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Montezuma Well is a limestone sink-hole located in the Upper Verde Valley of central Arizona (USA). Being a main freshwater source in a region where water is scarce, it was very attractive to past societies through time. Indeed, the surrounding Verde Valley has been occupied by hunter-gatherers and early farming societies since c. 5500 cal BC and the 1st century AD respectively, and sedentary societies from the Sinagua culture first settled in the Montezuma Well area since c. 650 AD. The lake is thus a key site to analyze the potential attractiveness of the long-term landscape dynamics and diversity as a function of subsistence practices. Two previous palynological studies of this site (Hevly 1974; Davis and Shafer 1992) have allowed the tracing of major vegetation changes under the influence of past climatic fluctuations throughout the last 9 millennia. Our new high resolution palaeoenvironmental analysis, provides the basis for re-assessing how climatic variations affected landscape's taxonomic composition (diversity of vegetation and fungal assemblages) and landscape organization (mosaic structure and habitat diversity) as well as landscape temporal variability, magnitude and frequency of changes. By scrutinizing the particular features of early Holocene environmental changes and how prehistoric societies adapted to these changing conditions in this semi-arid region, we obtained fresh insights on the long-term interplay between human adaptability, climate oscillations, and environmental evolution. This complex relationship deepened during the historical period with the colonial Euro-American settlement of the area. This issue is crucial in semi-desert areas such as the Verde Valley, which are highly sensitive to climatic and anthropogenic changes and thus particularly threatened by global change.

**Keywords:** pollen; non-pollen palynomorphs; Prehistory; Montezuma Well; Verde Valley; Sonoran desert.



POSTER

**Rain forest dynamics under changes in climate and human impact during the past millennia in northern Madagascar**

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Although it is obvious that humans substantially altered ecosystems, the timing of the arrival of humans in Madagascar as well as their impact is not well resolved. In this context, this research aims to study the influence of early human impact and climate change on rain forest dynamics in northern Madagascar. Palaeoenvironmental reconstructions from lake sediments in a montane environment support a major drought 1,100 years ago. This drought caused significant changes in lake levels and vegetation dynamics. Human impact, evidenced by fires, started a few decades later. Limited to the low-altitude areas, fires were therefore not the driving force behind these early changes observed in the lake catchment areas. Although this does not dismiss the strong impacts humans subsequently had on ecosystems, this demonstrates that the late Holocene drought significantly impacted the ecosystems independently of anthropogenic activities. This research points to the importance of a multi-site and multi-proxy comparison for deciphering the nature and succession of past environmental changes.

**Keywords:** palaeoecology; Holocene; megadrought; pollen; fire.



TALK

**Human impacts, fire, and vegetation change during  
the neolithization process in the Barcelona Plain**

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Mediterranean coastal areas hold some of the oldest and largest archaeological evidence of Neolithic farming communities in the Iberian Peninsula. These areas were valued for offering connectivity through land and sea, as well as access to a great diversity of resources, both terrestrial and maritime. Such strategic location explains its often-continuous occupation since prehistoric times, which resulted in landscape transformations taking place alongside coastal and climatic constrains.

Our area of study is the littoral plain of Barcelona, where research within the PaleoBarcino project has contributed to identify the existence of ancient marshlands along this narrow coastal plain, where Early Neolithic communities settled around 5600-5500 cal BC. Our aim is to explore the environmental evolution and landscape shaping resulting from farming practices around these marshlands during the arrival and consolidation of the Early Neolithic communities. Our research approach is based on the integration of paleoenvironmental records, geomorphology, and archaeological data. The suitable marsh records for high resolution paleoenvironmental studies, and their proximity to prehistoric settlements, will allow us to detect the transformations triggered by farming communities at a microlocal scale.

For this purpose, we focused on the Cagalell marsh, located between the hills of *Mons Taber* (16 m.a.s.l.) and Montjuïc (185 m.a.s.l.), which records lacunar sediments since the 8<sup>th</sup> millennium cal BC. We extracted new sedimentary sequences and performed paleoenvironmental analyses (pollen, non-pollen palynomorphs and sedimentary charcoal) in two of them, supported by a new chronological framework.

Palynological data show that, before 5550 cal BC, a largely forested landscape predominated, formed by broadleaf deciduous forests and littoral pinewoods, and evergreen oak and mediterranean shrubby communities had a secondary presence. We found an early biomass burning phase, holding the highest abundance of sedimentary charcoal in both sequences. Charcoal type and palynological data suggest an early phase of coastal marshland burning.

Between 5550-5300 cal BC, coetaneous to the earliest Neolithic sites in the area, episodes of landscape clearance, in most cases associated with the use of fire, attest the establishment of farming activities practicing forest management. For the following centuries of the 6<sup>th</sup> millennium cal BC, Neolithic occupation and land use is reflected by the increase of anthropogenic pollen assemblage, crops (*Cerealia*-type), coprophilous fungi, sedimentary charcoal, and faunal parasites eggshells. Pollen data suggests an early farming system that first co-lived with maintenance of mesophilous forests and riparian tree communities. Nonetheless, it triggered the development of shrubby formations (*Ericacea*, *Pistacia*, *Juniperus*) and herbaceous taxa.



During the 5<sup>th</sup> millennium cal BC, consistent agropastoral activities caused a more permanent openness in the landscape, with expansion of grasslands and richer sclerophyllous shrublands (with *Olea*, *Phillyrea*, *Cistus* and *Vitis*). Charcoal abundance diminished significantly compared to previous phases, suggesting a change in fire regime after the earliest Neolithic phase.

This study offers a comprehensive description of decadal to centennial landscape transformations, vegetation changes and fire dynamics at the onset of the Neolithic period in the Barcelona Plain, deepening our understanding of the Early Neolithic landscape and the people that shaped it.

**Keywords:** coastal landscape; human impact; agropastoral activities; vegetation change; fire; Neolithic; Mediterranean.





POSTER

## Native landscapes and colonial impact in a dryland. Multi-proxy study of Peck's Lake in the Sonora desert (Arizona, USA)

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Among the largest and richest in natural and cultural resources, drylands are also one of the most threatened ecosystems on earth. Drylands and deserts are also characterised by the scarcity of key resources such as water. Due to their particular sensitivity to climate change, human impacts and limiting resources, drylands are excellent scenarios for analyzing past human-environment relationships and assessing socio-economic and environmental responses to climate or human stress. These complex interactions, which can lead to human adaptive responses, are analysed in a dryland area with an average annual rainfall of 323 mm, located in the Upper Verde Valley of central Arizona.

The availability of stable water sources in this transitional zone between the high Colorado Plateau and the Sonoran Desert made it particularly attractive for human habitation in the past. In fact, the area was occupied by hunter-gatherer communities as early as 5.5 ky cal BC. Later, from the 1st century AD, cultivation was developed by prehistoric farmers, while permanent settlement began from 650 AD with the establishment of the Hisatsinom human groups (known as Sinagua) which practiced irrigated agriculture on low alluvial lands. The Euro-American colonization of the valley at the end of the 19th century meant a major socio-economic change, with the introduction of cattle ranching, grazing and, above all, large-scale copper mining, activities that had a major impact on the environment.

The palaeoenvironmental research was carried out in a 484 cm deep core from Pecks Lake, a waterbody formed in an ancient meander of the Río Verde. The presence of such a body of water in an arid environment could favor the establishment of Sinagua settlements, such as Tuzigoot. The sedimentological sequence covering the last ~2200 years, is the object of multi-proxy analyses, including pollen, non-pollen palynomorphs (algae and fungal spores), microcharcoal, gastropods, grain size, LOI, geochemistry (RX) and hyperspectral imaging.

The results indicate that significant landscape changes occurred, with the presence of milder conditions until 1500 A.D. After this date, pine and shrub dry communities expanded. Intensive mining activity since 1883 AD is evidenced in the upper 130 cm of the sequence, recording strong increases in Cu, Pb and Zn concentrations. The increase in coprophilous fungi during this period attests to the increase in grazing activity, which promoted erosion in the lake catchment.

**Keywords:** landscape change; drylands; Prehistory; colonial impact; Verde Valley; Sonoran desert.



TALK

**Between the grasslands and the sea: vegetation history around the Kuyalnik Estuary (SW Ukraine) in the Late Holocene**

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The Pontic steppe belt is an important region for understanding relationships between vegetation dynamics, history of sedentary and nomadic cultures, and climate variations during the Holocene, but there is a scarcity of palaeoecological records from this area due to the lack of suitable sites and/or absolute dating. Another interesting aspect is an interplay between terrestrial and marine processes in the coastal environments, and their impact on both the environment and the human practices. Here we present the first palynological record from the Kuyalnik Estuary, including pollen, non-pollen palynomorphs and microscopic charcoal. The data are supported by XRF and bulk organic (TOC, N) measurements. The estuary is a hypersaline waterbody separated from the sea by ca. 3 km wide sandbar, however the separation occurred relatively recently, around 15–16th century CE. The vegetation cover of the region has been largely transformed into agricultural fields, but the steep estuary slopes host vast grasslands, which are ones of the most preserved natural steppe communities in the Northern Pontic region.

The preliminary results show that steppe vegetation with Poaceae, Amaranthaceae and *Artemisia* dominated the study area from ca. 4600 cal. yr BP. More mesophilous herbaceous vegetation with Poaceae, Cyperaceae and various herbs was prevalent up to ca. 4200 cal. yr BP. Humid and cooler climatic conditions for this period are also inferred from relatively high pollen frequencies of *Fagus sylvatica*, *Carpinus betulus* and *Picea abies*. The following period (4200–3750 cal. yr BP) was marked by increased aridity based on the sharp decline in *C. betulus*, the appearance of *C. orientalis* and the expansion of Amaranthaceae, which presumably spread after the lowering of the estuary level. From 3750 cal. yr BP, the climate became progressively arid, which is evidenced by the spread of *Artemisia*, various Asteraceae and *Ephedra*. The stands of broad-leaved forests on the floodplains were reduced, although alder groves were particularly widespread around 3100 cal. yr BP. The appearance of Cerealia pollen around 3550 cal. yr BP may indicate the first instance of farming in the vicinity of the site, introduced by the Bronze Age cultures. This period was also marked by a noticeable increase in microcharcoal frequencies. More humid conditions were inferred from 3100 cal. yr BP with the expansion of grass steppe and the development of riparian forests in the area. The expansion of forests between 2500 and 1600 cal. yr BP is indicative of warmer and wetter conditions compared to the previous phase, although this period was interrupted by an aridity event (2100–1800 cal. yr BP), when more xeric vegetation spread and the stands of broad-leaved trees collapsed. The last 1600 years were characterised by the increased role of anthropogenic indicators, elevated microcharcoal frequencies and the reduction in forested areas.

**Keywords:** steppe; semi-arid environment; climate change; human impact; palaeofire; Black Sea.



POSTER

## Reconstruction of forest composition changes during the last 250 years in the Falun area (Sweden)

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Over the last ca. 200 years, Swedish forestry has moved from natural growth forests managed by selective-cutting to planted forests with clear-cutting as a major form of timber removal (Lundmark, 2020). While Sweden has implemented fire-suppression measures the fire frequency and intensity are predicted to increase along with climate warming. These changes have a profound impact on forest biodiversity and carbon storage, as well as the economic value of forest resources. Apart from human-induced vegetation changes and related changes in element cycling, natural disturbances like wildfires play an important role in shaping forest ecosystems. In this study we aim to analyse the effects of forestry practice on biodiversity, carbon transport and storage, and economic value in the boreal forests in Sweden. We use the Falun area (central Sweden), as a type region for reconstructing forest ecosystem responses to changes in forestry practices and fire regimes, and for tracing patterns in carbon transport and storage.

We use palaeoecological reconstructions of aquatic and terrestrial environments and published historical forest management and timber yield data, pollen and diatoms, combined with dynamic vegetation and forest ecosystem modelling, as well as charcoal influxes to infer palaeofire intensity and effects. We target three historical periods of forestry practices in Sweden: i) before 1850 CE (representative of selective-cutting, natural fire frequency); ii) 1850 – 1950 CE (representative of a transitional period from selective- to clear-cutting and from natural to artificially suppressed fire frequency); iii) after 1950 CE (representative of clear-cutting, full extent of modern fire-suppression measures).

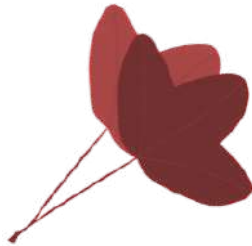
The preliminary results show that the composition of the boreal forest vegetation did not undergo drastic changes over the last 250 years. However, both high arboreal pollen concentrations and low frequencies of herbs indicate that the landscape was more forested between 1750 and 1900. Alder carrs were also more common during that time. Microcharcoal data show that local fires were rather common before the introduction of fire suppression measures. From 1900, the landscape became more open as evidenced by higher proportion of grasses and sedges. Ferns also became more abundant as they first colonised the areas after clear-cutting. The increase in pollen frequencies of *Cerealia* and *Rumex* suggests higher intensity of human subsistence in the area. The clear-cuts after 1950s are represented by the elevated role of open-landscape indicators and were followed by an expansion of birch groves as secondary succession. Although the regional fire activity did not significantly change over the last 250 years, local fires were much less common after 1950s.

**Keywords:** boreal forest; forestry; vegetation modelling; human impact; palaeofire.



**SESSION 4**

**VEGETATION DYNAMICS BEYOND  
QUATERNARY**







TALK

**Chattian to early Miocene (27.82-15.98 Ma) vegetation and climate of the UK from the Mochras borehole**

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The Oligocene to Miocene Transition (OMT, ~23.7—22.7 Ma) was a significant global cooling event, which was associated with the expansion of the Antarctic ice sheets. Palaeoclimate reconstruction of the OMT provides context for an Earth system without established, large-scale ice sheets in the northern hemisphere, with a palaeogeography similar to that of the present-day. 57 samples from depths 600.12—285.872 m were analysed for pollen, spore and fungal remains. Our assemblage reconstructed a transition from a mixed forest-type with emerging riparian wetland elements to a highly diverse forest with subtropical-tropical elements. The third pollen zone represents an open landscape, dominated by tropical fern-types, within distance of an emerging riparian wetland. Our results are compared to independently dated palynomorph samples from continental Europe to better refine the age estimates of the Mochras Borehole. We applied the Bayesian probability density function-based model Climate REconstruction SofTware (CREST) to our assemblages, so that we could reconstruct the palaeoclimate through this interval. This reconstruction provides new insight into the impact of the supposed cooling event on the region represented by the Mochras borehole.

**Keywords:** Mi-1; palynology; palaeoclimate; middle Cenozoic; Mochras borehole.



TALK

**Palynological contribution for a better understanding of the Sorgente Acero Unit, Upper Triassic, Lagonegro Basin (Basilicata, Southern Italy)**

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The Lagonegro Basin consists of a thick Meso-Cenozoic succession cropping out in the southern Apennines and it is arranged in different stacked tectonic units. At regional scale, it is possible to differentiate the proximal successions of Lagonegro II Unit overthrusting the distal Lagonegro I Unit. The complex structural frame and the limited lateral continuity made challenging to discern these two units. In the frame of the revision of the geological map, the informal lithostratigraphic unit of Sorgente Acero has been investigated in detail and been considered a key marker for the Calcarei con Selce (Formation) pertaining to the Lagonegro I Unit. Palynological, conodont and radiolarian investigations have been performed on samples collected from both wells and outcrops for biostratigraphic purpose. Specifically, a total of 70 samples from three hydrocarbon exploratory wells and two outcrops have been analysed.

The palynological assemblages result moderately rich and diversified but with poor preservation, with very dark palynomorphs and palynofacies. The assemblages are dominated by continental taxa, mainly consisting of Triassic bisaccate pollen, which are often damaged and difficult to be identified at generic and specific level. Additional species include *Paracirculina quadruplicis* and *Praecirculina granifer* that are continuous throughout the successions. *Ovalipollis* spp., *Enzonasporites vigens* and *Patinasporites densus* are also present, while *Samaropollenites speciosus* and *Camerosporites secatus* occur more irregularly. Other rarer taxa comprise *Densosporites fissus*, *Lunatisporites acutus* and *Lagenella martinii*. Sporadic marine elements such as *Michrishystridium* spp., *Veryhachium valensii*, *Leiosphaeridia* spp. and microforaminiferal linings (MFTL) are also observed.

The collected species are largely comparable to the Assemblage D described in the Mufara Formation by Buratti and Carrillat (2002) and by Trincianti et al. (2015), suggesting a Tuvalian age (lower Carnian). A good correlation can also be done to the assemblages described in the Tuvalian green clay-radiolaritic horizon of the Pignola 2 section, which is a well exposed outcrop described by Rigo et al. (2007) closer to the investigated area. It is also mentionable that the palynological association documented in a portion of one of the investigated wells and one outcrop shows similarities to the Assemblage C of Buratti and Carrillat (2002), which is early Tuvalian age.





The results of this palynological study along with the evidence of other biostratigraphic tools, the extensive field surveys and the data from wells provided a significant contribution to better define the stratigraphic framework of the Upper Triassic Lagonegro successions, offering new hints on the paleogeography of the Mediterranean area at that time.

**Keywords:** Triassic; Tuvanian; southern Apennines; palynology.



POSTER

**Palynology of the Cenozoic in the Colombian Caribbean**

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In Colombia, the study of palynology began in the 1950s and its progress has been primarily linked to the interests of the hydrocarbon industry and the pursuit of understanding the geological evolution of the country's basins. Despite the existence of a significant number of palynological publications in Colombia, much of the generated data cannot be published due to confidentiality inherent to the industry. This means that even today, there are areas in the country with restricted or scarce published palynological information. In the Colombian Caribbean region, the Sinú-San Jacinto basin has been considered a frontier basin and has been extensively studied in the last decade, becoming a unique opportunity to fill the knowledge gap in this area of the country. A composite section of 14 cores drilled from the Sinu-San Jacinto Basin in the Colombian Caribbean (NW South America) provides for the first time a Cenozoic palynostratigraphic zonation scheme for this region. Calcareous nannofossils and planktonic foraminifera allowed an independent calibration of the palynomorph assemblages to the international chronostratigraphic chart. Twelve Late Paleocene-Pliocene palynological zones (Car.01-Car.12) are proposed for the Caribbean, some of which differ from those proposed for the Llanos and Llanos Foothills basins. A Paleocene palynological assemblage is reported for this part of the basin. Variations in the biostratigraphic ranges of some palynomorphs and new species with stratigraphic value are described. High diversity and abundance of dinoflagellate cysts in some stratigraphic intervals require more detailed study. Evidence of reworking in some stratigraphic intervals, makes it necessary to be careful about the last appearance record of microfossils in exploration and geologic mapping.

**Keywords:** palynological zonation; Paleogene; Neogene; Colombian Caribbean; calcareous microfossils.



TALK

**Vegetation dynamics, climate changes and the origin of proto-cereals in Eastern Mediterranean from pollen and NPPs during the last 4 Ma: the case of Lake Acigöl and Lake Burdur in Turkey**

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The Eastern Mediterranean is a hotspot of biodiversity and an important refuge area for plants. The Mediterranean climate began to become more seasonal with summer drought and cooler winter since the Mid-Pliocene. This period can be considered as a past analogue for future climate change linked to the increase in greenhouse gases. The Eastern Mediterranean is also considered as a key region on the crossroad between Europe, Asia and Africa. The first hominins are out of Africa at least around 2.5 Ma and the Eastern Mediterranean is the cradle of agriculture at the beginning of the Holocene and a major center of crop plant diversification. The domestication of Poaceae by humans and thus the appearance of cereals is attested at around 12,000 years BP in the Fertile Crescent. However, cereal harvesting is evidenced 23 ka ago in the Levant (Ohalo II, Groman-Yaroslavshi et al., 2016), and the presence of pollen of Cerealia-type (proto-cereals) is attested in Lake Acigöl, South-Western Turkey since 2.3 Ma (Andrieu-Ponel et al., 2021). As proposed by Andrieu-Ponel et al. (2021), the appearance of proto-cereals could be linked to the pressure of large herbivore herds on steppe ecosystems, leading to gene mutations of Poaceae.

In the framework of the ANR project FOOD-RE, the environmental and climate study of the Mid-Pliocene BS 87 series of Lake Burdur (ca 30 km west of Lake Acigöl) is currently being reconstructed. The aim of this study is 1) to reconstruct vegetation, lake dynamics, and water level changes based on pollen and NPPs, 2) to characterize morphologically the pollen grains of Cerealia-type, and 3) to quantitatively reconstruct the climate using a multimethod approach (Modern Analogue Technique, Weighted Averaging Partial Least Squares regression, Random Forest, and Boosted Regression Trees and Climatic Amplitude Method).

Our first results indicate that, during the Mid-Pliocene, the vegetation was dominated by steppes dominated by Poaceae, Artemisia, and Amaranthaceae. After 3.8 Ma, arboreal taxa significantly decreased, and we see the alternation of steppe grasslands with deciduous *Quercus* and steppes dominated by Amaranthaceae. The lacustrine ecosystem was characterized by semi-aquatic vegetation and freshwater algae, exhibiting alternating oligotrophic and eutrophic conditions. The pollen of Cerealia-type is recorded in the series, but the percentages are lower



compared to those of Acigöl (Andrieu-Ponel et al., 2021), not exceeding 3.5%. Morphological characteristics of pollen of Cerealia-type from Burdur are similar to pollen from domesticated cereals in recent periods and do not permit a clear distinction between pollen of wild and domesticated Poaceae. Climate reconstructions show similar trends among different methods, and the reconstructed values during the Mid-Pliocene are close to current values. After a climatic optimum in terms of precipitation and temperature, climate reconstructions show an alternation between cool, wet conditions and warm, dry conditions after 3.8 Ma. Around the Mediterranean basin, climate reconstructions indicate warmer conditions and contrasting precipitation patterns between 3.3 and 3 Ma.

**Keywords:** vegetation dynamics; paleoclimate; transfer functions; pollen of Cerealia-type; Pliocene; Turkey.



TALK

**High rainfall provided resilience to palaeotropical rainforests during Early Eocene Climatic Optimum (EECO): palynological evidence from western India**

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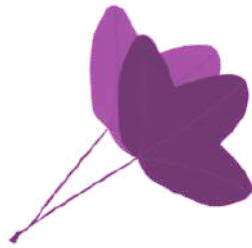
The Indian plate is a typical example of a drifting isolated island subcontinent across the equatorial zone during the Paleocene-Eocene. Its ultimate collision with Eurasia somewhere in the early Paleogene had an intense effect on the global climate as well as shaped biodiversity and its distribution. Coupled with geodynamics, the early Paleogene global warming also resulted in the prolific spread of tropical flora and fauna over the Indian subcontinent. Across the globe, the Paleocene-Eocene has been the area of focus among the geoscientists for the past several decades leading to ample information from mid- and high-latitude regions whereas the low equatorial latitude's data are still sparse. The western Indian lignites and the associated sediments provide an ideal source of information about the early Paleogene warming in the course of the crucial phase of India's drift history. To trace the floristic changes during the Early Eocene Climatic Optimum (EECO), palynological records from lignite mines of Kutch Basin, Western India have been analyzed. A diverse palynological assemblage consisting of algal and fungal remains, pteridophytic spores, angiosperm pollen, and dinoflagellate cysts recovered from the Akri lignite mine, Kutch Basin, Gujarat suggested highly diverse tropical rain forest was present during EECO in contrast to present-day xeric shrub-land and grassland ecoregion is thriving. The terrestrial vegetation was dominated by megathermal plant families such as *Arecaceae*, *Bombacaceae*, *Ctenolophonaceae*, *Dipterocarpaceae*, and *Meliaceae*.

The study also suggests that rainforests near the equator were resilient to warming during the early Eocene greenhouse world in contrast to mid-latitudes. The mechanism of resilience remains poorly known due to the lack of terrestrial quantitative climate data from the equator. Near the equator, the early Eocene marine and terrestrial reconstructed temperatures have contrasting viewpoints. Based on plant pollen proxy, the quantified terrestrial temperature data suggested a warmer equator (~2.6° N) than mid- and high latitudes during the EECO. The reconstructed data also suggested abundant rainfall near the equator that might have provided resilience, by increasing water use efficiency in plants, to rainforests for their survival in order to remain functional in a warm greenhouse world during the EECO.

**Keywords:** Palynology; western India; Early Eocene Climatic Optimum (EECO); Palaeovegetation; Palaeoclimate.



**SESSION 5**  
**GENERAL PALYNOLOGY**









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**KEYNOTE**

**A 3 body of water problem**

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Salt minerals form in a variety of depositional settings and can be excellent repositories for environmental data. When salt minerals grow rapidly, they trap parent waters, gas, crystals, and any organic material within primary fluid inclusions or as solid inclusions. These inclusions are “snapshots” of the hydrosphere, atmosphere, lithosphere, and biosphere. However, the preservation of the biosphere, organic and fossil material, in salt minerals remains relatively untested.

Several long-lived assumptions mean that most palaeontologist and sedimentologists overlook the preservation potential of salt minerals. These assumptions are (1) salt minerals cannot preserve organic material, (2) all salt minerals form in marine environments, and (3) salt minerals represent non-habitable environments. While it is true that salt minerals are strongly influenced by environmental conditions during deposition, recent studies are showing how unaltered salt minerals can preserve microfossils, microorganisms, organic compounds, and other environmental data for hundreds of millions of years. Using 3 bodies of water across time and space we will explore how these assumptions are untrue.

Firstly, the Permian Zechstein Group (~258-252 Ma) of Central Western Europe contains >2500m of halite. The halite is often interpreted as being deposited by a shallow epicontinental sea surrounded by a barren desert. Palynological analysis of Zechstein halite from northeast England suggests a conifer-dominated vegetation surrounded the Zechstein Sea, and that perhaps it persisted up to the Permian-Triassic boundary. The Zechstein halite provides evidence that salt minerals have an excellent preservation potential for fossil material.

Secondly, halite and gypsum from modern acid saline lakes in Western Australia and Chile, and ancient acid saline lakes of the Permian Nippewalla Group, USA, reveal chevron and cumulate crystals that contain Archaea, bacteria, fungi, green algae, pollen and spores, diatoms, plant cuticle, and organic compounds beta-carotene and chlorophyll inside fluid inclusions and as solid inclusions. These findings demonstrate that not all salt minerals form in marine environments and that salt minerals forming in shallow saline surface waters may represent the most important sink for terrestrial organic matter in arid environments.

Lastly, examples of algae, fungi, diatoms, protozoa, and organic compounds trapped inside mirabilite, a Mars-analogue sulphate salt, from Great Salt Lake, USA, will show how diverse salt minerals have important implications for astrobiological research and the study of the habitability of other planets.

These examples will showcase the diversity of life trapped inside salt minerals from a combination of original data and representative literature. The properties of salt minerals that promote excellent preservation, the challenges to and strategies for studying organic material trapped in salt minerals, and the implications for the future of palynology will also be discussed.

**Keywords:** evaporites; taphonomy; Permian; Western Australia; Chile.



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**KEYNOTE**

**Moving Palynology into the digital era**

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Palynology started more than a century ago and provides the fundamental basis to understand vegetation changes through time, date sedimentary rocks through biostratigraphy, and track plant evolution among many other applications. Since its origin, palynology has relied on the manual counts using a microscope. This is a process that requires a long time, years of training, and produces data that is not fully reproducible. The advent of new robotic tools that can digitize complete microscope slides and the fast development of neural network algorithms have provided the timing for Palynology to enter a new era in data generation and analysis. We are developing a training set of neotropical pollen to be used in a neural network that will assist pollen counts and identification. The developments produced here could be applied to multiple research questions where pollen can be used from paleoecology and paleoclimate, biostratigraphy to pollination biology and honey production.

**Keywords:** nanozoomer; CNN; neural network.



TALK

**A Holocene Record of Non-Pollen Palynomorphs from  
a Costa Rican Páramo**

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There has been growing interest in non-pollen palynomorphs (NPPs), especially fungal spores, as environmental proxies. Fungal spore records from the Southern Hemisphere are growing in number, but are still few in number compared to those published for the Northern Hemisphere. We have developed a record of NPPs for highland Costa Rica from Lago Morrenas 1 (9.4925N, 83.4848W; 3480 m), only the second such record from this country. Following methods previously applied to Venezuelan NPPs (Loughlin et al., 2018), we used Canonical Correspondence Analysis to investigate paleoenvironmental drivers of change in the NPP assemblage at Lago Morrenas 1 since the Early Holocene (ca. > 10,000 cal yr BP).

Our results indicate that grasses and organic matter exert the greatest influence on fungal spore abundance in the Costa Rican páramo, with water level (based on *Isoëtes* spores), fire, and the relative abundance of shrubs, forbs, and conifer trees playing secondary roles. The abundance of coprophilous *Sporormiella* spores co-varied more strongly with páramo grasses than other fungal spores. Further, these and other coprophilous fungal spores (CFS) are more abundant in the early portion of the Morrenas 1 sediment core— this reinforces conventional knowledge that has associated CFS with megafauna. Our record of CFS had an inverse relationship with the most abundant spore from Lago Morrenas 1, cf. *Arthrinium*. We also report aquatic insects, flatworm egg cases, and algae, in addition to > 100 different fungal spores from the Costa Rican páramo.

**Keywords:** NPP; fungi; Costa Rica; Holocene; dung; lake sediment; non-pollen palynomorph.



POSTER

**Paleoenvironment of the Lake Izabal Basin Infill: Insights from Palynofacies and Element Geochemistry**

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The Lake Izabal Basin is a pull-apart basin located in the eastern lowlands of Guatemala and one of the few Central American basins preserving Neogene sediments. In this study, we infer the depositional environment and processes during the initial infill of the basin by integrating palynofacies and element geochemistry data collected from cuttings from an industry well. Phytoclasts are the dominant particulate organic matter components (~90%) in the sediments, while amorphous organic matter (AOM, ~ 9%) and palynomorphs (~1%) are minor components. Cluster analysis was used to identify four palynofacies zones, which were further confirmed by selected major element composition, including titanium (Ti), calcium (Ca), silicon (Si), potassium (K), and aluminum (Al). We observed that Ti, K, Al, and Si have similar trends but contrast with the downhole trend exhibited by Ca. Correlation between major elements suggest a common sediment source through time, while Ca probably reflects time of increased carbonate deposition. Palynofacies Zone 1 (1200 m – 1001 m) is characterized by fluctuating but generally lower Ti, although they sharply increase at the base and trend higher towards the top of the zone. A previous palynological study dated this zone as late Miocene. Palynofacies Zone 2 (1001 m – 798 m) is marked by two distinct upward decreasing trends in Ti values, coinciding with a significant increase (27.4%) in AOM. This observation suggests that the basin experienced decreases in detrital input and increases in paleoproductivity during these specific intervals. Palynofacies Zone 3 (798 m – 645 m) exhibits a similar pattern of Ti values to that observed in Palynofacies Zone 1, with an upward increasing trend. In Palynofacies Zone 4 (645 m – 550 m), sharp increases in Ti correlate with increased phytoclast abundances, suggesting that detrital input reached its highest levels during this depth interval. Based on phytoclast content, we infer that deposition occurred in a proximal fluvial-deltaic environment that occasionally experienced high productivity. Our palynofacies and element geochemistry data also suggest that the Lake Izabal Basin experienced a wet and humid climate during the late Miocene-Pliocene, providing initial paleoenvironmental constraints for this deep sedimentary basin.

**Keywords:** paleoenvironment; palynofacies; element geochemistry; Neogene.



POSTER

**A freshwater cap in the Early Miocene of Egypt – A palynological inference**

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Samples retrieved from two subsurface boreholes in the north Western Desert, Egypt from the early Miocene Moghra Formation, yielded a well-preserved and diverse palynofloral assemblage. The palynofloral composition displays mixed marine and nonmarine assemblages. Marine elements are expressed by diverse and well-preserved dinoflagellate cysts together with microforaminiferal test linings. Terrestrial elements comprise diverse and well-preserved lineages of algae, spores, and pollen.

Of special interest is the presence of spores of free-floating water ferns (Salviniales; mainly *Azolla*) and other cryptogams, including bryophytes, with non-frequent amounts of gymnosperm and angiosperm pollen. Together with frequent Chlorophyta such as *Botryococcus* and *Pediastrum*, filamentous algae from the family Zygnemataceae, mainly *Ovoidites*, *Spirogyra*, and *Zygnema*, and desmids were important components of the algal assemblage. Prasinophyceae (*Tasmanites* and *Leiosphaeridia*) were also found with diverse arrays of non-pollen palynomorphs. Most of the identified algae prefer mesotrophic to eutrophic conditions and are characteristic of stagnant or slow-flowing shallow water.

Our ongoing study of these new finds promises to allow a first detailed reconstruction of the aquatic plant ecosystem of the peculiar, still poorly understood strata.

**Keywords:** Miocene; Moghra Formation; non-pollen palynomorphs; algae; Egypt.



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**TALK**

**Some advantages of digital slide technology for palynological research:  
morphometric and palynofacies case studies.**

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The application of advanced computational methods for palynological studies has gained considerable traction in recent years, providing a means through which routine labour-intensive processes and bottlenecks can be streamlined and, in some cases, automated. In line with the growing interest of such methods, we test the efficacy of digitally scanned, high resolution slides for: (1) conducting morphometric analyses of Early Eocene dinoflagellate species, (2) assessing the palynofacies of Early Eocene samples, and (3) their effectiveness for Palaeozoic and Mesozoic samples. With these case studies, we demonstrate that digitally scanned slides streamline the collection, storage, and use of substantial amounts of data for morphometric and palynofacies analyses.

**Keywords:** digitisation; computational; streamlining; morphometrics; palynofacies.



POSTER

**Return to the type locality: palaeoecology of Middle Ordovician acritarchs of Öland, Sweden**

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The Middle Ordovician of the palaeocontinent Baltica provides some of the best preserved and most diversified acritarch assemblages of the Lower Palaeozoic. A great number of widely used acritarch genera and species have been described since the 1960s from the island of Öland, Sweden. Many of these taxa are considered as biostratigraphically useful, for both regional and international correlations.

Here, we document the morphological plasticity and diversity of acritarch morphotypes through the Middle Ordovician of several sections from Öland. Progressive changes of morphological characters (such as process length, for example), but also the relative abundances of different morphotypes are continuous throughout the sections.

The progressive change within the acritarch populations confirm the transition of assemblages from deeper to shallower water environments. Our results show that previously recorded biostratigraphical signals can at best be interpreted as responses to the changing palaeoenvironment. The morphological plasticity challenges the validity of biostratigraphically useful taxa, questioning their accuracy and validity for precise correlation.

**Keywords:** phytoplankton; palaeoecology; acritarchs; dinoflagellates; Ordovician.



TALK

**Chitinozoan-based paleogeographic patterns in the Lower and Middle Devonian. A review of the similarity coefficient methods**

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The paleogeography during the Devonian included two supercontinents, Gondwana and Euramerica, with smaller continents and terranes separated by oceans. Throughout this period, Gondwana migrated northward to finally collide with Euramerica in the Carboniferous forming Pangea (Torsvik & Cocks, 2017). The proximity of the landmasses, combined with a high sea level, might have created an interconnection between the different basins from the Early to the Middle Devonian. Some authors suggest that during the Early Devonian, Western Gondwana was characterized by a pronounced provincialism across different taxonomic groups (Capel et al., 2023) - acritarchs, however, do not confirm this pattern (Rubinstein et al., 2008). Statistical techniques can be used to quantify the affinities of different assemblages between two geographic areas and analyze the paleogeography. One method commonly used in palynology is the coefficient of similarity, which relies on the presence or absence of taxa.

This study aims to review and discuss the different similarity coefficients to identify the most suitable for analyzing the distribution and affinities of chitinozoans. Furthermore, we aim to recognize paleogeographic patterns in the Lower and Middle Devonian from Western Gondwana using chitinozoan assemblages.

Statistical analysis was conducted on two chitinozoan assemblages obtained from three boreholes. Two are located in northwestern Argentina, and the third in southern Bolivia. The classical similarity coefficients Jaccard, Dice and Simpson were applied using the statistical program 'PAST', the results being compared with the modified Forbes index (Alroy, 2015). The main problem with using similarity coefficients is their high sensitivity to variations in the total number of species within the assemblages being compared. Our results showed that with the same data, the classical indexes suggested either no affinities or great similarity. However, the modified Forbes index ( $F'$ ) showed more reliable results and therefore was adopted to analyze the paleogeography.

The chitinozoan assemblage from the Early Devonian, compared with other chitinozoan assemblages of the same age, have  $F'$  values between 0.1 and 0.3. These low results may indicate the pronounced provincialism recorded during this period. Conversely, the results from the Middle Devonian assemblages indicate a better connection of the basins in general. The  $F'$  between all Western Gondwana basins are between 0.5 and 0.43 and would suggest an interconnection between them. Nonetheless, the  $F'$  between other regions are less than 0.24 which may indicate a provincialism in Western Gondwana for the Middle Devonian. However, the discrepancy between the number of identified taxa and the taxonomic classifications within the different chitinozoan assemblages may have influenced in the low values of the similarity





coefficients since the data is not always reliable. As a consequence, the relatively high values of the  $F'$  between the Western Gondwana assemblages probably reflect the interconnection between the basins and the proximity of the landmasses, but the low values, may not be indicating the opposite necessarily. This shows that a taxonomic revision of chitinozoan taxa is necessary to clarify the results and allow more precise paleogeographic interpretations. From these results, the coefficient of similarity  $F'$  appears the most suitable for paleogeographic analysis.

**Keywords:** chitinozoans; paleogeography; Devonian; coefficient of similarity; statistics.



TALK

## Changes in average miospore size through the Silurian and Devonian

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An increase in spore size is a well-known feature of the Devonian paleobotany record. Early land plant spores were generally small (<50 microns in diameter), but maximum sizes increased dramatically over the Middle Devonian. This increase has often been linked with the initial evolution of heterospory and large megaspores, but it also encompasses many apparently homosporous taxa with intermediate spore size ranges (100-200 microns in diameter) which are rare outside of the Devonian. The late Early through Middle Devonian then represents one of the most unusual intervals in the palynological record, but the exact nature, timing, and geographic extent of the trend towards larger spores is unclear. We have compiled spore corpus diameter measurements in published Silurian and Devonian palynofloras from modern North America, Europe, South America, Africa and the Middle East, Australia, and China to explore when the spore size increase occurs, whether it occurs globally or regionally, and whether it best corresponds to a passive or an active trend.

We find that large spores are characteristic of the Middle Devonian generally, but the exact timing and extent of increased spore size varies. A strong rise is most pronounced in North American and European palynofloras, with increases in spore size beginning in the Pragian. By contrast, assemblages from Africa and the Middle Eastern floras show a more muted increase in average spore size. Across regions, shifts in spore size are associated with taxic turnover, where late Early to Middle Devonian increases reflect the appearance of larger spore genera combined with the loss of smaller ones. Consistent with this, increasing spore size appears to be an active trend in regions with appropriate sampling, reflecting a shift in the mean and distribution of spore sizes rather than simply an increase in maximum size. Our data then suggest that the larger spores characteristic of the late Early to Middle Devonian are a global phenomenon that likely reflects changes in plant ecology towards the end of the Early Devonian that favored the evolution of larger spores.

**Keywords:** spore size; evolutionary trends; Devonian; ecological change.



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**TALK**

**Investigating plant communities and the effects of the End-Triassic-Extinction in the Barents Sea – A high resolution study.**

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The Arctic region of Norway's Barents Sea contains thick Triassic sedimentary successions, preserving a record of the evolution of plant and environmental change. Studying these successions allows us to examine alterations in plant communities leading up to the End-Triassic Extinction (ETE).

This study analysed 44 palynological samples covering a 52-meter segment of the Ringvassoy-Loppa Fault Complex, Late Triassic in the southwestern Barents Sea. This section comprises the Snadd, Fruholmen, and Tubaen formations, featuring three distinct mudstone sections interspersed with oil-bearing sandstones. Sampling was undertaken at 0.5m intervals in the mudstone zones to allow detailed examination of Late Triassic palynology. The analysis focused on identifying key palynological assemblages and their implications for palaeoclimatology and vegetation dynamics. Comparison with prior palynological studies from the Barents Sea and North Sea has provided insight into the Triassic climate and depositional conditions along the margins of Fennoscandia.

**Keywords:** palynology; Late Triassic; Barents Sea; End-Triassic-Extinction.



TALK

**Systematic Palynology of Sterculiaceae s.l. in Malaysia with Special Emphasize on Exine Sculpturing**

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A comprehensive palynology study was conducted on 58 species representing 16 genera of Sterculiaceae s.l. in Malaysia. The selected genera include *Abroma* Jacq., *Byttneria* Loeffl., *Commersonia* J.R.Forst. & G.Forst., *Firmiana* Marsili, *Helicteres* L., *Heritiera* Aiton, *Kleinhovia* L., *Leptonychia* Turcz., *Melochia* L., *Pterocymbium* R.Br., *Pterospermum* Schreb., *Pterygota* Schott & Endl., *Scaphium* Schott & Endl., *Sterculia* L., *Theobroma* L., and *Waltheria* L. This study aims to determine the pollen similarities, variations, and diagnostic characteristics from pollen morphological characteristics among subfamilies, genera, and species in Sterculiaceae. Methods employed include the acetolysis technique, single-grain technique, critical point drying, and observation under light microscope (LM) and scanning electron microscope (SEM). Variation in pollen morphological characteristics is assessed, including aperture types, pollen shape and amb, presence and width of colpus, size of lumen and murus, length and distance between pollen spikes, length and width of pollen, numbers of pores as well as exine sculpturing. *Byttneria* can be differentiate from other genera by the absence of colpus region while *Waltheria* is pantocolporate with six pores and colpus region. *Pterospermum* exhibit the largest pollen size whilst *Sterculia* has the smallest. The pollen's amb, P/E value, C/P value, d/D value, shape and apertures are useful for genus differentiation. Common characteristics in Byttnerioideae include the presence of three pores except in *Waltheria indica*, while tricolporate pollen is common in Sterculioideae. Few diagnostic characters were identified for species identification and differentiation. A dichotomous key of genus and species identification was constructed based on pollen morphological characteristics observed in this study. This study confirms that pollen morphological characteristics have taxonomic value for species and genus identification and differentiation within the family of Sterculiaceae s.l.

**Keywords:** palynology; Sterculiaceae; pollen morphology; microscopy analysis.



POSTER

**Non-pollen palynomorphs from the Devonian (Givetian/Frasnian) of east-central Poland**

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Givetian and Early Frasnian deposits from south-central Poland (Kielce Area of the Holy Cross Mountains, Łysogóry-Radom and Lublin Basins) reveal a great abundance of non-pollen palynomorphs (NPP) of high palaeoenvironmental value. Palynostratigraphic analysis places the fossiliferous sequences in AD-TCo Opper Zones.

The analysed sections provided the oldest known organic tentaculitoids as well as the first specimen of the organic and mineral tantaculitoids combined together. All of them belong to the subclass Dacryoconarida. Other animal remains were represented by *Eurypterid* respiratory organs (*Kiemenplatten*) and arthropods cuticles. The assemblage was enriched by the presence of scolecodonts, however they were limited in number (families Paulinitidae, Kielanoprionidae, Mochtyellidae, Atraktoprionidae, and Polychaetaspidae). What is important, the sampled sections revealed the presence of the first Givetian chitinozoans from Poland. Although the chitinozoan distribution throughout the studied sections showed a low diversity and abundance, the recovered specimens are relatively well preserved. Beside these groups, a small number of phytoplankton represented by acritarchs and prasinophytes was documented. Acritarchs were less numerous; however, a new genus in this group was established (*Teleostomata rackii* sp. and gen. nov., Kondas et al. 2021). Beside these groups, single specimens of coenobial algae (*Mussivum gradzinskii* Wood & Turnau, 2001) and nematophytes (the genus *Nematothallus*) were noticed. The NPP of plant origin were represented by plant debris. Each section also provided the fungi and fungi-like filaments.

The palynofacies indicate the deposition in shallow-water marine environment with high terrestrial input and noticeable changes in palaeoshoreline proximity. Documented assemblage confirms the complexity and diversity of Givetian-Frasnian ecosystems in the Polish part of the Laurussian shelf basin.

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**Keywords:** palynology; Middle Devonian; non-pollen palynomorphs; palynofacies; Poland.



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**TALK**

**Netromorphs and related morphotypes in the middle Paleozoic**

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The acritarchs are a group of organic-walled microfossils previously classified as hystrichospheres, until one group was determined to be dinoflagellate cysts. Since then, the remaining hystrichospheres of unknown biological origin have been relegated to a new group Acritarcha. Because of this biological ambiguity taxonomic classification is difficult, generally relying on morphology rather than phylogenetic affinities. Presently accepted schemes subdivide acritarchs into various subgroups based on the outline of the main vesicle.

In this study we review and emend the taxa attributed to netromorphs, an acritarch subgroup comprised of fusiform morphotypes which were diverse during the Silurian and Devonian. We propose a classification scheme based on qualitative characteristics of reported taxa. Several informal groups and new combinations are also proposed.

**Keywords:** acritarchs; netromorphs; Silurian; Devonian.



POSTER

**Associations between modern pollen, fungi and open and shrubby vegetation in Southern California**

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Despite their importance in interpreting fossil palaeoenvironmental datasets in terms of vegetation and land use, few studies of modern pollen-vegetation relationships exist for Southern California (SoCal), and these have focused on coastal mountainous areas. Moreover, none of these previous studies have systematically examined plant-related fungi, which provide local paleoecological information complementing pollen data. In 2022, we initiated a study of modern pollen and fungal spore assemblages in order to improve the palaeoenvironmental reconstructions carried out in the MeSCAL project, which examines the shaping of Late Holocene SoCal cultural landscapes.

We collected around 115 modern surface soil, moss, dung, roots and leaves samples from the major vegetation communities along a gradient from sea level on the Pacific coast to ~2500 m a.s.l. in the Transverse Ranges. We also collected around 10 samples from historic Spanish Mission gardens. Environmental and landscape metrics, land use information and vegetation variables were registered at each point. Samples are currently being analyzed and dissimilarity coefficients (e.g., Jaccard and Shannon indexes, Square Chord Distance) and ordination techniques (e.g., Ward's clustering and Principal Component Analysis) are being used to 1) assess the relationship between modern pollen and fungi taxa and the environmental and landscape variables, and 2) obtain specific pollen and fungal indicators of local vegetation and land use so that plant communities and human practices can be better characterized in the fossil record. We will present preliminary results obtained from open (e.g., grasslands) and shrubby vegetation (e.g., coastal scrub, sagebrush and chaparral) ranging along an altitudinal transect from the Ventura and Santa Barbara coast to the San Emigdio Mountains and Kern County.

**Keywords:** pollen; fungi; vegetation diversity; landscape; southern California; dissimilarity coefficients; calibration of fossil palynological datasets.



POSTER

**Multiplicisphaeridium: dinoflagellate cyst or fungal spore?**

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Late Pleistocene sediments in Marmara Sea, Turkey, contain abundant palynomorphs resembling the Ordovician acritarch *Multiplicisphaeridium*, concurrent with fungal spores, chytrids, and rare brackish-water dinocysts in glacial Marine Isotope Stages. Morphotypes of this acritarch have been called "*Multiplicisphaeridium*-type cysts," and grouped with dinocyst counts. The Pleistocene taxon resembles the late Oligocene dinocyst, *Microsphaeridium ancistroides* interpreted as "detached opercula of skolochorate dinoflagellate cysts" (Benedek and Sarjeant, 1981), later considered similar to the living dinoflagellate *Cladopyxis*. New LM and SEM studies therefore re-examine the morphology of *Multiplicisphaeridium*-type cysts compared to the Oligocene and living dinoflagellate taxa. Cf. *Multiplicisphaeridium*-type cysts have elongated subtriangular body/vesicles with a dark brown wall 1 µm thick, typically with 2-4 branched processes arising from a subquadrate basal area that splits along curved to angular triple-junction sutures around the process bases. The hollow process walls are thicker than 1 µm except the ultimate end branches which have thin, semitransparent walls, often embedded in chitinous material, indicating a saprophytic/parasitic trophic status. The sporangia-like body, embedded process endings, and apical pore or sporangium discharge tube are characteristics of aquatic Chytridiomycotes that co-occur in many MIS2 samples. *Multiplicisphaeridium* and *Microsphaeridium ancistroides* differ from cf. *Multiplicisphaeridium* in having spherical bodies and closed branch tips. SEM studies show no trace of plates that characterize *Cladopyxis*, and evidence of a chasmic archaeopyle indicating nontabulate gymnodinioid affinity is weak.

Micro-FTIR spectroscopy was used to investigate wall compositions of palynomorphs from a 13,000-yr sample containing common cf. *Multiplicisphaeridium* and fungal spores, and few *Spiniferites* and *Brigantedinium* cysts. *Multiplicisphaeridium* spectra cluster primarily with fungal spores and turbellarian eggs but with some resemblance to *Gymnodinium* cysts, although a different protein structure. Average spectra of cf. *Multiplicisphaeridium* show that wall sugars are most similar to *Glomus* mycorrhizal fungal spores. Morphologically and spectrochemically, more evidence supports affinity with fungi than dinocysts. If assigned to Chytridiomycote fungi, the sparseness of dinocysts concurrent with cf. *Multiplicisphaeridium* sporangia conforms to studies of parasitism in marine communities.

**Keywords:** Pleistocene Marmara Sea; micro-FTIR analysis; *Cladopyxis*; Chytridiomycota.





TALK

**Closing the temporal gap: century-scale changes in terrestrial and marine ecosystems through the Early Toarcian (Early Jurassic) extinction event**

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The fossil record of ancient warming events provides direct evidence of how our planet's ecosystems were structured and functioned at times of climate change and biodiversity loss, how they responded to such changes and how they recovered. Information locked in the fossil record should enable better understanding of how Earth's present-day ecosystems will respond to continued warming and help us test predictions of future change. One problem with using the fossil record in that way is that most studies look at past changes that occurred over intervals of 10s to 100s of thousands of years, but ecologists today are more interested in what will happen in years, decades and centuries.

In order to try and close this temporal gap so that we can make more meaningful comparisons between the past and present, we have conducted high-resolution, sub-centimetre sampling at three key intervals through the Early Toarcian (Early Jurassic) extinction and warming event. This was achieved by field-based bulk sampling from outcrops exposed on the Yorkshire Coast, UK, followed by finely slicing samples in the lab. Correlation using the latest radiometric and astronomical timescales suggests that the temporal resolution of our sampling is on the order of centuries.

The results of our palynological analyses are presented and show how marine and terrestrial ecosystems changed on century-resolution scale. Our data are then compared to the best available published data from the same sites that were collected at more typical, geological-scale temporal resolution. Significant challenges remain if such an approach is going to be expanded to cover the whole event (ca. 80m of strata at the study sites), not least the number of samples that would be generated and analysed. Artificial Intelligence (machine learning) approaches offer potential solutions and their potential is discussed.

**Keywords:** Jurassic; extinction; terrestrial; marine; high-resolution; dynamics.



**TALK**

**The fascinating development of palynological preparation techniques**

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Palynology is a relatively recent branch of science; the term itself was introduced in 1944. Compare the history of ammonite research, which is over 200 years. One of the major breakthroughs in palynology was the use of inorganic acids to extract palynomorphs by dissolving the surrounding mineral matrix during the 19th century. The number of practitioners using of hydrochloric and hydrofluoric acids to extract organic microfossils at this time was very small. Later, the joined-up use of HCl and HF followed by oxidation, centrifugation, and sieving only developed during the 1950s. Since then, the literature on palynomorph preparation has burgeoned, and includes two textbooks and several major papers. Most palynological preparations are based around HCl and HF digestion. Following acid treatment, palynomorphs are concentrated before being mounted on microscope slides or SEM stubs. There is no such thing as the 'standard preparation technique', this is because each sample is different and most require individual treatment. Great care must be taken following acid digestion because damage to, and loss of, palynomorphs can be caused by injudicious acetolysis, bleaching, heating, oxidation, ultrasonic treatment etc. This individual attention, sample-by-sample, is one of the principal reasons that automation and mechanisation of laboratory preparation of palynomorphs has not developed. Most samples processed are clay-rich; other lithotypes such as coal require different techniques. Clearly, the use of mineral acids requires modern laboratory equipment and extreme care to avoid accidents. Because palynomorphs are so numerous and ubiquitous, all efforts should be made to avoid contamination right through from sample collection to slide mounting. Non-acid preparation offers a cheaper, less hazardous, and faster method of preparing palynomorphs for study. A recently documented technique used sodium hexametaphosphate as a clay deflocculant and this has proved a very effective alternative to acid digestion for most siliciclastic samples.

**Keywords:** history of development; palynomorphs; preparation techniques.



POSTER

**University campus as laboratory for palynology applications: exploring pollen morphology and diversity at the Universidad Nacional de Colombia, sede Medellín**

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A vast number of studies are reporting an increase in the prevalence of people contracting allergic respiratory diseases caused by pollen. The main reasons are the rise in temperatures produced by climate change and high exposures to particulate matter in cities. One way to prevent this impact is by monitoring flowering peaks through the analysis of the airborne pollen content, creating pollen calendars. Surprisingly, in the South American tropics, particularly in Colombia, information regarding airborne pollen in cities is scarce and mostly non-existent. Studies have been limited to one-year durations and to single areas within large cities. Implementing pollen monitoring systems in urban areas could provide solutions for preventing respiratory diseases within highly polluted cities. Furthermore, exploring the pollen diversity in urban spaces provides an understanding of the biological interactions, such as the availability of food for pollinators and the complex web of interactions among organisms that depend on pollen for their daily functions. In this sense, this study proposes establishing a baseline for characterizing the airborne pollen content in the city of Medellín, using the campus of the Universidad Nacional de Colombia, sede Medellín, as the starting point. The campus is renowned for its plant diversity, ranking as the second most diverse and green area in the city after the city's botanical garden, containing around 500 species of trees and herbs. The first phase of the project seeks to characterize the pollen morphology of each of the plants that belong to the campus, which in a subsequent phase will aid in identifying the botanical source of the airborne pollen content. These activities will result in a pollen atlas of the campus created by students and a preliminary pollen calendar of the campus. In the end, we aim to use the campus as a laboratory, provide support for the palynology and ecological interactions classes, strengthen the pollen collection (PALUN) and provide solutions for the prevention of respiratory diseases for the Colombian society.

**Keywords:** pollen; morphology; diversity; tropics; Colombia.



POSTER

**MUPA, Montpellier University Pollen Atlas**

S. Rouland\* & MUPA members

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MUPA, Montpellier University Pollen Atlas is a pollen database reference collection that includes a microscopic slide reference collection of pollen grains of 30 000 species distributed all around the world and which are being digitalized.

Initiated by Madeleine Van Campo at the Museum National d'Histoires Naturelles (MNHN) in 1945, the reference slide collection was moved to Montpellier in 1967. Over the years, the collection has been enriched by samples taken directly from plants during fieldwork, samples from herbariums and exchanges with other laboratories in France and abroad. The richness of the collection of reference slides of angiosperm pollen grains (around 50,000 slides) stems from the great geographical diversity of the specimens, particularly those originating in tropical Africa (Madagascar) and Asia (India, Tibet), which represent approximately 30,000 taxa; a large number of families are included (e.g. Celastraceae, Icacinaceae, Aquifoliaceae, Loranthaceae, Arecaceae, Mimosaceae). The collection also houses 2,400 slides of gymnosperm pollen grains and 2,000 slides of pteridophyte spores.

The collection has been transposed into a database by CNRS engineers from the OSU-OREME (Observatoire de REcherche Méditerranéen de l'Environnement) 'Information System' platform, and is freely accessible via the OREME CNRS website. This database will be continually updated with new photographs of pollen grains. These photographs are taken by a technician dedicated in part to the collection. Students and researchers who consult and use the reference slide collection are invited to take new photographs to add to the database. MUPA is constantly evolving, and we have added descriptive sheets for each pollen. In the short term, it will be possible to search by geographical origin.

The richness of the reference slide collection housed at the Institut des Sciences de l'Evolution de Montpellier (ISEM) is inestimable due to its wide diversity of taxa and the number of slides referenced. MUPA allows this collection to be consulted freely, enabling researchers to identify the taxa present in a sample of pollen grains and/or spores from a field survey, a honey sample, or a sample of clothing or old dishes. In addition, very specific collections, such as those from Greenland, Asia, Africa, China, Martinique, etc., have been built up and used as the basis for the pollen atlases that are essential for analysts.

**Keywords:** pollen grains; database; microscopic slide; reference collection; worldwide.



TALK

**How many species?  
The trouble with ecophenotypism in early Palaeozoic acritarchs**

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Acritarchs have largely been used for biostratigraphical purposes, mostly in the early Palaeozoic, when they were the most abundant and diversified group of organic-walled microfossils. Our literature review shows that more than 4000 species have been described throughout the Palaeozoic.

Taxonomical reviews of several acritarch genera, including biometrical analyses of large assemblages, reveal that morphological variability is usually very important, and that it is often difficult, if not impossible, to delimit previously described taxa. For example, the revision of the Cambro-Ordovician acritarch genus *Vulcanisphaera* Deunff, 1961, pointed out that only three species are easily differentiable, although a total of 32 species have been assigned to the genus. Many of the described species seem indeed to be actually only junior synonyms of previously described taxa from other localities. The recent review of *Aryballomorpha* Martin and Yin, 1988, indicates that all described species belong to a single entity with very large morphological variation, in particular of the process length. Another example is the revision of the peteinoid acritarch complex that includes the genera *Peteinosphaeridium* Staplin et al. 1965, *Cycloposphaeridium* Uutela and Tynni, 1991, and *Liliosphaeridium*, Uutela and Tynni, 1991. The distinction into the three genera is impossible, as individual taxa are essentially arbitrary as morphotypes intergrade.

The comparison with biometrical studies on modern dinoflagellates becomes straightforward: many dinoflagellates develop variable cyst morphologies depending on environmental factors. For instance, the dinoflagellate cyst *Lingulodinium machaerophorum* (Deflandre and Cookson, 1955) Wall, 1967, displays different process lengths that can be related to low and high salinity/temperature ratios. By analogy, we therefore hypothesize that the different morphologies observed among Palaeozoic acritarchs, in particular illustrated by the variable process length, reflect an ecophenotypical response to changing environmental conditions. It is possible, if not probable, that many fossil acritarch 'species' and even 'genera' are cysts produced by only very few phytoplanktonic organisms (or even a single biological species) that display very high morphological variability.

**Keywords:** phytoplankton; ecophenotypes; acritarchs; dinoflagellates; Ordovician; Silurian; Devonian.



TALK

***Reduviasporonites*: where are we at with this enigmatic  
Permian-Triassic palynomorph?**

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Occurrences of *Reduviasporonites* around the Late Permian mass extinction event, and in particular apparent short-term peaks in its abundance, led to the hypothesis that a ‘fungal spike’ was associated with this event (Eshet, 1995; Visscher et al. 1996). Fungal spikes were then recorded at other locations, and at other extinction events; interpreted as indicating widespread collapse of ecosystems with a substantial short-term increase in the amount of decaying matter. However, this interpretation depends on the biological affinity of the palynomorph. Debate about its affinity has continued for >20 years, with different authors arguing for fungal or algal origins, amongst others, but none have supplied conclusive evidence either way. Often the same data are used to support both sides of the argument, e.g. geochemical data have been cited as supporting one interpretation (Foster et al. 2002), and the same results taken to argue for an opposing theory (Mays et al. 2021). Settling the affinity will have profound impacts on our interpretations of these major biological crises. Was it responsible for mass saprophytic metabolism in the wake of catastrophic ecosystem collapse, or does it indicate a significant global aquatic change, such as an algal bloom? Or neither? Here, we provide a synthesis of current data, a critical review of the literature, supplemented by new data, and discuss the most likely affinity.

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**Keywords:** extinction; Permian; Triassic; CLSM.



POSTER

**Palaeo-ecology of chitinozoans in the Anti-Atlas: Implications for biostratigraphic correlation in Upper Ordovician successions of Oued Mellili and Bou Ingarf**

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The Late Ordovician was one of the major icehouse states of the Phanerozoic, forming the backdrop for a large marine species extinction (85%). In rocks this age, telling time is a major challenge, although this is one of the most important factors, if not the prime requisite, for geologists to start addressing cause-and-effect relationships, e.g., between climate change and palaeobiodiversity crises (e.g., Rasmussen et al., 2023). One of the tools used to correlate Ordovician geological units is chitinozoan biostratigraphy. In addition, palaeobiogeographic studies of latitudinal migration of chitinozoans have strengthened our understanding of the mechanisms behind the changes in the Ordovician climate (Vandenbroucke et al., 2010).

These applications of chitinozoan micropalaeontology have, in the past, glanced over palaeo-ecological control on temporal and spatial distribution of chitinozoans. However, there are indications that palaeo-ecological factors should be firmly taken into account in order to understand the full potential of chitinozoan biostratigraphy and palaeo-climate reconstructions (e.g., Achab et al., 2011, De Backer et al., 2024). Here, we present the preliminary results of a study that aims to shed light on the palaeo-ecology of chitinozoans.

The presented case study focuses on the relatively thick Upper Ordovician (Hirnantian stage ~444 Ma) successions in the Anti-Atlas basin of Morocco, and more particularly on the ice-sheet proximal Oued Mellili sections and more ice-distal Bou Ingarf section. In these rocks, a solid sequence stratigraphy (Ghienne et al., 2014) provides an independent correlation framework for this study on the potential influence of facies, palaeobathymetry and the local environment on chitinozoan distributions. We use the carbonate nodular Ouzregui bed as a regional sequence stratigraphic marker, which correlates the Oued Mellili and Bou Ingarf sections (Ghienne et al., 2014). One of the questions that will be addressed is whether the occurrences of *Tanuchitina elongata*, the regional marker for the Katian/Hirnantian boundary is subject to palaeo-ecological control, and whether facies dependence could explain the apparent diachroneity of *T. elongata* across these sections. This will be a spring board to expand our study of the ecological signature of chitinozoans into longer and more time intervals for a set of Upper Ordovician successions from ice-sheet proximal to distal locations in the Anti-Atlas basin.

**Keywords:** Upper Ordovician; chitinozoans; palaeo-ecology; biostratigraphy; Anti-Atlas basin; Ouzregui bed, *elongata* biozone.



TALK

**Palynological and organic carbon isotope records of the early Permian Galilee Basin (Queensland Australia): Insights into the termination of the Late Palaeozoic Ice Age**

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The end of the Late Palaeozoic Ice Age (LPIA) in the early Permian marks a dramatic climatic and floral shift across Gondwana resulting in the formation of widespread coal deposits. In Australia, records of this transition have mainly been studied in the Sydney Basin (New South Wales), Tasmania and in sections of the Bowen Basin (Queensland). The intracratonic Galilee Basin (Queensland), however, features a sequence spanning from the Asselian through to the lower Kungurian allowing for high resolution records to be examined in a fully terrestrial sequence. Two boreholes (Longreach 1-1A and Muttaborra 1) were selected to examine the palynological and carbon isotope records of the Jochmus Formation, including the Edie Tuff, and the Aramac Coal Measures.

Both sections show an upsection decrease in the relative abundance of monosaccate pollen grains (*Plicatipollenites*, *Potonieisporites*) and increases in both striate bisaccate (*Protohaploxypinus*) and non-striate bisaccate pollen (*Scheuringipollenites*, *Alisporites*). This represents the shift from cordaitalean-dominated floras to the *Glossopteris/Gangamopteris*-dominated flora that would become established across Gondwana until the end-Permian extinction. Herbaceous floras are dominated by spores (*Leiotriletes*, *Acanthotriletes*, *Laevigatosporites*, *Indotriradites*) produced by ferns, lycopsids and horsetails, representing a diversifying lowland flora.

Organic carbon isotope trends in both sections show a decrease in the upper Jochmus Formation from approximately -22.5‰ to -25‰. In the Aramac Coal Measures, both sections show three cycles of enrichment and depletion, though the magnitude of the depletion in Muttaborra 1 appears to exceed Longreach 1-1B with values as low as -27.2‰. The timing of this negative excursion is assessed to be mid-to-late Artinskian in age and would appear to coincide well with the Artinskian Warming Event, though this period is also marked by an increase in local volcanism along the eastern margin of Australia.

**Keywords:** palynology; carbon isotopes; Permian; Gondwana; Late Palaeozoic Ice Age; Galilee Basin; Australia.









