

Abstracts

Resúmenes

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• ANNUAL MEETING •
MANIZALES - COLOMBIA 2022

54TH Annual Meeting **AASP**

**The Palynological
Society**

First hybrid meeting (In-person/online)

August 7 to 11 2022

54 Encuentro Anual **AASP** La Sociedad Palinológica

Primer encuentro híbrido (En persona/online)

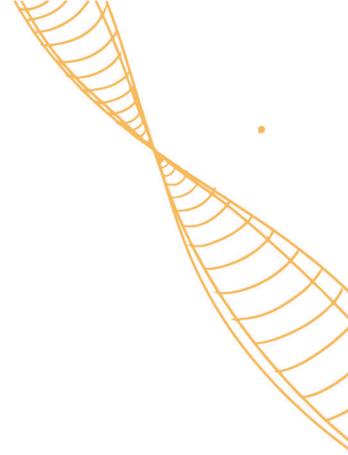
Agosto 7 al 11 2022



Universidad de Caldas







**54th Annual Meeting AASP The Palynological Society
54° Encuentro Anual AASP La Sociedad Palinológica**

Abstracts / Resúmenes

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The logo for this meeting was designed by María Paula Quintero, Sebastian Marquez, and Santiago Romero.

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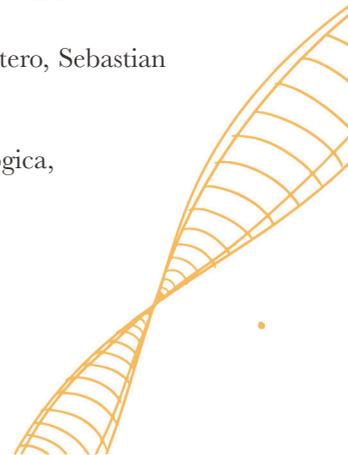
La AASP - Sociedad Palinológica y el IIES agradecen la colaboración de las siguientes entidades porque sin ellas, este encuentro no hubiera sido posible.

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Code of conduct

The 54th annual meeting of the AASP-The Palynological Society, which will be held for the first time in Colombia and for the second time in South America, seeks to celebrate not only the palynological diversity of the Neotropics but also the diversity of the worldwide palynological community, encouraging the free expression and the exchange of scientific knowledge.

By attending this event, you agree to adhere to the following code of conduct, either as an in-person or virtual participant. The AASP-TPS and the event organizers are fully committed to equity, diversity, inclusion, and accessibility. As such, the organizers will enforce this code as necessary to ensure that all participants feel welcome in an inclusive and harassment-free environment. Accordingly, all participants are expected to treat one another with respect regardless of gender, gender identity and expression, sexual orientation, marital or parental status, age, disability, physical appearance, body size, race, ethnicity, nationality, religion, socioeconomic background, educational background, and career stage.

Questions and discussions should be respectful and constructive. Engaging in harassing or discriminatory behavior will result in organizers taking appropriate action, including warning the offender and/or expulsion from the event. Participants asked to stop any harassing or other prohibited behaviors are expected to comply immediately. If you are being harassed and/or discriminated, notice that someone else is being harassed or discriminated, or have any other concerns, please contact any of the meeting organizers, which will be properly identified, either in person or via email. All reports will remain confidential.

Note:

Participants must not record or take photos of any part of the semi-nars and/or other participants without their consent.

Due to the rapid increase of COVID cases, and considering immunocompromised participants, the use of a facemask, regardless of vaccination status, is required during indoor meeting activities unless otherwise instructed. Disposable facemasks will be provided at registration.



Código de conducta

La 54ª reunión anual de la AASP-The Palynological Society, que se celebrará por primera vez en Colombia y por segunda vez en Sudamérica, busca celebrar no sólo la diversidad palinológica del Neotrópico sino también la de la comunidad palinológica mundial, fomentando la libre expresión y el intercambio de conocimientos científicos.

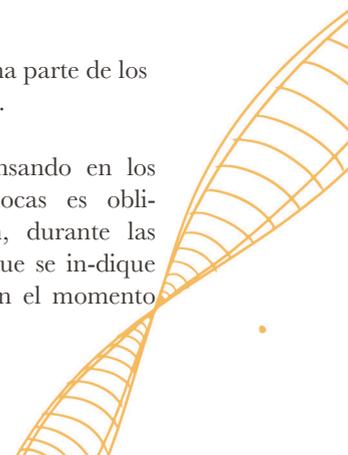
Al asistir a este evento, usted acepta adherirse al siguiente código de conducta, ya sea como participante presencial o virtual. La AASP-TPS y los organizadores del evento están plenamente comprometidos con la equidad, la diversidad, la inclusión y la accesibilidad. Por lo tanto, los organizadores harán cumplir este código según sea necesario para garantizar que todos los participantes se sientan bienvenidos en un entorno inclusivo y libre de acoso. En consecuencia, se espera que todos los participantes se traten con respeto, independientemente del género, la identidad y expresión de género, la orientación sexual, el estado civil o parental, la edad, las discapacidades, la apariencia física, el tamaño del cuerpo, la raza, el origen étnico, la nacionalidad, la religión, el nivel socioeconómico, la formación académica y la etapa profesional.

Las preguntas y discusiones deben ser respetuosas y constructivas. La participación en comportamientos de acoso o discriminación dará lugar a que los organizadores tomen las medidas oportunas, incluida la advertencia al infractor y/o la expulsión del evento. Los participantes a los que se les pida suspender cualquier tipo de acoso u otro comportamiento prohibido deberán cumplirlo inmediatamente. Si usted está siendo acosado y/o discriminado, nota que otra persona está siendo acosada o discriminada, o tiene cualquier otra preocupación, por favor póngase en contacto con cualquiera de los organizadores de la reunión, que estarán debidamente identificados, ya sea en persona o por correo electrónico. Todas las denuncias serán confidenciales.

Nota:

Los participantes no deben grabar ni tomar fotos de ninguna parte de los seminarios y/o de otros participantes sin su consentimiento.

Debido al rápido aumento de casos de COVID y pensando en los participantes inmunocomprometidos, el uso de tapabocas es obligatorio, independientemente del estado de vacunación, durante las actividades de la reunión en lugares cerrados, a menos que se indique lo contrario. Se proporcionarán tapabocas desechables en el momento de la inscripción.





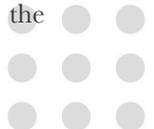
Introduction

Palynology in Colombia began to develop from the work of the Dutch professor Thomas van der Hammen (1924-2010), who in the 1950s served as chief paleobotanist of the National Geological Service (today the Servicio Geológico Colombiano). Dr. van der Hammen began to study the palynology of Cretaceous and Cenozoic deposits in different sectors of Colombia, such as the Eastern Cordillera and the Magdalena and Cauca valleys. In 1959, he returned to the Netherlands to work in the Department of Geology at the University of Leiden. In 1996, he started his work at the University of Amsterdam as a professor of palynology and developed numerous projects in geology, biostratigraphy, climate, and vegetation history of tropical ecosystems. Professor Van der Hammen left an important legacy in the study of palynology in South America. Likewise, some of his Colombian and foreign students have made important contributions to palynology and paleoecology. Starting from this school, since the 70s, some palynology labs have been developed in different universities in the country as well as schools associated with the petroleum industry.

For ten years, the Universidad de Caldas has had the Instituto de Investigaciones en Estratigrafía-IIES (Stratigraphy Research Institute), where the main aims are research, consulting, and training of students in geological topics, such as basin analysis, stratigraphy, sedimentology, micropaleontology, ichnology, petrography, and volcanology. The IIES is part of the National Network of Geoscience Laboratories (RNLG), sponsored by the National Hydrocarbon Agency-ANH and the Ministry of Science, Tech-

nology and Innovation-Minciencias. Since its creation, the IIES has been consolidating the Research Group in Stratigraphy and Volcanology-GIEV Cumanday, through multidisciplinary geological studies, both for industry and academia. Currently, the GIEV group has a multidisciplinary team and is currently active through research projects and the training of undergraduate and graduate students, as well as the divulgation of their work at national and international scientific levels. IIES research is currently focused on the geological, biological, oceanographic, and climatic evolution of the last 70 million years of northwestern South America (mainly the Cauca Valley, the Western Cordillera, the Caribbean, and the Pacific). One of the main lines of research is micropaleontology including foraminifera, calcareous nannofossils, ostracods, and palynology. This has given us the opportunity to contribute to the knowledge of the geological evolution of some of the country's frontier basins such as Chocó, Tumaco, Cauca-Patía, Sinú-San Jacinto, Cesar-Ranchería, Lower Magdalena Valley, thanks to the sponsor of the ANH.

With our laboratory and the experience acquired in these last 10 years, we wanted to hold the 54th AASP-TPS Annual Meeting to invite you to visit our country, meet and share our culture, and experience it through palynology and other areas of interest. We wish you a wonderful stay in Manizales and we hope that this event will strengthen the scientific and human ties among the participants.



Introducción

La palinología en Colombia comenzó a desarrollarse a partir de los trabajos del profesor holandés Thomas van der Hammen (1924-2010), quien en la década de 1950 se desempeñó como paleobotánico jefe del Servicio Geológico Nacional (hoy Servicio Geológico Colombiano). El Dr. van der Hammen comenzó a estudiar la palinología de los yacimientos cretácicos y cenozoicos en diferentes sectores de Colombia, tales como la Cordillera Oriental y los valles del Magdalena y del Cauca. En 1959 regresó a los Países Bajos a trabajar en el departamento de geología de la Universidad de Leiden. En 1996 inició su labor como profesor de palinología en la Universidad de Ámsterdam y desarrolló numerosos proyectos de geología, bioestratigrafía, clima e historia de la vegetación de los ecosistemas tropicales. El profesor Van der Hammen dejó un importante legado en el estudio de la palinología en Sudamérica. Así mismo, algunos de sus estudiantes colombianos y extranjeros han hecho importantes aportes a la palinología y paleoecología. A partir de esta escuela, desde los años 70, se han desarrollado algunos laboratorios de palinología en diferentes universidades del país, así como asociados a la industria petrolera.

Desde hace diez años la Universidad de Caldas cuenta con el Instituto de Investigaciones en Estratigrafía-IIES, donde se realizan investigaciones, asesorías y formación de estudiantes en análisis de cuencas, estratigrafía, sedimentología, micropaleontología, icnología, petrografía y vulcanología. El IIES forma parte de la Red Nacional de Laboratorios de Geociencias (RNLG), patrocinada por la Agencia Nacional de Hidro-

carburos-ANH y el Ministerio de Ciencia, Tecnología e Innovación-Minciencias. Desde su creación, el IIES viene consolidando el Grupo de Investigación en Estratigrafía y Vulcanología-GIEV Cumanday, a través de estudios geológicos multidisciplinarios, tanto para la industria como para la academia. En la actualidad el grupo GIEV cuenta con un equipo multidisciplinar y desarrolla su actividad a través de proyectos de investigación y la formación de estudiantes de grado y postgrado y la divulgación de sus trabajos a nivel científico nacional e internacional. La investigación del GIEV se centra actualmente en la evolución geológica, biológica, oceanográfica y climática del noroeste de Sudamérica en los últimos 70 millones de años (principalmente el Valle del Cauca, la Cordillera Occidental, el Caribe y el Pacífico). Una de las principales líneas de investigación es la micropaleontología, incluyendo foraminíferos, nanofósiles calcáreos, ostrácosos y palinología. Esto nos ha dado la oportunidad de contribuir al conocimiento de la evolución geológica de algunas cuencas de frontera del país como Chocó, Tumaco, Cauca-Patía, Sinú-San Jacinto, Cesar-Ranchería, Valle del Bajo Magdalena, gracias al patrocinio de la ANH.

Con nuestro laboratorio y la experiencia adquirida en estos últimos 10 años hemos querido realizar el 54° encuentro de la AASP para invitarlos a visitar nuestro país y reunir-nos para compartir nuestras culturas y experiencias a través de la palinología y otras áreas de interés. Les deseamos una excelente estadía en Manizales y esperamos que este evento fortalezca los lazos científicos y humanos entre los participantes.



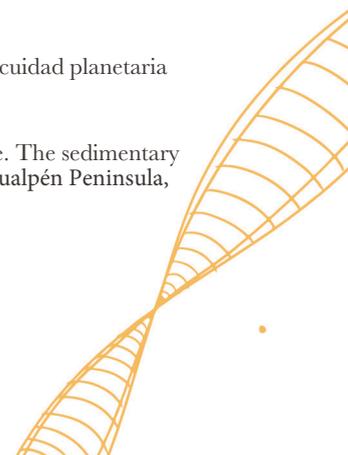
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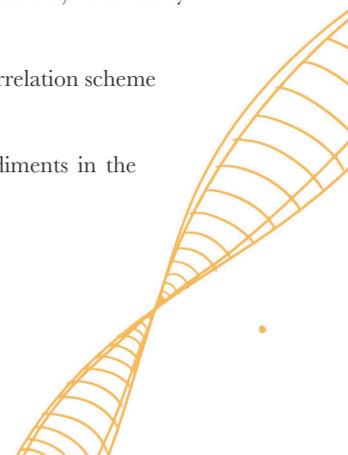
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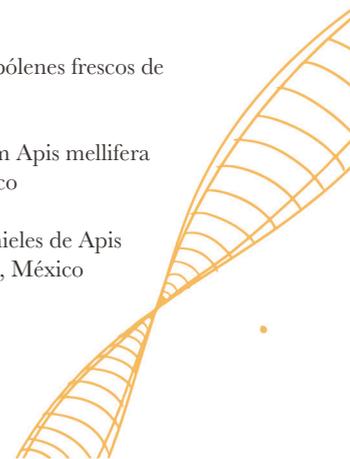




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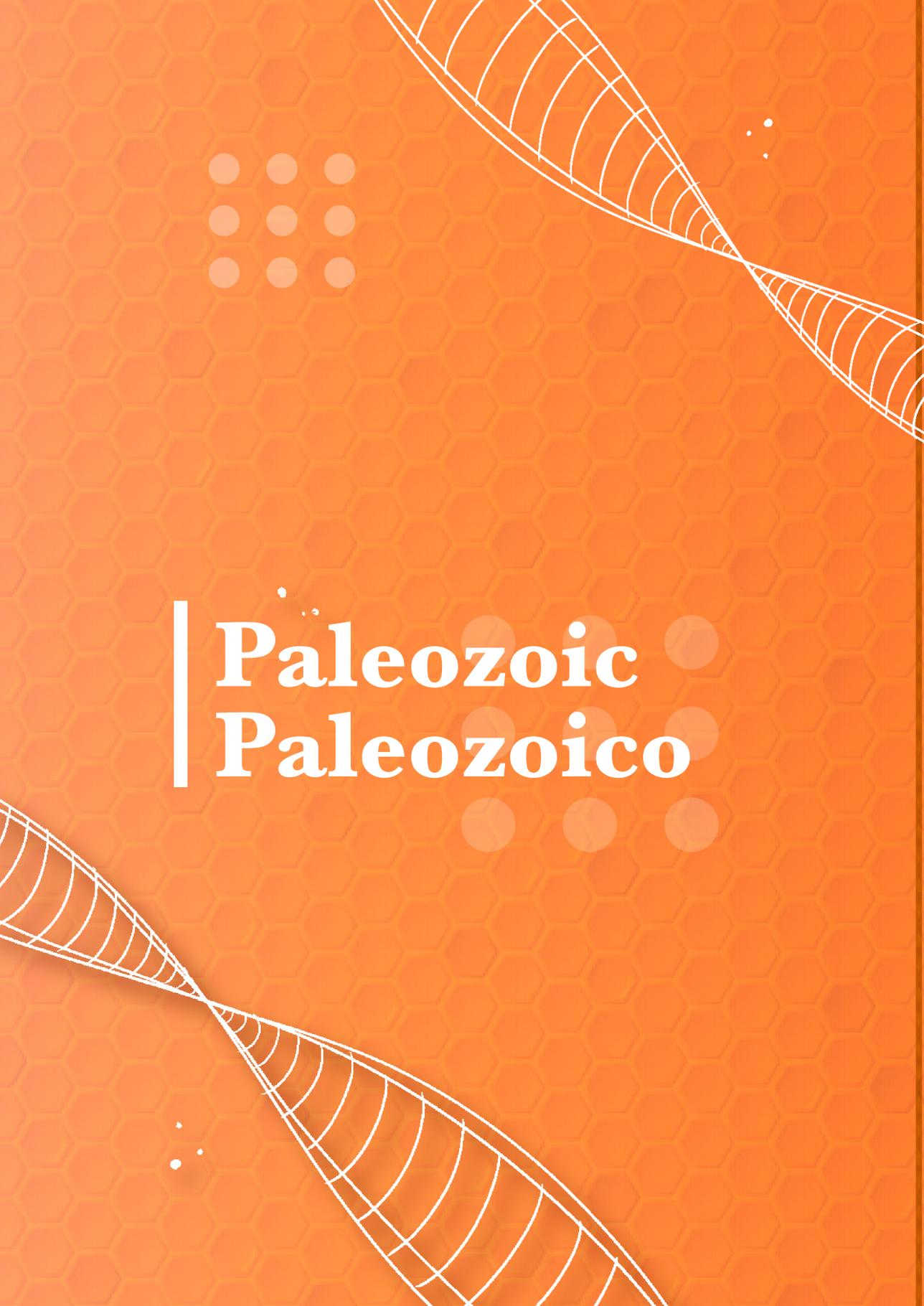


155. Ramírez-Arriaga et al. Melisopalynological analysis of honey samples from different types of vegetation and cultivated areas in Veracruz, Mexico
157. Torres Meza et al. Palynological characterization of the tropical dry forest of northern Bolívar department, Colombia
157. Torres Meza et al. Caracterización palinológica del bosque seco tropical del norte del departamento de Bolívar, Colombia
158. Torres Meza et al. Pollen spectrum of honey and pollen pots of 5 species of bees from the municipality of San Jacinto, Bolívar-Colombia
159. Torres Meza et al. Espectro polínico de miel y pots de polen de 5 especies de abejas del municipio de San Jacinto, Bolívar-Colombia
161. Gibson and Benison. The palynology of Mars analog acid saline lakes
163. Martínez-Murcia et al. Palynology is now digital. Neotropical pollen collection is the first stage of a new era
165. Andrade and Gasparino. Pollen morphology in ornamental species of the genera *Aeschynanthus*, *Columnnea*, *Nematanthus*, *Sinningia* and *Streptocarpus* (Gesneriaceae)
166. Bellonzi and Gasparino. Preliminary qualitative pollen grains data from the clade “*Paradrymonia* alliance” and *Nautilocalyx Linden ex Hanst.* (Gesneriaceae)
167. Boler et al. Stones Field well WR 508 #1, Gulf of Mexico palynology: a Momipites-dominated environment for this deepwater Wilcox Group
168. Costa et al. Data analysis of pollen rain and atmospheric transport: Study of the pattern for the Fontes do Ipiranga State Park
169. Dutra et al. Pollen morphology in *Dryades Groppo*, *Kallunki* & *Pirani*, a new genera of Rutaceae, and related species
170. Lopes and Gasparino. Palynotaxonomy of *Columnnea* L. (Gesneriaceae)
171. Pereira et al. Modern Pollen rain at different altimetric levels in seasonal extremes of the southern portion of the Metropolitan Region of São Paulo, Brazil: evaluation and proposal of a dispersion model
172. Sousa and Gasparino. Previous pollen data of Ornamental Brazilian Plants
173. Souza et al. Palynotaxonomy in species of *Trichosporeae* (*Didymocarpoideae*, Gesneriaceae)



TALKS CHARLAS





**Paleozoic
Paleozoico**



Floral diversity, disparity and ecological turnover at the Siluro- Devonian boundary: palynological evidence from the Anglo-Welsh Basin, UK

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Few other successions have contributed as much to our understanding of late Silurian – Early Devonian land plants as the Lower ‘Old Red Sandstone’ of the Anglo-Welsh Basin, U.K. The nearly continuous fluvial deposits of the basin straddle the Siluro-Devonian boundary, which is a key moment for early land plants. Here, the >40myr long ‘slow-fuse’ evolutionary stasis of primitive cryptospore producing land plants ends with an explosive radiation of tracheophytes and their immediate progenitors as they diversify and dominate terrestrial ecosystems. A comprehensive appraisal of the dispersed spore record from the latest Ludlow to middle Lochkovian (late Silurian – Early Devonian) of the Anglo-Welsh Basin, building on previous work, has revealed an unprecedented increa-

se in diversity amongst dispersed cryptospores and miospores. Here, we present a quantitative analysis of diversity and disparity (morphological diversity) change amongst the trilete miospores and cryptospores, alongside exploring floral turnover across several, coeval environmentally variable sites, which allows temporal and spatial comparisons of the above. Our findings suggest that not only did trilete spores see immense changes in diversity and disparity across the Siluro-Devonian boundary, but cryptospores also exhibit their own adaptive radiation. The environmental differences between coeval sites may also hint at palaeoecological preferences for certain dispersed spore species and their parent plants.

Keywords: Early Land Plants, diversity, disparity, turnover, Siluro-Devonian, Old Red Sandstone, palaeoecology



Palynological assemblages from the Neoproterozoic-Paleozoic. Lower Llanos basin. Colombia

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Colombia occupies the northwestern corner of South America. The most outstanding physiographic feature is the Andean Cordillera, which has three branches. The Llanos is a structural depression located to the east of the Eastern Cordillera, being the most hydrocarbon prolific and the largest sedimentary basin in Colombia covering more than 200.000 km². Bounded on the west by the Andean Cordillera and limited to the south by outcrops of the igneous-metamorphic rocks belonging to the Guyana Shield. The Llanos contains some of the most extensive oil discoveries in Colombia, and it is still considered as a potential basin for big and medium-size discoveries.

Sharing the same surface area, the Llanos have two overlapping basins; the lower one includes Neoproterozoic and Paleozoic sediments that suffered the avatars of the separation of Pangea and the upper one that developed during the Mesozoic and Cenozoic. The two basins share the compressional history of the collision of the tectonic plates during the Andean orogeny.

The basement of the llanos is densely fractured and presents a rift-like tectonic system where seismically narrow and elongated engravings can be observed in an east-west direction. In the deepest part of these engravings very old sedimentary sequences (Ediacarian-Tonian) have been protected from erosion.

Nineteen of the Paleozoic sections drilled at Los Llanos have been analyzed palynologically and their results are used to elaborate the Figure 1. Future work has been planned to obtain the missing pieces of this puzzle.

The Neoproterozoic assemblages (Palma Real-1, Chilacoa-1S, La Tortuga-1, Coralito-1S, La Coral-1, Vaco-1X, Torodoi-1X and Rondon-1 wells) includes: *Kildinosphaera verrucata*, *Kildinosphaera chagrinata*, *Leiosphaeridia asperata*, *Leiosphaeridia* spp., *Coneosphaera cf. arctica*, *Cymatiosphaera* spp, *Dictyodinium* spp.[?], *Lophosphaeridium* spp. and *Micrhystridium* spp. among several others. The Cambrian recovered assemblages Chiguiro-1 well are dominated by the common presence of *Crystallinium cambriense* and the presence of *Adara alea*, *Vulcanisphaera lanugo*, and *Eliasium llanicum*. The Ordovician palynomorph associations Rancho Hermoso – 2p well include *Villosacapsula setosapellicula*, *Veryhachium trispinosun* group, *Veryhachium lairdi*, *Leiofusa litotes*, *Orthosphaeridium* spp, *Acanthodiacrodium* spp, *Baltisphaeridium* spp, *Striatotheca principalis* var. *parva*, *Striatotheca cf. frequens*, *Orthosphaeridium tematum*, *Striatotheca quieta*, *Frankea sartbemarzensis*, *Dicrodiacrodium ancoriforme*, *Stellechinatum uncinatum*, *Cymatiogalea* spp., *Peteinosphaeridium armatum*, *Arbusculidinium filamentosum*, *Poikilofusa cf. plethysticha*, *Ammonidium multipugiunculatum*, *Petaloferidium florigerum*, *Striatotheca transformata*, *Comatiogalea* spp, and *Pachysphaeridium rhabdocladium* among others.

The Silurian acritarch assemblages (Paso Real-1 and La Maria-1 Well) are characterized by the presence of *Neoverghachium carminae*, *Dactylofusa* spp., *Tylotopalla cf. caelmenticutis*, *Villosacapsula* spp., *Eupoikilofusa cabotii*, *Dactylofusa marahrenis*, and *Baltisphaeridium tenuata*. The Carboniferous trilete spore assemblages SM-4 are characterized by the presence of *Grandispora spiculifera*, *Auroraspora solisorta*, *Retusotriletes crassus*, *Apiculiretusispora multisetata*, *Anapiculatisporites concinnus*, and *Speleotriletes* spp.

No Permian strata have been reported in the Llanos. The Permian was probably a time of nondeposition or intense erosion. Recent seismic studies have allowed us to observe that the basement of the basin is densely affected by rift faults that have compartmentalized the basin making it too complex to explain the distribution of Neoproterozoic and Paleozoic sediments.

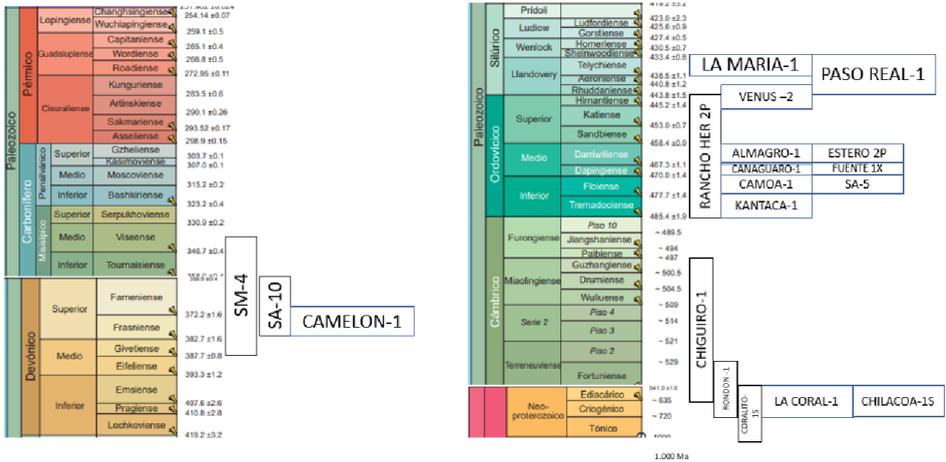


Fig.1 Stratigraphic range established for Paleozoic sections drilled in selected wells, Lower Llanos Basin.

Keywords: Llanos Basin Colombia, Carboniferous, Neoproterozoic palinomorphs, Paleozoic palinomorphs



The impact of land plants on Earth systems: a palynological, palaeobotanical, and geochemical perspective

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The diversification and spread of terrestrial plants was one of the most profound changes in the history of Earth. Plants affect Earth's climate and the global hydrologic cycle through evapotranspiration and by altering planetary albedo. They also alter the landscape; they have transformed river morphologies and the distribution of mud in sedimentary systems. While it is long accepted that the evolution of terrestrial plants had considerable impact on Earth systems, there are still widely varying views about the extent to which the emergence of land plants increased global productivity, drove atmospheric oxygenation, and altered the global marine redox landscape. The goals of this project are to connect and evaluate the effects of plant evolution on the marine redox record through palynology, paleobotany, and geochemistry.

Sampling efforts focus on stratigraphic successions spanning the Silurian-Devonian transition, specifically the Road River Group and McCann Hill Chert, as sampled on the Tatonduk River and McCann Hill type section, Alaska, USA. These successions provide an exceptional opportunity to characterize both marine and terrestrial processes across the Silurian-Devonian transition and to explore the impact of land plant evolu-

tion on Earth systems. The interbedded limestones, shales, and cherts of these units record slope deposition on the northwestern margin of Laurentia, likely spanning the basal Silurian through Middle Devonian. The generation of palaeobotanical and palynological records from these successions will be used to track changes in plant diversity. If palynomorph and plant macrofossil diversity and abundance changes in tandem with shifts in geochemical redox tracers this will allow for the detailed, high-resolution linkage of plant evolution and marine geochemistry through the Silurian-Devonian interval. Alternatively, lack of coupled change would suggest that hypothesized linkages likely require revision. The specific hypotheses to be tested is that plants increased nutrient delivery to the oceans, causing locally anoxic water columns to become sulfidic. This will be tested by analysis of iron speciation and Mo/U ratios. The geochemical and paleobotanical data from the Tatonduk River and McCann Hill successions will provide well-calibrated records of redox change through the Silurian-Devonian transition, directly connected to palaeobotanical records, and thus the best test to date of whether terrestrial evolution is temporally associated with redox changes in the marine realm.

Keywords: early plants, geochemistry, oxygen, redox records



The Late Givetian palynology of the south-central Poland

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Eight new sections were investigated for palynostratigraphy and palynofacies. The investigated area covers two basins: the Łysogóry-Radom Basin and The Lublin Basin, of south-central Poland. Both basins during the Devonian formed a part of a wide tropical belt of a shelf margin of the Laurussia continent and that gives an opportunity to look into the interval of noticeable palaeoenvironmental changes. Despite the fact that Givetian palynology of Poland is recognized to some extent, there are only few papers that consider the Givetian Taghanic Event from the palynological point of view. The most prominent feature of the palynological Taghanic record was a noticeable decrease in miospores taxonomic diversity. Here the miospore assemblage was represented by

80 taxa and the sections that showed well preserved material follow this low-diversity pattern. The noticeable taxonomic decrease was observed around the Givetian/Frasnian boundary and the dominant genera were small miospores with fine ornamentation (*Aneurospora* and *Geminospora*). Beside the miospores, the palynomorph assemblage contained plant remains (cuticles, tracheids), scolecodonts, acritarchs, prasinophytes and first Givetian chitinozoans from the area of Poland. Two sections contained also the oldest known organic tentaculitoids. Palynofacies analysis confirmed the complex palaeoenvironmental situation with the few transgressive-regressive impulses that affected the relatively shallow marine shelf with the high terrestrial input.

Keywords: palynostratigraphy, palynofacies, Middle Devonian, Taghanic



Problems and challenges for Permian palynostratigraphy: a global review

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Since 2018 when a global review of the Permian (Lucas and Shen, *The Permian Timescale*, Geological Society, London, Special Publications, 450) and Permian palynostratigraphy (Stephenson, pages 321-347 in the same volume), were carried out, it has been clear that there are certain challenges for Permian biostratigraphy and palynostratigraphy.

Permian palynostratigraphy has been used primarily to correlate coal- and hydrocarbon-bearing rocks within basins and between basins, sometimes at high levels of biostratigraphic resolution. Though these palynostratigraphic schemes related to resource extraction have been very successful, their main shortcoming has been a lack of correlation with schemes outside the basins, coalfields and hydrocarbon fields that they serve, and chiefly a lack of correlation with the international Permian scale. The benefits of a better integrated general palynostratigraphy are very great scientifically because there are numerous events of global scientific interest in the Permian, for example the timing and order of deglaciation events and the detailed characteristics and timing of mass extinction events within the Permian and at the Permian-Triassic boundary.

Permian palynostratigraphy is strongly affected by phytogeographic provinciality, as predicted by palaeobotanical studies. This makes correlation between regional palynostratigraphic schemes difficult. For these reasons it is unlikely that a single comprehensive palynostratigraphic scheme for the Permian globally will ever be developed. However local high resolution palynostratigraphic schemes for regions are being linked either by precise assemblage-level quantitative taxonomic comparison or by the use of single well-characterised palynological taxa that occur across Permian phytogeographical provinces. Such taxa include: *Scutasporites* spp., *Vittatina* spp., *Weylandites* spp., *Lueckisporites virkkiae*, *Otynisporites eotriassicus* and *Con-*

verrucosisporites confluens. These palynological correlations can be facilitated and supplemented with radiometric, magnetostratigraphic, independent faunal, and strontium isotopic dating.

None of the Permian GSSPs involve palynological definitions, which may be problematic given the importance of palynology in correlation in the commercial and academic worlds. However there appear to be taxa that occur at GSSPs or well-dated boundary sections that could be used to correlate those boundaries. For example *Aratrisporites* and *Otynisporites eotriassicus* may be useful to correlate the Permian-Triassic boundary into non-marine sections or sections without radiometric dates. *Converrucosisporites confluens* may be useful in correlating the Carboniferous-Permian boundary.

The Subcommittee for Permian Stratigraphy (ICS) has established a new working group to work towards better correlations between Gondwana and Euramerica in the Permian, and a substantial part of the working group will be concerned with palynology.

References

- Stephenson, M H. 2018. Permian palynostratigraphy: a global overview. In: Lucas, S G, and Shen, S Z. (eds) *The Permian Timescale*. Geological Society, London, Special Publications, 450; 321-347.
- Lucas, S G, and Shen, S Z. 2018. (eds) *The Permian Timescale*. Geological Society, London, Special Publications, 450.

Keywords: Permian, review, palynostratigraphy, correlation



The Permian of Israel and Jordan and the antiquity of the Dead Sea Fault

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Palynology is usually associated with simple dating or palaeoenvironmental and climate studies, but it can be used to solve larger regional geological problems. One example relates to the origin and history of the Dead Sea Fault famous for its destruction of Jericho. The Dead Sea Fault extends for around 1,000 km, and produced more than 100 km of displacement between the Negev and Jordan. Although the fault in its present form is Miocene in age, an older pre-existing deformed zone was also probably present. Here palynology analysis shows that a precursor to the fault was probably active during the Permian.

The Dead Sea Fault is a major tectonic element in the Middle East which extends from the Red Sea to Turkey, and contains evidence indicating ca. 107 km of strike-slip left-offset across the Negev-Jordan segment since the early to middle Miocene. Although the Dead Sea Fault and its sinistral movements are widely accepted as Miocene in age, evidence suggests it may relate to an older pre-existing deformed zone as revealed from Eocene – Oligocene successions.

Evidence from palynology shows that the fault or its precursor was also likely to have been active during the Permian. This is because it is possible to show through the occurrence of stratigraphically important fossil pollen species, that strata of the same age either side of the precursor are of very di-

fferent thickness, and that a large part of the Permian succession is missing on the Jordanian side. On the Negev side, the key formations are the Saad and Arqov formations which vary in thickness across the Negev with the lower Saad Formation being thickest in the southern Negev and in the east adjacent to the Dead Sea Fault.

On the Jordanian side of the Dead Sea, the Permian succession is limited to the Umm Irna Formation. Palynology shows that the formation is likely of latest Permian age (Changhsingian) because it contains the pollen *Pretricolpипollenites bharadwajii*. Cored sections of the Arqov Formation in the Negev boreholes Avdat-1 and Makhtesh Qatan-2 also contain *Pretricolpипollenites bharadwajii*. This indicates that the Umm Irna Formation is at least in part equivalent to the Arqov Formation (Fig. 1). However palynology also indicates that the Saad Formation does not occur to the east of the present day fault in the Dead Sea area of Jordan (Fig. 1).

In this example palynology is shown as being very powerful in being able to differentiate the character of strata either side of the fault. This would be very difficult using other palaeontological groups because macrofossil and other microfossils are very rare in these Permian beds, whereas fossil pollen are very abundant in the Negev and Jordanian rocks at outcrop and in borehole cores.

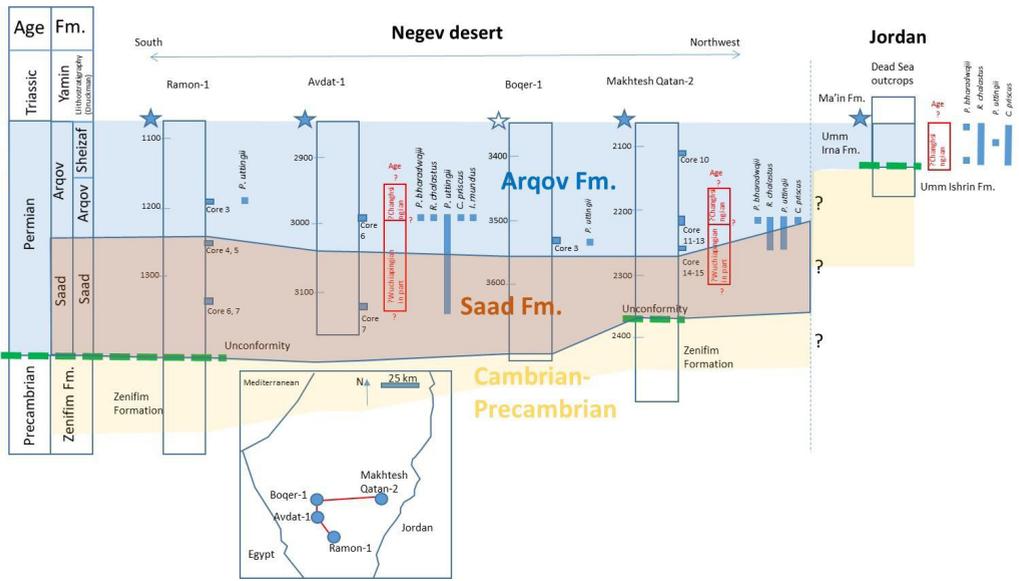


Fig. 1. Lithostratigraphy, palynology and biozones of Makhtesh Qatan-2; Ramon-1, Boqer-1, Avdat-1 and Jordanian Dead Sea outcrops; solid star indicates Permian-Triassic boundary depth, blank star indicates approximate depth of the Permian-Triassic boundary

Keywords: Palynology, Israel, Jordan, Dead Sea Fault, Permian



A new hypothesis proposing a protonematal origin to plant conducting tissue

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The origin of land plants represents a major evolutionary advancement during which simple aquatic charophyte algae evolved a *de novo* developmental program, resulting in a level of complex multicellularity that still characterizes land plants today. One might suppose that the Cambrian to Devonian interval provides a basic stratigraphic record of the evolutionary assembly of the upright

axial plant sporophyte, but this is not the case with how most paleobotanists interpret that record. Instead, the present paleobotanical paradigm posits a Precambrian/Cambrian origin of land plants followed by a lengthy missing record after which vascularized plant axes finally appear during the latter half of the Silurian Period. This interpretation of a missing fossil record has been

driven by a reluctant acceptance of molecular time-trees as accurate, in combination with the acceptance of claims of the oldest plants and spores.

Here, by assuming the primacy of the fossil record and rejecting the inclusion of rare temporal outliers, I present an evo-devo model of embryophyte assembly, which is

consistent with a late arrival to the upright axial sporophyte. This literal interpretation of the fossil record begins with a previously published record of Cambro-Ordovician cryptospores *sensu lato* and ends with a novel interpretation of the so-called “banded tubes” as tracheid homologs, rather than as fungi as they are most often viewed.

Keywords: nematoclast, *Dyadospora*, plant meiosis, charophyte, ChIN, protonema, plant development



A palynological investigation of the Devonian sequence of Northern Spain

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Northern Spain (Asturias-Leon-Palencia) hosts an extensive sequence of Devonian rocks that covers most of the Devonian System. It accumulated in the shallow seas surrounding the Armorican Terrane Assemblage (ATA), a development of island located between Laurussia to the north and Gondwana to the south. The sequence is entirely marine and consists of alternating thick limestone units and thick terrigenous units. These are well age-constrained based on the presence of conodonts and invertebrate macrofaunas, and their sedimentology and palaeoenvironments extensively studied. Rich palynomorph assemblages

have been recovered from throughout the sequence yielding marine elements (acritarchs, prasinophycean cysts, chitinozoans and scolecodonts) and terrestrial spores. Due to the isolated position of the ATA the palynomorphs are somewhat endemic, but also contain a mixture of recognizable forms of Laurussian and Gondwanan affinity. Most of the global Devonian events can be recognized in the sequence (e.g. Kellwasser and Hangenberg events). This provides an opportunity to study these events in a relatively isolated oceanic setting away from the supercontinents of Laurussia and Gondwana.

Keywords: Devonian; mass extinctions; spores, acritarchs, chitinozoans.



Palynology of the Wolfgang Basin: implications for floral composition, climate and environment

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The Permian basins of eastern Australia host extensive coal deposits that act as an archive of climate, environment and floras following the end of the Late Palaeozoic Ice Age (LPIA). This study focused on the examining palynofloral records from the Wolfgang Basin, an isolated half graben containing significant accumulations of coal, adjacent to the foreland Bowen Basin. The main aims of this work were to better constrain the timing of deposition and understand the composition of the basinal floras and the climate and environment in which they grew. Four seams were targeted for sampling: the Wolfgang Main and Upper seams as well as the overlying Prospect and Gowrie seams. Samples were collected both from the coals themselves to examine the in-situ peat-forming floras, as well as from mudstone and claystone partings to examine regional floral trends.

Previous studies constrained the Wolfgang and Blair Athol basins to the Kungurian, however new calibrations of the eastern Australian biostratigraphy allow for a reassessment of these ages. The observation of index taxon *Praeocolpites sinuosus* (APP3.2) would suggest a Kungurian or lower Roadian age for the Wolfgang Main and Upper seams whereas the first appearance of *Microbaculispora*

villosa (APP3.3) in the Prospect and Gowrie seams suggests a Roadian age.

Palynofloras in the coals were dominated by diverse spores (*Leiotriletes*, *Granulatisporites*, *Horriditriletes*, *Converrucosisporites*) and striate bisaccate pollen (*Protohaploxylinus*) indicative of a peat-forming assemblage dominated by ferns and Glossopterids. Samples from the seam partings included higher abundances of monosaccate (*Plicatipollenites*, *Cannanoropollis*) and bisaccate (*Triadispora*) pollen potentially indicative of conifers and cordaitaleans either occupying non-peat-forming environments or transported from upland areas. One sample featured a particularly high abundance of cavate trilete (*Indotriletes*) and monolete (*Laevigatosporites*) spores that is suggestive of groups such as horsetails and lycopsids that grew around lakes and ponds in the periphery of the mire. Algal assemblages comprise of freshwater taxa (*Botryococcus*, *Tetraporina*, *Peltacystia*) and indicate no marine influence.

Keywords: Permian, palynology, Gondwana, Wolfgang Basin, Australia, coal



Mesozoic
Mesozoico



The Upper Jurassic - Lower Cretaceous in the Richardson Mountains (Northwest Territories, Canada): palynostratigraphy and palynological insights on the tectono-stratigraphic architecture of the Canadian Arctic mainland

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The Sverdrup Basin is a sedimentary basin underlying the Canadian Arctic Archipelago; it currently provides the primary reference framework for the tectono-stratigraphic architecture of the Canadian Arctic. It contains a nearly continuous record of the Mesozoic rifting events that led to the formation of the Arctic Ocean and the associated Amerasia Basin including a sub-Barremian unconformity. The Richardson Mountains, located in northwestern Canada, also contain a nearly continuous sedimentary record of Mesozoic events and are ideally positioned to investigate links between the tectono-stratigraphic evolution of the Sverdrup Basin and adjacent landmasses. Within the Richardson Mountains is a sub-Barremian unconformity, developed during a period of rifting and occurring erosionally at the base of the Mount Goodenough Formation. However, the precise age of the Mount Goodenough Formation, the unconformity, and its relation to polar tectonics remains uncertain.

The aims of this project were to temporally correlate the intra-Mount Goodenough Formation Barremian-aged unconformity in the Richardson Mountains region with the poorly constrained sub-Barremian unconformity in the Sverdrup Basin, and to provide new insight into (1) tectono-stratigraphic linkages with circum-Arctic areas and (2) the

development of polar terrestrial ecosystems during a warm interval in Earth's history. This was accomplished using quantitative palynology to statistically correlate pollen and spore assemblages from the Richardson Mountains to those published from the Sverdrup Basin to test time equivalence and reconstruct paleoenvironmental conditions. Palynoassemblages of the Richardson Mountains (from the Husky and Mount Goodenough formations) were compared to the Sverdrup Basin palynoassemblages (from the Deer Bay and Isachsen formations). Comparison indicated that the Deer Bay Formation and Isachsen Formation are time equivalent to the Husky Formation and Mount Goodenough Formation respectively. Therefore, if the Mount Goodenough Formation and Isachsen Formation consist of time equivalent strata and contain similar palynoassemblages, the sub-Berriman unconformities present in the two formations may be coeval. Paleoenvironmental reconstruction shows that the environment was humid and alternated between warmer and cooler intervals.

Keywords: Canadian Arctic, Jurassic, Cretaceous, biostratigraphy



Preliminary observations and implications of a new Bathonian (Middle Jurassic) lagerstätte in Wiltshire, UK. With a focus on the palynology, micropalaeontology and geochemistry

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A new UK Bathonian (Middle Jurassic) lagerstätte has been revealed and was publicised last year as one of the most important Jurassic echinoderm localities in the world. Excavation of the site has produced thousands of exceptionally preserved articulated echinoderms including at least 18 species, belonging to all five extant echinoderm classes. A closer look however, at the range of other fossil groups has shown the exceptional preservation and diversity is not limited to the echinoderms.

I'll be presenting initial findings from the palynological and microfaunal investigations along with some geochemical analysis in order to help understand the local palaeoenvironment and why this 'unique' site exists. Diverse, well-preserved dinocyst assemblages add to a deeper, nutrient-rich environmental interpretation and a 'mistake' in processing reveals a fascinating new discovery.

Keywords: Jurassic, Dinocysts, Sporomorphs, Bathonian



Palynological insights from the Early Jurassic of Lyme Regis, UK

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and S. Stukins^a

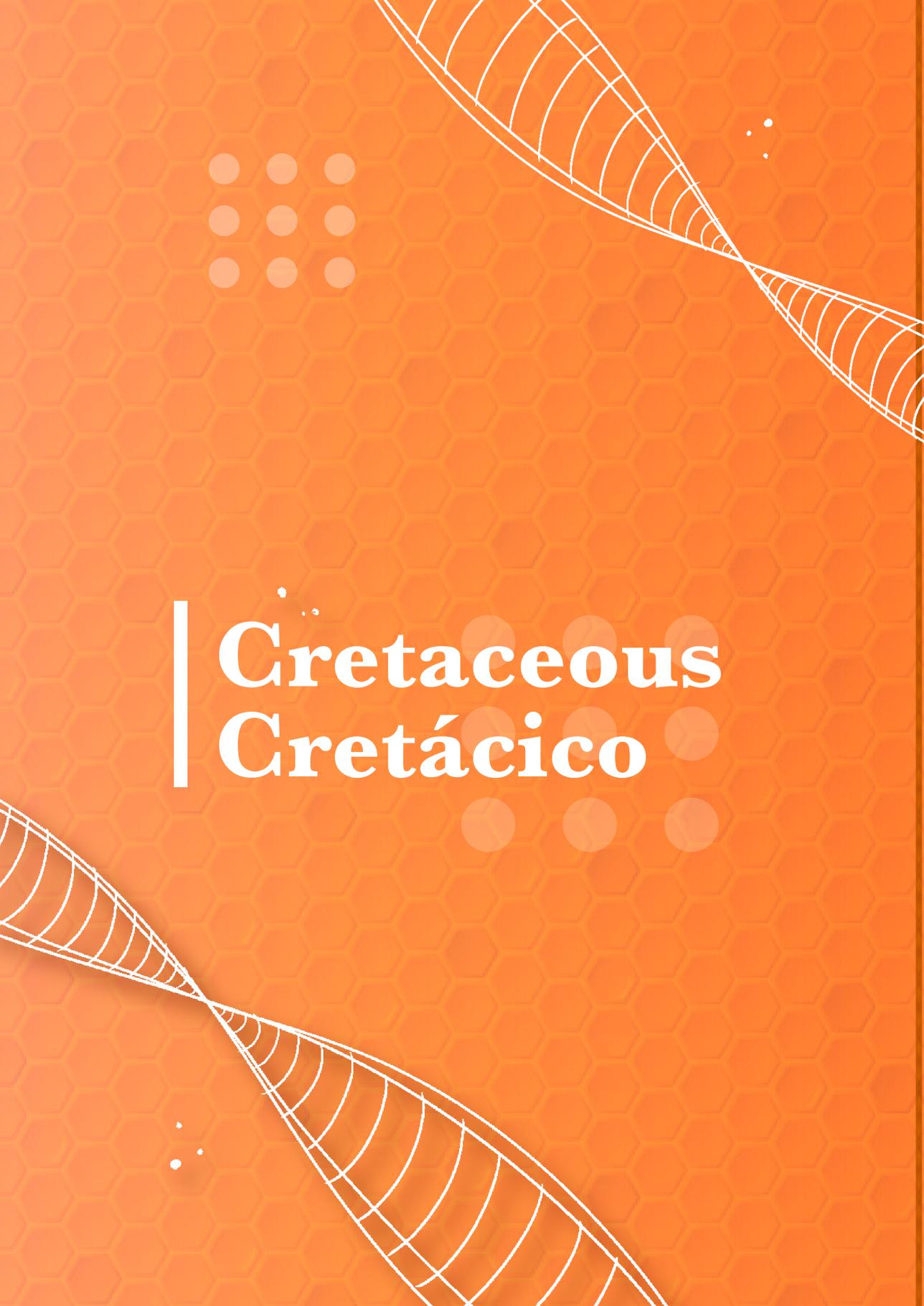
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The Triassic-Jurassic extinction-recovery interval records a period of global climate change; evidenced through carbon isotopes, biomarkers and marine faunal extinctions from a multitude of sites across the globe. Utilising the well-exposed natural laboratory of SW Britain, we investigate the recovery patterns of the early Jurassic. Combining novel palynological, marine invertebrate and geochemical data, spanning the late Rhaetian to the early Sinemurian, we show variable terrestrial input through the early Jurassic.

The terrestrial palynological record at Lyme Regis is dominated by *Classopollis* spp., Krau-

selisporites reissingeri and bisaccate pollen, with a concentration of fern spores around the Triassic-Jurassic boundary (*Baculatispores* spp., *Deltoidospora* spp., *Trachysporites* spp.). The marine palynological record has an abundant assemblage of acritarchs throughout, whilst dinoflagellates are almost wholly represented by *Beaumontella langii*. These initial findings support similar timings for the recovery of diversity of both palynomorphs and marine invertebrates, which is also apparent in preliminary data from sites in South Wales, UK.

Keywords: Jurassic, Lyme Regis, geochemistry,
marine invertebrates



Cretaceous Cretácico



Cretaceous-Eocene dinoflagellate blooms of the James Ross Basin, Antarctic Peninsula

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Studies conducted to date indicate that the records of fossil dinoflagellate blooms are relatively well-known. This natural phenomenon of flowering or proliferation (bloom) of algae usually occurs in response to sudden environmental or climatic changes, leading to a monospecific or few-species assemblages. Some dinoflagellate bloom events, evidenced by their cysts (dinocysts), have been recognized in Antarctica in both Cretaceous and Cenozoic strata. In this preliminary study, five blooms events are characterized, three of them identified from material collected in the James Ross Basin, Antarctic Peninsula (Cretaceous and Eocene) while the remaining two were obtained from the literature (late Maastrichtian and K/Pg boundary). In the Santa Marta Formation (lower Santonian) outcropping on James Ross Island, a bloom of *Odontochitina porifera* was recorded, reaching 80% of the marine assemblage (92 cysts in total). This bloom matches with the lowest values of continental-derived elements (spores, pollen grains and phytoclasts), which indicates a marine environment far from terrigenous sources. In the Snow Hill Island Formation (late Campanian - early Maastrichtian) cropping out on James Ross and Snow Hill Islands, two peaks of abundance of *Impletosphaeridium clavus* were identified (73% and 31% of the marine assemblage, respectively), which

would have been occurred in response to cold pulses during the Cretaceous, however, without the development of sea ice cover. Likewise, the bloom of *Impletosphaeridium clavus* (99% of the marine association) in a section of the López de Bertodano Formation (late Maastrichtian) on Marambio Island (Seymour) was reported in the literature associated with the presence of seasonal sea ice and a stratified water column. In the same section, a bloom of different *Manumiella* species (68% of cysts) was recognized. This genus is characteristic of coastal and shallow-marine environments and could indicate short-term regressions and/or an oceanic cooling that occurred just before the Late Cretaceous massive extinction (K/Pg boundary). Finally, the proliferation of *Impletosphaeridium clavus* together with *Manumiella* could be due to the combination of cold and nutrient-rich surface waters that would have favored the increase of both taxa. For the early Paleocene (Danian), the literature indicates an increase in *Senegalinium obscurum* (23% of the cysts) in the Sobral Formation near the base of a glauconite-rich level, which helps to identify the K/Pg boundary in Marambio Island (Seymour). In addition, *Palaeoperidinium pyrophorum* was recorded in this same formation, in intervals that show a conspicuous increase in abundance. Finally, in the La Meseta Formation (middle-late

Eocene), in the Valle de las Focas and Acanthados I (or Telm 1) allomembers, the bloom is attributed to the dinoflagellate or acritarch species *Enigmadinium cylindrifloriferum*, which represents more than 90% of the marine assemblage (~150 cysts). Previous work associates the abundance of this species with a shallow and stressful marine environment, interpreted as an outer part of a wave-dominated estuary. Evidently, the causes of the dinoflagellate blooms are diverse, but they

are constantly repeated throughout the Mesozoic and Cenozoic of Antarctica. These blooms are manifested mainly as peridinooid cysts (*Manumiella*, *Senegalinium*, *Palaeoperidinium*) and, somewhat, as gonyaulacoid forms (*Odontochitina porifera*, *Impletosphaeridium*, and possibly *Enigmadinium*). Peridinooid blooms mark bioevents, some of which are globally recognized (e.g., *Manumiella spike*). [CNPq/PROANTAR 442765/2018-5]



Floraciones de dinoflagelados del Cretácico-Eoceno de la cuenca del James Ross, Península Antártica

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Los estudios realizados hasta el momento indican que los registros de floraciones de dinoflagelados fósiles son relativamente bien conocidos. Este fenómeno natural de floración o proliferación (bloom, en inglés) de algas suele ocurrir en respuesta a bruscos cambios ambientales o climáticos, dando lugar a una asociación monoespecífica o con escasas especies. En la Antártida se han reconocido algunos eventos de floración de dinoflagelados, evidenciados por sus quistes, tanto en estratos del Cretácico como del Cenozoico. En este estudio preliminar se caracterizan 5 eventos de floración, siendo 3 de

ellos identificados en material recolectado en la Cuenca James Ross, Península Antártica (Cretácico y Eoceno) mientras que los 2 restantes fueron obtenidos de la literatura (Maastrichtiano tardío y Maastrichtiano/Daniano o límite K/Pg). En la Formación Santa Marta (Santoniano inferior) aflorante en la Isla James Ross, se registró una floración de *Odontochitina porifera*, alcanzando el 80% de la asociación marina (92 quistes en total). Esta proliferación coincide con los valores más bajos de elementos de origen continental (esporas, granos de polen y fitoclastos), lo que indica un ambiente mari-

no alejado de las fuentes terrígenas. En los estratos de la Formación Snow Hill Island (Campaniano superior - Maastrichtiano inferior) reconocidos en las islas James Ross y Snow Hill, se identificaron dos picos de abundancia de *Impletosphaeridium clavus* (73% y 31% de la asociación marina, respectivamente), que se habrían producido como respuesta a pulsos fríos durante el Cretácico, sin desarrollo de cubierta de hielo marino. Asimismo, en la bibliografía se informó la proliferación de *Impletosphaeridium clavus* (99% de la asociación marina) de una sección de la Formación López de Bertodano (Maastrichtiano tardío) en la isla Marambio (Seymour), y se la asoció a la presencia de hielo marino estacional y a una columna de agua estratificada. En esta misma sección se reconoció una floración de distintas especies de *Manumiella* (68% de los quistes).

Este género es característico de ambientes marinos costeros y de plataforma interna y podría indicar regresiones de corto plazo y/o un enfriamiento oceánico ocurrido justo antes de la gran extinción de finales del Cretácico (límite K/Pg). Por último, la proliferación conjunta de *Impletosphaeridium clavus* y *Manumiella* podría deberse a la combinación de aguas superficiales frías y ricas en nutrientes que habrían favorecido el aumento de los taxones. Para el Paleoceno temprano

(Daniano), la literatura indica que la Formación Sobral registra un aumento de *Senegalinium obscurum* (23% de los quistes) cerca de la base de un nivel rico en glauconita, lo que ayuda a identificar el límite K/Pg en la isla Marambio. Además, en esta misma formación se registró *Palaeoperidinium pyrophorum*, en intervalos que presentan en gran número. Finalmente, en la Formación La Meseta (Eoceno medio-tardío), en los alomembros Valle de las Focas y Acantilados I (o Telm 1), la floración se atribuye a la especie de dinoflagelado o acritarca *Enigmadinium cylindrofloriferum*, que representa más del 90% de la asociación marina (~150 quistes). Trabajos previos asocian la abundancia de esta especie a un ambiente marino poco profundo y estresante, interpretado como la parte externa de un estuario dominado por oleaje. Es evidente que las causas de las floraciones son variadas, pero se repiten de forma constante a lo largo del Mesozoico y Cenozoico de Antártida. Estas proliferaciones se manifiestan principalmente como quistes peridinoides (*Manumiella*, *Senegalinium*, *Palaeoperidinium*) y, en menor medida, como formas gonyaulacoides (*Odontochitina porifera*, *Impletosphaeridium* y posiblemente *Enigmadinium*). Las floraciones de peridinoides marcan bioeventos, algunos de los cuales son reconocidos a nivel mundial (por ejemplo, el pico de *Manumiella* o “*Manumiella spike*”).



Early angiosperms – how far can we reliably go back in the pollen record?

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The timing of the origins of angiosperms is a long-standing topic of debate in plant evolution. Different disciplines and approaches provide highly variable age estimates. It is generally accepted, that early macro- and mesofossils showing unequivocal angiosperm features occur in Early Aptian deposits. The oldest widely accepted fossilized flowers and reproductive structures are from the Torres Vedras mesoflora and have been found within continental strata in the Lusitanian Basin tentatively assigned to Late Barremian – Early Aptian. Workers employing palynology, i.e. the extremely durable, abundant, and widespread pollen record, have suggested much earlier, but highly disputed ages. To date it remains questionable how far back pollen with unequivocally angiospermous features can push back the age for

(early) angiosperms.

Here we review existing challenges in the study of palynological records of early angiospermous pollen. Additionally, we present new ‘early records’ from pre-Aptian coastal marine strata from the Lusitanian Basin of Portugal that are known for their excellent pollen preservation from previous studies. Employing chemo- and biostratigraphy we aim to provide a refined stratigraphic framework for existing and newly studied sections to improve our temporal understanding of subsequent palynological findings. Further we document challenges and solutions to finding the extremely rare angiosperm pollen and illustrate new preliminary finds of early angiosperms, especially triaperturate pollen, which suggest the presence of eudicots.

Keywords: early angiosperms, angiosperm evolution, stratigraphy, Lusitanian Basin, Barremian



Testing deep-time fungi and algae as proxies in palaeoecological analysis: A case study of a Maastrichtian flora from Patagonia, Argentina

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Using form-taxa names in deep-time studies and modern taxa names in quaternary studies is a common practice, particularly for fungi. In recent discussions about how to designate NPP taxa, researchers are reaching a consensus to follow modern taxonomic schemes whenever possible. The main goal of this research work is to assign modern affinities to fossil fungi and algae from Puntudo Chico Formation (Campanian?-Maastrichtian) of basin Cañadón Asfalto, Chubut Province, Argentina. Also, testing how useful will be to assign modern taxa names, specially to these geologically old fossil fungi avoiding form-taxa designations when those species have no stratigraphic values but valuable paleoecological information. The studied samples (n = 6, NF 1-6) came from a small profile of grey-brown limestone and claystone, and those facies could represent a floodplain environment. These samples have micro and mesofossils, abundant paly-

nomorphs like algae, fungi, spores of bryophytes, lycophytes, and Monilophyta, and pollen grains of conifers (Araucariaceae, Cheirolepidiaceae, and Podocarpaceae), cycads (*Cycadopites* sp.) and angiosperms (i.e., Arecaceae, Liliaceae, Proteaceae) typical of a continental association of an open forest with a clear dominance of angiosperms. After this study, algae were found in the 6 samples with a total of 12 taxa mainly from shallow nutrient-rich freshwater environments (*Botryococcus*, *Lecaniella*, *Leiosphaeridia*, *Ovoidites* spp., and *Pediastrum*). A total of 12 fungal taxa were identified in 4 out of the 6 samples (cf. *Dyctiosporium*, cf. *Endophragmiella*, cf. *Monodictys*, cf. *Sporidesmium*, cf. *Taeoniella*, among others). Modern ecological requirements of the NPPs identified lead us to conclude this study site was a woody forest, with an understory of herbaceous angiosperm, and after the register of, for example cf. *Endophragmiella* and cf. *Monodictys* sp., indicate the presence of lichens as a fungal substrate. Also, the presence of the fungal genus cf. *Entorrhiza* could indicate the presence of marsh vegetation in one of the samples (NF 2). The level water fluctuation can be notice by the distribution of algae taxa, along with the presence of some fungal taxa found in a freshwater setting with temperate to tropical climate. This study highlights the importance of designate NPPs in deep time studies using modern taxonomic schemes and particularly for fossil fungi linking form-taxa names with modern fungal genera along with their ecological requirements (trophic mode, guild, substrate preferences, climatic range, etc) allowing us to test fungi as valuable proxies for paleoenvironmental reconstructions despite how old the sediments are.

Keywords: Paleomycology, Modern fungal ecology, NPP, Algae, Deep time, Maastrichtian, Paleoenvironment



Evaluación del uso de hongos y algas como indicadores paleoecológicos: Un caso de estudio en una flora del Maastrichtiano de Patagonia, Argentina

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El uso de morfogéneros en estudios palinológicos es una práctica común en muestras desde el Devónico al Neógeno y la aplicación de nombres modernos a distintos taxones se aplica en estudios cuaternarios, particularmente para los hongos. En discusiones recientes sobre cómo designar taxones de palinomorfos no-polínicos (PNP), los investigadores han llegado a un consenso para seguir los esquemas taxonómicos modernos, siempre que sea posible. El objetivo principal de este trabajo de investigación es asignar afinidades modernas a hongos y algas fósiles de la Formación Puntudo Chico (¿Campaniano?-Maastrichtiano) de la cuenca Cañadón Asfalto, Provincia de Chubut, Argentina. Además, evaluar la utilidad de asignar nombres de taxones modernos a hongos fósiles pre-cuaternarios evitando las designaciones de morfogéneros, dado que no tienen valor estratigráfico, pero sí información paleoecológica valiosa. Las muestras estudiadas (n = 6, NF 1-6) proceden

de un pequeño perfil de limolitas y arcillitas de color marrón grisáceo, las facies podrían representar a un ambiente de llanura aluvial. Dichas muestras contienen micro y mesofósiles, abundantes palinomorfos tales como algas, hongos, esporas de briofitos, licofitos y Monilophyta, y granos de polen de coníferas (Araucariaceae, Cheirolepidiaceae y Podocarpaceae), cicas (*Cycadopites* sp.) y angiospermas (i.e., Arecaceae, Liliaceae, Proteaceae) propias de una asociación continental de bosque abierto con clara dominancia de angiospermas. En este estudio, se encontraron restos algales en las 6 muestras con un total de 12 taxones principalmente de ambientes de agua dulce, poco profundos, ricos en nutrientes (*Botryococcus*, *Lecanietella*, *Leiosphaeridia*, *Ovoidites* spp. y *Pediastrum*). Se identificaron un total de 12 taxones fúngicos en 4 de las 6 muestras (cf. *Dyctiosporium*, cf. *Endophragmiella*, cf. *Monodictys*, cf. *Sporidesmium*, cf. *Taeoniella*, entre otros). Los requisitos ecológicos de estos PNPs identificados permiten interpretar, que el sitio de estudio era un bosque con un sotobosque con angiospermas herbáceas, y el registro de taxones por ejemplo cf. *Endophragmiella* y cf. *Monodictys* sp. nos indicaría la presencia de líquenes. Asimismo, el registro del género cf. *Entorrhiza* podría indicar la presencia de vegetación palustre en una de las muestras (NF 2). La fluctuación del nivel del agua se puede notar por la distribución de taxones de algas, junto con la presencia de algunos taxones de hongos que se encuentran en cercanía de cuerpos de agua dulce con clima templado a tropical. Este estudio destaca la importancia de designar PNPs en estudios pre-cuaternarios utilizando esquemas taxonómicos modernos y particularmente para hongos fósiles, y de esta forma vincular esos taxones con sus requisitos ecológicos actuales (modo trófico, gremio, preferencias de sustrato, rango climático, etc.) comprobando así que los hongos son importantes para las reconstrucciones paleoambientales a pesar de la antigüedad de los sedimentos.

Palabras clave: Paleomicología, Ecología fúngica actual, NPP, Algas, pre-cuaternario, Maastrichtiano, Paleambiente



Acme zones of dinoflagellate cysts in the Cretaceous of Colombia: A harmful algal bloom for every occasion?

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Maximum abundances of particular dinoflagellate cysts are common in the Cretaceous sequence of Colombia. These events have been explained as the bloom of dinoflagellates in response to the upwelling of nutrient-rich waters or the eutrophication of surficial waters induced by enhanced input of nutrients from the continent. In both cases, it has been assumed that the acme zones of dinoflagellate cysts represent the record of harmful algal blooms. This hypothesis, however, has not been properly tested using palynology *in tandem* with other geological data (i.e., sedimentology, geochemistry, and other fossil groups). In this work, we present three cases in which palynology is studied along with other proxies aiming to decipher the mechanism that explains each acme zone. The first example corresponds to the Aptian-Albian boundary. During this transition, a bloom of *Criboperidinium* and *Palaeohystrichophora* is commonly found in Colombia. This event is better explained by a rise in the sea level as the acme zone coincides with a maximum flooding surface that is supported by a minimum in the content of elements associated with detrital minerals and the presence of limestones overl-

ying siliceous mudstones. A second example corresponds to a bloom of *Subtilisphaera*/*Palaeohystrichophora* at the dawn of the Cenomanian-Turonian oceanic anoxic event 2 (OAE2). In this case, the peak of superabundance corresponds with an increase of terrestrial palynomorphs and the Ti/Al and K/Al ratios indicating ocean fertilization driven by an enhanced influx of nutrients from the continent. Finally, cherts, phosphorites, and packstones of fish remains and pellets of Campanian age are widespread in eastern and central Colombia. These rocks yield a characteristic palynological assemblage dominated by the tropical genera *Senegalinium* and *Andalusiella*. The rock type, the high contents of Si, P, and other micronutrients, and the high abundances of peridinioid dinocysts are all consistent with an overturn of the water column induced by seasonal upwelling that resulted in a harmful algal bloom and massive fish mortality. Our results caution against interpreting every acme zone of dinoflagellates as the result of eutrophication of the water column and a harmful algal bloom as this interpretation is simplistic and not necessarily correct.

Keywords: harmful algal blooms, Cretaceous, acme zones

Aquatic and semiaquatic
lacustrine flora from
Late Cretaceous-Early
Paleocene Deccan
volcanic associated
sedimentary beds:
implications in assessing
Paleoclimate and
depositional environment



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Distinctly diverse aquatic and semiaquatic flora has been recorded from the Deccan volcanic associated infra and intertrappean beds across the Cretaceous-Paleogene. The floral communities are represented by algal remains of, Chlorophyceae, Cyanophyceae and Zygnemataceae. Bryophytes are represented by Anthocerotopsida, Bryopsida, and Hepaticopsida. Aquatic ferns Salviniaceae (*Azolla*), Marsileaceae (*Crybelosporites* and *Gabonispuris*) are the most dominating group. Other pteridophytes such as *Achrostichum* (*Pteridaceae*), *Equisetum*, *Isoetes*, *Selaginella*, and *Thayeriorhizomoxylon chandrai* (*Polypodiaceae*) are scarcely represented in Deccan volcanic province. Deccan aquatic and semiaquatic angiosperms record is not

taxonomically very diverse but they are represented by some of the important taxa such as *Nymphyocaulon* (*Nymphaeaceae*), *Aerophyllites* (*Typhaceae*), *Similacites*, *Eriospermocormus*, *Liliaceae* (*Liliaceae*), *Acanthus* (*Acanthaceae*), *Eichhnornia* (*Pontederiaceae*) and *Sparganiaceae* (*Sparganiaceae/Typhaceae*), Abundant fossil remains of thermophilic vegetation like palms, macrophytes and microfloral remains of algae (*Oedogonium*), *Salviniaceae* (*Azolla*), *Marsileaceae* as well as paleosol indicate frost free, warm, humid tropical to subtropical climatic with intermittent dry semiarid climatic conditions across Late Cretaceous-Early Paleocene during Deccan transition.

Keywords: aquatic, palynomorph, Deccan intertrappean, Late Cretaceous-Early Paleocene



Cretaceous palynostratigraphy in the Caguán-Putumayo Basin, Colombia: an example of data integration in hydrocarbon exploration

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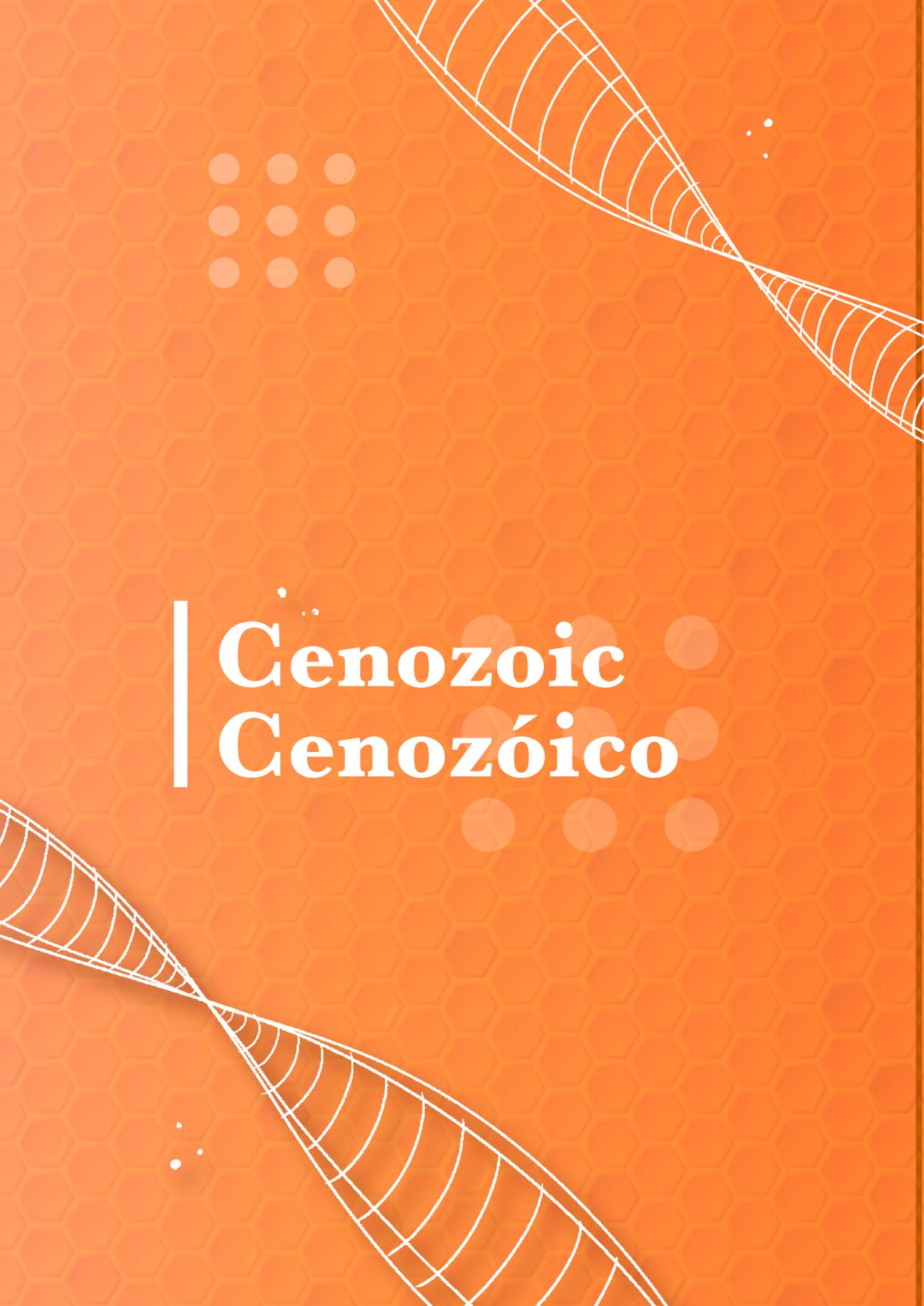
The Cretaceous of the Caguán-Putumayo basin in southern Colombia has many prospective levels of interest for oil exploration and production, mostly related with sandstones within a predominant shaly to calcareous sequence. The stratigraphic framework has been mainly correlated using three Maximum Flooding Surfaces (MFS) that have been used to interpret their lateral extent and in the understanding of the possible reservoirs in this basin. These surfaces have been named, from oldest to youngest, as SI-C, SI-B and SI-M. To corroborate their behavior, extent and relative age, the stratigraphic location of these surfaces was integrated with biostratigraphic events found in palynological analyses from 13 drilled core wells. These data were integrated and interpreted using RASC (Ranking and Scaling) statistical analysis; this technique allows to give an optimal order to the observed events. The most important events were

selected from each well, especially the Last Appearance Datum (LAD), as well as events with high relative abundances (ACME) of species that have been recorded in previous works as characteristic of a particular zone. Maximum Flooding Surfaces were also included to evaluate their stratigraphic position with respect to biostratigraphic events.

The palynological results indicate that two biozones can be recognized in the Cretaceous sequence, the Cyatheacidites zone (Albian – Turonian) which is subdivided into the Heteroretitrescolpites and *Callialasporites* subzones, and the *Dinogymnium* zone (Coniancian - Campanian) which is subdivided into the *Dinogymnium* ACME and *Droseridites-Amorfo* subzones. The RASC analysis shows 25 relevant events in the sequence, gathered in three main groups. From base to top, it was observed that the first group is defined in the Cyatheacidites zone, the second in the *Droseridites-Amorfo* subzone, and the last one with the *Dinogymnium* ACME subzone.

It was also observed a close relationship between the stratigraphic location of the MFS and some events and zones of the basin. SI B is related to the upper part of the Cyatheacidites zone and SI M to the *Dinogymnium* ACME event. These results will allow to compare, with constrained stratigraphic resolution, the Cretaceous sequence of Caguán Putumayo with other basins of Northern South America in order to improve the knowledge of its evolution and extent its interest in oil exploration.

Keywords: Caguán-Putumayo, Cretaceous, Hydrocarbon, Villeta Formation



Cenozoic Cenozóico



A globally wetter Middle Miocene with a narrower intertropical convergence zone

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The Middle Miocene Climatic Optimum (MCO; 16.9-14.7Ma) was the warmest interval of the Neogene and is a potential analogue for the IPCC RCP 4.5-6.0 (intermediate scenarios). Global mean annual temperatures are estimated to have been 4–6°C warmer and pCO₂ was slightly higher than present day (above 500 ppm), with an asymmetric latitudinal temperature gradient, tropical temperatures in the mid-latitudes and reduced polar ice sheets. However, our understanding of Middle Miocene terrestrial climate at broad spatial scales is still developing as there are difficulties reconciling proxy-based climate reconstructions with climate models.

One of the current views of Miocene terrestrial climate is based on the Co-existence Approach which has given a broad view of global temperature and precipitation across the Neogene. However, the Co-existence Approach reconstructs an equal likelihood range for climate parameters that can be

wide and therefore hampers our understanding the water cycle. These reconstructed ranges also hinder quantitative data-model comparisons (proxy-ranges vs. climate model uncertainty).

Here we present the first global reconstruction of mean annual precipitation and seasonality from 189 Middle Miocene sites. We use two probability-based terrestrial paleoclimate reconstruction techniques, CREST (Climate Reconstruction Software) and CRACLE (Climate Reconstruction Analysis using Coexistence Likelihood Estimation), that employ Bayesian and likelihood estimation probability respectively to generate 2σ confidence intervals.

This is the first application of these models at a global scale. Our results show a globally wetter than present-day world, with the exception of a narrow band around the equator. This we attribute to a narrower Intertropical Convergence Zone that, due to the asymmetric distribution of ice in the Middle Miocene, was also located in the northern hemisphere over a yearly average.

The impacts of climate change on the global hydrological cycle will have profound impacts on society. Changes in precipitation will be a cause of concern for flood defense and accompanied infrastructural and financial challenges, water scarcity and agricultural productivity, ecosystem functioning and biodiversity. This statistically generated terrestrial climate reconstruction for the MCO will aid in the evaluation of climate reconstruction models in deep time, enabling an understanding of hydrology in the globally warmer conditions of the MCO. This new reconstruction will also contextualize botanical and fungal biodiversity during the MCO.



Response of Recent to Late Cenozoic Subtropical and Tropical Dinoflagellate Assemblages to Climatic/Oceanographic Changes

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There is much information on climatic changes and their reflection by dinoflagellate cyst assemblages (DCA) in high latitude sites, and comparatively less is known from tropical to subtropical localities. To diminish this imbalance, we present Recent data from temperate to tropical environments on the Pacific coast of Mexico to identify the response of the DCA to known climatic events and changes. In particular, they reflect marine primary productivity (MPP) and are

influenced by sea surface temperature. We then compare fossil data from similar environments in the Eastern Pacific to interpret oceanographic changes in the Late Cenozoic. Our recent database reflects regional climatic-oceanographic changes on yearly to decadal scales, indicating that MPP is directly related to cyst concentration, and it is modulated by climatic factors, mainly in the tropical area. Additionally, the proliferation of dinoflagellates is usually directly related to heterotrophic taxa, so an H-A Index helps identify high productivity intervals. The current global warming is strongly reflected by increasing MPP, mainly in the tropical locality, while it is almost absent in the cool site. DCA reflects similar patterns of MPP in sequences from offshore Costa Rica and western Colombia in Middle to Late Miocene and an Oligo-Miocene sequence from western Baja California.



Reworked pollen reduces apparent floral change during the Paleocene-Eocene Thermal Maximum

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Plant megafossils from the Paleocene-Eocene Thermal Maximum (PETM) in the Bighorn Basin, USA, document a dramatic shift in floral composition whereas palynofloral change from the same sections has appeared to be more subtle. We investigated this discrepancy by quantifying pollen preservation and by measuring the stable carbon isotope composition of specific pollen taxa. Pollen grains belonging to two common latest Paleocene taxa are poorly preserved in PETM samples, and the $\delta^{13}\text{C}_{\text{pollen}}$ values of these taxa are similar during the latest Paleocene and PETM. In contrast, pollen grains of a tropical taxon that became more abundant during the PETM are pristine and their $\delta^{13}\text{C}_{\text{pollen}}$ values are $\sim 4\%$ lower during the PETM than latest Paleocene. More broadly, pollen grains belonging

to lineages currently centered in temperate climates are typically poorly preserved when found in PETM samples, whereas in the same samples pollen belonging to lineages now centered in the tropics are well preserved. Differences in preservation and isotopic composition indicate extensive redeposition of older pollen grains during the PETM. Increased abundance of Cretaceous palynotaxa in PETM samples confirms erosion and redeposition, likely resulting from more

episodic and intense precipitation. Excluding reworked pollen from analyses reveals that, as in the megafloora, temperate taxa were absent during the body of the PETM at the time when dry tropical taxa briefly appeared. Blurring of microfloral change by reworking may be a common feature of major climatic perturbations that destabilize landscapes, leading to underestimation of the rate and magnitude of floral response to past global change.

Keywords: PETM, Bighorn Basin, pollen preservation, reworking, $\delta^{13}\text{C}$



Apocalypse past: coastal fungal assemblages following warming events

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Fungal community response to warming events is of great interest to mycologists and paleoecologists as they seek to develop models to forecast future changes. Equally important, however, is how fungal communities respond to cooling conditions and whether those responses can be teased apart from response to changing depositional environments. Here we examine two different examples of fungal assemblages preserved in coastal sediments following warming events: those from the Carrizo Formation

(Ypresian, Eocene, Texas) and those from the Upper Hattiesburg Formation (Serravallian-Tortonian, Miocene, Mississippi). The sand-dominated Carrizo Formation was deposited in a shallow marine setting, possibly a tidal delta, while the clay-dominated Upper Hattiesburg was deposited as a series of interfluvial overbank deposits adjacent to a coastal fluvial system. As such, the fossil fungal communities preserved in each setting are different, however, both record variations in fossil fungal assemblage upward. Preliminary interpretation of these results indicates that those assemblages in the Carrizo Formation record a transition from tropical to sub-tropical wet to sub-tropical less-wet conditions while those in the Hattiesburg Formation record a transition from warm, moist temperate conditions to drier temperate conditions.

Keywords: Fossil Fungi, Hattiesburg Formation, Claiborne Formation



Maastrichtian to Neogene Palynology from the Colombian Caribbean (Sinú-San Jacinto and Cesar Ranchería basins)

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The Colombian Caribbean has a sedimentary record ranging from the Late Cretaceous to the Quaternary. Its high number of oil and gas seeps indicates an active petroleum system and, therefore, potential for hydrocarbon exploration. The study of calcareous and organic walled microfossils has been one of the main tools to know the age and depositional environment of the sedimentary deposits. However, very little information has been published. To fill this gap, in recent years the National Hydrocarbon Agency (ANH) has carried out regional geological studies that include seismic line acquisition, drilling of core wells, geological mapping and different types of sample analysis. The University of Caldas is studying the micropaleontology (palynology, foraminifera, nannofossils and ostracods) of drill core samples from a record ranging from the Maastrichtian to the Miocene. This study presents palynological information from 875 samples obtained from 17 core wells in the Cesar-Ranchería and Sinú-San Jacinto basins. In the wells drilled in the Cesar-Ranchería basin (5 wells), a

continuous record from the Maastrichtian to the Eocene (Molino, Barco, Los Cuervos and Tabaco? formations) is observed. The palynomorphs are very well preserved and their Thermal Alteration Index indicates early stage of hydrocarbon generation. The ratio of marine vs. terrestrial palynomorphs suggests a shift from marine to continental environments between the Maastrichtian and Paleocene. The presence of Malvaceae (*Bombacacidites annae* among others), the high content of Araceae (*Proxapertites operculatus*), Arecaceae (*Mauritiidites franciscoi*, *Longapertites vaneendenburgui*) and fungal remains (e.g. *Diporopollis assamica*), suggest lowland tropical rainforest. The sedimentary record of the Sinú-San Jacinto Basin (12 wells) includes Maastrichtian rocks (Cansona Fm.) with well-preserved marine and terrestrial palynomorphs. Over them, there are discordant Eocene deposits (San Cayetano Fm.). The palynomorphs are well preserved and reach hydrocarbon generation window. During the early-middle Eocene, a diverse association of Malvaceae (*Bombacacidites*) and Araceae (e.g. *Psilamonocolpites*, *Clavamonocolpites*, *Gemmamonocolpites*, *Spinizonocolpites*) is observed, as well as variations in the percentage of marine vs. terrestrial palynomorphs, indicating changes in relative sea level. During the Oligocene-Lower Miocene deposits (Ciénaga de Oro Formation), marine palynomorphs and mangrove vegetation suggest littoral environments with fluctuations in the coastline. In general, the palynological zonation proposed for the Cenozoic of the Llanos basin can be applied to the Caribbean with slight variations. New pollen and spore species are recognized that seem to have biostratigraphic value.

Keywords: Palynology, Maastrichtian, Paleogene, Neogene, Colombian Caribbean



Palinología del Maastrichtiano al Neógeno en el Caribe Colombiano (cuencas Sinú-San Jacinto y Cesar Ranchería)

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El Caribe colombiano presenta un registro sedimentario que va desde el Cretácico Superior al Cuaternario. Su elevado número de rezumaderos de petróleo y gas indica un sistema petrolífero activo y, por tanto, potencial para la exploración de hidrocarburos. El estudio de microfósiles calcáreos y de pared orgánica han sido una de las principales herramientas para conocer la edad y el ambiente de depósito de los depósitos sedimentarios. Sin embargo, muy poca información ha sido publicada. Para llenar este vacío la Agencia Nacional de Hidrocarburos (ANH) ha realizado en los últimos años estudios geológicos regionales que incluyen adquisición de líneas sísmicas, perforación de pozos corazonados, cartografía geológica y diferentes tipos de análisis de muestras. La Universidad de Caldas se encuentra estudiando la micropaleontología (palinología, foraminíferos, nanofósiles y ostrácodos) de muestras de núcleos de perforación de un registro que va desde el Maastrichtiano hasta el Mioceno.

En este estudio se presenta la información palinológica de 875 muestras obtenidas en 17 pozos corazonados en las cuencas Cesar-Ranchería y Sinú-San Jacinto. En los Pozos perforados en la cuenca Cesar-Ranchería (5 Pozos), se observa un registro continuo desde el Maastrichtiano hasta el Eoceno (formaciones Molino, Barco, Los Cuervos y Tabaco?). Los palinomorfos se encuentran

muy bien preservados y, su Índice de Alteración Térmica indica que las rocas se encuentran en la fase temprana de generación de hidrocarburos. La relación de palinomorfos marinos vs. terrestres sugiere, un cambio de los ambientes marinos a continentales entre el Maastrichtiano y el Paleoceno. La presencia de Malvaceae (*Bombacacidites annae* entre otras), el alto contenido de Araceae (*Proxapertites operculatus*), Arecaceae (*Mauritidites francisci*, *Longapertites vaneendenburgui*) y restos de hongos (e.g. *Diporopollis assamica*), sugieren ambientes de bosques tropicales húmedos de tierras bajas. El registro sedimentario de la Cuenca Sinú-San Jacinto (12 pozos), incluye rocas del Maastrichtiano (Fm. Cansona) con palinomorfos marinos y terrestres bien preservados. Sobre ellas, se encuentran discordantemente depósitos del Eoceno (Fm. San Cayetano). Los palinomorfos presentan una buena preservación y se encuentran en la ventana de generación de hidrocarburos. Durante el Eoceno temprano-medio, se observa una diversa asociación de Malvaceae (*Bombacacidites*) y Arecaceae (e.g. *Psilamonocolpites*, *Clavamonocolpites*, *Gemmamonocolpites*, *Spinizonocolpites*), así como variaciones en el porcentaje de palinomorfos marinos vs. terrestres que indican cambios en el nivel relativo del mar. En los depósitos del Oligoceno-Mioceno inferior (Formación Ciénaga de Oro) se observan palinomorfos marinos y de vegetación de manglar que sugieren ambientes litorales con fluctuaciones en la línea de costa. En general, la zonación palinológica propuesta para el Cenozoico de los Llanos Orientales y el Piedemonte puede ser aplicada en el Caribe con ligeras variaciones. Se reconocen nuevas especies de polen y esporas que, al parecer, tienen valor bioestratigráfico.

Palabras clave: Palinología, Maastrichtiano, Paleógeno, Neógeno, Caribe Colombiano



Lake chemistry variation in the Lockichar and Kerio Valley Basins, Kenya

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This study compares the water chemistry of two lakes within the Kenyan rift system; the northern Lokichar Basin and the southern Kerio Valley Basin. Loperot-1 well in the Lockichar Basin is made up primarily of Paleogene to middle Miocene sandstones overlying the Precambrian basement. Within the sandstone unit are two prominent shale members; the Palogene Loperot Shale member and the Oligocene Lokhone Shale Member within which ditch cutting samples were processed for palynological studies. Palynomorph assemblage was good and forms were well preserved, with *Pediastrum*, palm pollen and fern spores dominating the total organic assemblage. The lithology of the Kerio Valley Basin from Cheptuket-1 well is comprised of the basal phonolites, claystones, greenish evaporite-rich claystones and capped by the Ewalel Phonolites and Quaternary sands. The evaporites were mainly gypsum and halites indicative of

low lake water level and high salinity. Ditch cutting samples within the sedimentary Tambach and Ngorora formations of the Cheptuket-1 well yielded low palynomorph diversity with *Botryococcus braunii* dominating the total organic assemblage. Though both basins, Lockichar and Kerio Valley Basin were dominated by freshwater chlorophycean algae, *Pediastrum sp* and *Botryococcus braunii*, the total absence of *Pediastrum sp.* within Cheptuket-1 well with corresponding *Botryococcus braunii* bloom within it shows a major variation in lake chemistry to the Lockichar Basin which has high recovery of *Pediastrum sp.* and no *Botryococcus braunii* count in Loperot-1 well. The variation in lake water chemistry within both basins might have resulted from acidification and alkalinity of the lakes which might be closely linked to the lake recharge system.

Keywords: Lake Chemistry, acidification, alkaline lake



Paleoclimatic and depositional controls on the palynostratigraphy of the Malembo Formation (Oligocene-lower Miocene, offshore Angola)

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In 2006 Eni Exploration & Production took over the operatorship for hydrocarbon exploration in Block 15/06 offshore NW Angola. Since then, more than thirty exploration wells have been drilled targeting the Oligocene-Miocene deepwater turbidite channel systems of the Lower Congo Basin ascribed to the Malembo Formation. Biostratigraphic studies carried out in-house yielded crucial information to pinpoint correlations of the main horizons in 3D seismic projects. The identification of a series of organic-walled dinoflagellate cyst events (highest and lowest occurrences, influxes and acmes), recurring in the same stratigraphic position in different wells and cross-calibrated by calcareous nannofossil data, resulted in a zonation suitable for age control and correlation of Oligocene and lower Miocene sequences on a regional scale.

Proceeding downwards in the stratigraphy of the examined succession, the lowest occurrence of *Pyxidinoopsis pastilliformis*, detected within the CN3 nannofossil Zone, approximates the Langhian-Burdigalian boundary, whereas the lowest occurrences of *Sumatradinium druggii* and *Sumatradinium hispidum* occur at the base of the CN2 nannofossil Zone in the Burdigalian. The lowest occurrences of *Sumatradinium soucouyantiae* and *Barssidinium taxandrianum* fall at the Burdigalian-Aquitania transition within the Zone of acme of

Hystriocholpoma rigaudiae that seems to reflect a relative climate warming interlude following the Mi-1a cooling pulse that is instead recorded by the underlying acmes of cold water taxa *Cribopteridinium tenuitabulatum* and *Systematophora Cleistosphaeridium* spp.

The presence of *Chiropteridium* spp. and *Membranophoridium aspinatum* is limited to the upper part of the Chattian, hence in the Angolan basin these taxa have a limited stratigraphic distribution compared to the North Atlantic and Mediterranean records. An influx of *Tuberculodinium vancampoeae*, possibly related to a warmer interlude during a period of overall climate cooling, occurs in proximity of the Chattian-Rupelian boundary. The nearly synchronous highest occurrences of *Gerdicocysta conopeum*, *Eocladopyxis peniculata* and *Heterosphaeridium* sp. provide a robust infra-Rupelian biohorizon. Further down in the Rupelian, the influxes of *Pentadinium laticinctum* and *Distatodinium paradoxum* are interpreted as responses to Oi-2 cooling pulse. The lowest occurrence of *G. conopeum*, detected in the basal part of the NP23 nannofossil Zone, corresponds to the global first appearance of this excellent Rupelian marker.

The recorded alternation of influxes and acmes of Gonyaluacoid dinocyst taxa indicative of cooler and warmer water condi-

tions was apparently climate-driven, paced by cooling pulses and relatively warmer interludes characterizing the overall climate cooling trend during the Oligocene and early Miocene. The lack of acmes of Protoperidinioid cysts suggests that climate, rather than constantly elevated nutrient levels ensured by the Congo River discharge, was the discriminant factor triggering blooms of these Gonyaluacoid cyst forming taxa.

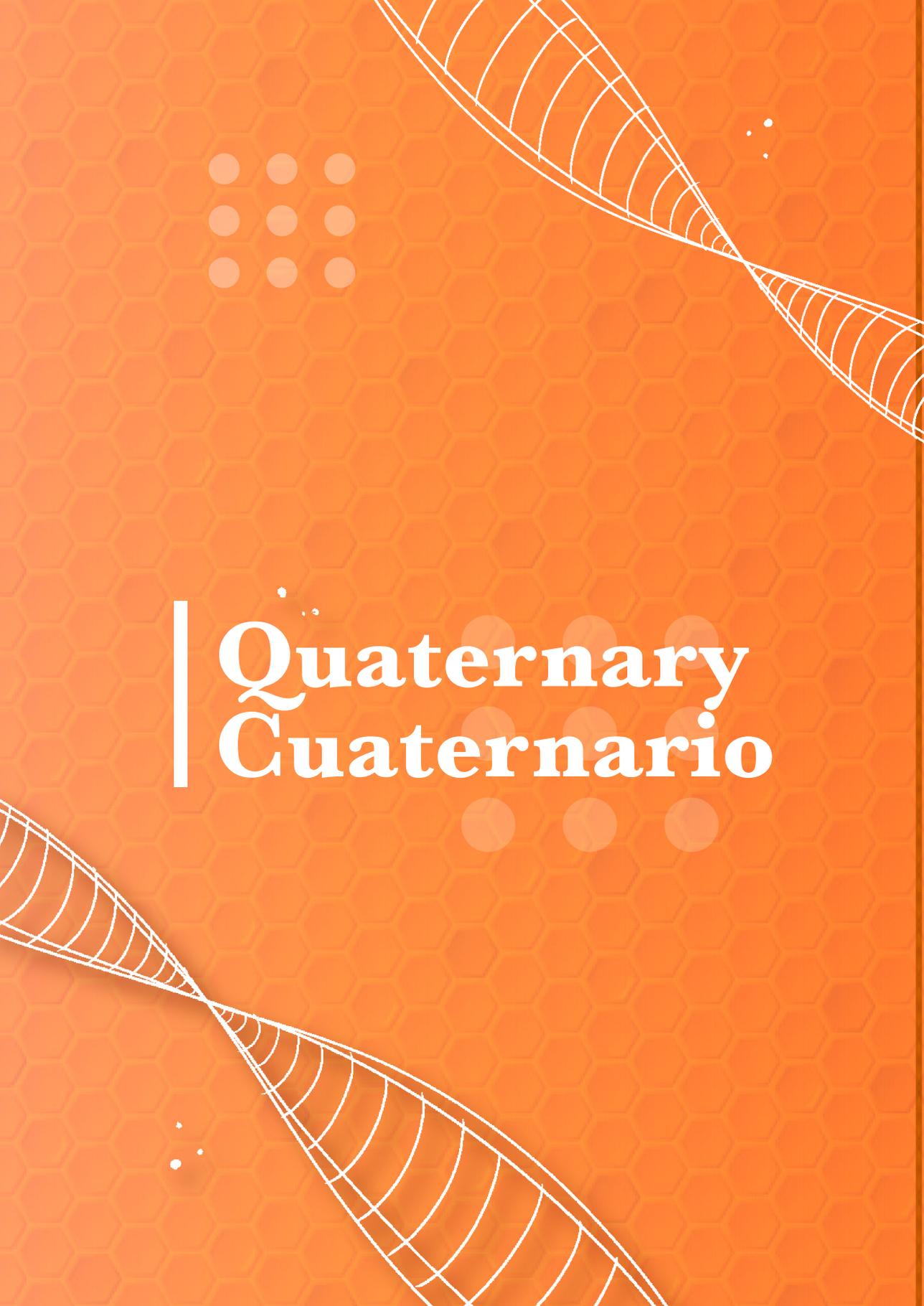
In addition to paleoecological factors, hydraulic fractionation resulting from sedimentary processes that transported palynomorphs down the slope as part of turbidite fluxes, contributed to shape the palynological assemblages observed in this study. We suppose that even the taxonomic composition of dinocyst assemblages might have been biased accordingly. At this regard, acmes of *Cribopteridinium* and *Systematophora-Cleistosphaeridium* are apparently coeval expressions of Mi-1a cooling pulse, but they never occur in the same samples. The partition of proximate (*Cribopteridinium*) and chorate cysts (*Systematophora-Cleistosphaeridium*) was probably due to hydraulic sorting operated by currents that displaced these taxa offshore from the coastal settings where they lived.

Terrestrial palynomorphs are abundant in the examined material but useless for indus-

trial biostratigraphy in the Lower Congo Basin, hence they were not considered for the present zonation. Indeed, all sporomorphs of the Malembo Formation underwent aerial and aquatic dispersion, fluvial transport and hydraulic sorting operated by turbidity currents before final sedimentation into deep marine environments, far from the settings where they originated. Therefore, quantitative patterns of their stratigraphic distributions do not automatically reflect changes in the hinterland vegetation but changes in sedimentological processes that artificially enhanced or diminished their abundances. In our experience, the marked quantitative fluctuations of terrestrial palynomorphs in deepwater turbidites do not have the potential to be synchronous except on short distances and depending on alignment of samples with sediment flux directions.

The delivery of large volumes of sands into deepwater settings via gravity-driven fluxes was favored by sea-level drops associated with pulses of climate cooling and Antarctic ice-sheet growth. The combination of paleoclimatic and depositional factors finally shaped the composition of the palynological assemblages under investigation.

Keywords: biostratigraphy, dinoflagellate cysts, sporomorphs, paleoclimate, Oligocene, Miocene



**Quaternary
Cuaternario**



Possible association of particle size and planetary obliquity during the Late Holocene in the Lachuá Region, Guatemala

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The climatology of our planet responds to multiple factors linked to multiple spatio-temporal scales. Among these factors, we can find the astronomical ones described by the Milankovitch Cycles, which operate at the millennial-scale, and other ones such as the zonal-related atmospheric latitudinal cells. Due to these various factors, climatic processes cannot be explained under linear models due to distortion of the azonal process, such as topographic barriers and elevational and continentality gradients.

Guatemala is currently localized at the northern displacement limit of the Intertropical Convergence Zone (ITCZ). This thermo-pluvial non-geographic equator varies in latitudinal maximum and minimum migration spans thousands of years. Despite Guatemala's narrow territory, its climatic variability is amplified due to the multiple factors mentioned above.

Based upon a sedimentary core from the Lachua lakeshore at the Lachua Lake National Park, along the Northern Transversal Strip, the paleoenvironment of the last six millennia was reconstructed after combining multiple paleoecological proxies (e.g., parti-

cle size, Zygnemataceae spores, pollen and fungal spores). The particle size (PS) of the last millennia has decreased progressively from sand to silt-clay sizes, suggesting a stratigraphic sequence associated with obliquity and a more extensive influence of the North American Monsoon (NAM).

The Lachua PS database positively correlated with the Cariaco Basin titanium sedimentary record. This pattern suggests that parallel to the decreasing precipitation in northern South America during the Late Holocene due to the southern ITCZ migration, precipitation in the Lachua Region has been increasing, possibly to a more extensive influence of the NAM.

Correlation analysis, including global databases, can enrich localized observations by providing a regional context that facilitates visualizing non-linear processes. The results presented suggest the need for further exploration regarding paleoenvironmental reconstructions to strengthen climate change predictions, even more in narrow territories that exhibit complexity, such as Guatemala.

Keywords: Paleocology, Milankovitch Cycles, trans-gression, sedimentary core, Mesoamerica



Posible asociación del tamaño de partícula con la Oblicuidad planetaria durante el Holoceno tardío en la Región de Lachuá, Guatemala

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La climatología planetaria responde a múltiples factores que se vinculan a través de múltiples escalas en el espacio y en el tiempo. Entre estos factores, se encuentran los astronómicos descritos principalmente por los Ciclos de Milankovitch que se manifiestan en la escala milenaria, además de otros como la zonalidad de celdas atmosféricas ajustadas a la latitud geográfica. Es por esta razón que los procesos climatológicos no pueden explicarse bajo modelos lineales, ya que procesos azonales los distorsionan, lo cual presenta un reto cuando se integran factores como barreras topográficas, gradientes altitudinales y continentales.

El territorio de Guatemala se localiza cercano al límite máximo norte de la Zona de Convergencia Intertropical (ZCIT), la cual, al representar el ecuador térmico-pluvial, varía en la escala milenaria en sus distancias máxima y mínima al ecuador geográfico. Entonces, a pesar del estrecho territorio guatemalteco, su variabilidad climatológica es amplia por la interacción de los múltiples factores ya mencionados.

A partir del estudio de un núcleo sedimentario de las orillas de la Laguna de Lachuá, localizada en el Parque Nacional Laguna Lachuá situado en la Franja Transversal del Norte, se logró la reconstrucción del paleoambiente de los últimos ca. 6000 años, luego de combinar múltiples indicadores paleoecológicos (e.g., tamaño de partícula, esporas de Zygnemataceae, polen y esporas fúngicas). La tendencia del tamaño de partícula (TP) de los últimos milenios ha sido progresivamente de arenas hacia limo-arcillas, en un proceso alternante que sugiere ciclos de una secuencia estratigráfica, posiblemente asociada parcialmente a la oblicuidad planetaria y a una mayor influencia del Monzón Norteamericano (MNA).

La comparación de la base de datos de TP de Lachuá con valores de titanio de la Bahía de Cariaco, presentó una correlación positiva. Este patrón sugiere que a medida que durante la segunda mitad del Holoceno el norte de Suramérica tiende a una menor precipitación, por la migración sureña de la ZCIT, la región de Lachuá tiende a una mayor precipitación, posiblemente por la mayor influencia del MNA.

Las correlaciones de bases de datos globales pueden enriquecer resultados puntuales ya que proveen de un contexto regional que puede facilitar la visualización de procesos no lineales. Los resultados presentados sugieren una exploración más profunda en cuanto a las reconstrucciones paleoambientales para fortalecer las predicciones de cambio climático futuro, en territorios estrechos pero complejos como el de Guatemala.

Palabras clave: Paleoecología, Ciclos de Milankovitch, transgresión, núcleo sedimentario, Mesoamérica

Paleoenvironmental
history of South Central
Chile. The sedimentary
and palynological
record of “Laguna Verde
wetland” (36°47'S),
Hualpén Peninsula, Bío-
Bío District, Chile



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A new sedimentological and palynological record from the Hualpén Peninsula, BioBio district, reconstructs the elusive environmental history during the middle to late Holocene transition in Southern Central Chile (34°-38°S). The study area is located into the “Parque Rio Zañartu”, a Wild Life Area where a small wetland surrounded by native vegetation occurs (i.e. sclerophyllous forest). In this location, a number of activities were executed in order to: (i) characterize the modern vegetation and pollen rain that would later allow interpreting the pollen record, and (ii) the recovery of multiple sediment cores from the wetland with the purpose to reconstruct the environmental history. In specific, a detailed survey to characterize the predominant plant communities into the wetland catchment (170 ha) was performed, and later plant communities were estimated by means of remote sensing and GIS analyses. For each of these plant communities, soil samples were obtained to characterize modern pollen rain. Also, multiple sediment cores (n=5) were extracted from different sectors of the Laguna Verde wetland (36°47'S, 73°09'W; 22 m.a.s.l; ~4 ha), in order to

examine the evolution of different sedimentary environments occurring on. Later, soil samples and sedimentary cores were geochemically (e.g. LOI) and palynological analyzed in the laboratory with standard techniques. Additionally, several radiocarbon dates (n=15) provides a robust chronology for the sedimentary and pollen record, allowing to examine the environmental history during the Holocene in the study area and make comparisons with other records of Central Chile. The results indicate the feasibility to recognize main plant communities by its pollen rain, with some distinctive taxa as key. On the other hand, the sedimentary and pollen record show a remarkable transition during the middle Holocene, suggesting an underlying climatic mechanism. In particular, the sedimentary record of Laguna Verde wetland indicates that site formation occurs around 6,800 cal years BP, as result of a damming process by dunes in the wetland micro-basin. The palynological record shows a predominance of non-arboreal taxa during this first phase, with an increase in the arboreal taxa around 5000 cal years BP. This change is encompassing by an important increase in the input of lithic materials mobilized by wind and precipitation, and the formation of a permanent body of water (e.g.lagoon). Finally, an abrupt change in the sedimentological and the palynological record is observed around 1850AD, related with a transformation in the vegetal landscape and the sedimentary regime. Specifically, a decrease in native tree taxa and the appearance of exotic taxa account for human activity in the wetland micro-basin, while a significant increase in detrital sedimentary input is observed. This change demarks the transformation from a lagoon to the current wetland, and reveals the relationships between human activity and surface processes such as erosion and runoff. In summary, this study highlight the potential to identify paleoenvironmental changes associated with natural (e.g. climate) and anthropogenic processes by means of

sedimentological and palynological records from wetlands in Central Chile. Furthermore, the results provide of new and relevant information for the mid Holocene transition

for Southern Central Chile, indicating an important shift in the Southern Westerlies Wind belt dynamics.

Keywords: Central Chile, Bío-Bío District, sclero-phyllous forest, pollen rain, remote sensing; Mid Holocene transition, Southern Westerlies



Tras la historia paleoambiental de Chile Central Sur. El registro sedimentario y palinológico del humedal “Laguna Verde (36°47’S)”, Península de Hualpén, Región del Bío-Bío, Chile.

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La presente presentación de cuenta de los resultados de un trabajo inédito que incluye el primer registro palinológico para el Ho-loceno medio y tardío en la porción sur de Chile Central. El área de estudio se encuen-tra ubicada en el Santuario de la Naturale-za “Parque Río Zañartu”, localizado en la Península de Hualpén, región del Bío-Bío, Chile. En dicha locación, se realizó un tra-bajo integral que busco en primera instancia caracterizar la vegetación a fin de obtener muestras actuales de la lluvia polínica que permitieran posteriormente interpretar el registro polínico. Para esto, primeramente se realizó un trabajo en terreno que permito identificar las comunidades vegetales predo-minantes en el área, y que fue apoyado por un levantamiento de las coberturas vegeta-les utilizando teledetección. Posteriormente, múltiples testigos de sedimentos (n=5) fue-

ron extraídos desde diferentes sectores del humedal Laguna Verde (36°47’S, 73°09’O; 22 m.s.n.m), ubicado en la porción sur de la Península de Hualpén y cuya superficie es de ~4 ha. Los testigos sedimentarios fueron analizados mediante técnicas estándares como la pérdida por ignición que permitieron realizar correlaciones estratigráficas entre los diferentes ambientes sedimentarios. Así también, dataciones radiocarbónicas (n=15) fueron obtenidas de los diferentes núcleos de sedimentos lo cual en conjunto con el análisis palinológico permitió examinar la historia paleoambiental del área de estudio y a su vez realizar comparaciones de una manera adecuada con otros registros que igualmente pretenden descifrar la historia climática de Chile central durante el Holoceno. Los resultados dan cuenta de la notable transición climática que ocurre en

Chile Central durante el Holoceno medio, y el cual está aún lejos de ser comprendido en su real magnitud. En este caso, el registro sedimentario del Humedal de Laguna Verde pareciera dar cuenta que la señal climática se ve expresada en el registro sedimentario de manera sitio dependiente, en relación a factores como la geomorfología local. En específico, el registro sedimentario da cuenta de la formación de un cuerpo de agua en torno a los 6800 años cal AP, producto del represamiento por una duna. El registro palinológico, muestra una predominancia de taxa no arbóreos durante esta primera fase, siendo posteriormente observable un aumento de estos en torno a 5000 años cal AP. Así también, se observa en este punto un cambio importante en el aporte de materiales líticos movilizados por viento y precipitación dando cuenta de la formación de un cuerpo de agua permanente (.e. laguna). Finalmente, un abrupto cambio tanto en los sedimentos como en el registro pa-

linológico se observa en torno a 1850AD, dando cuenta de una transformación en el paisaje vegetal y en el régimen sedimentario. En específico, una disminución en los taxa arbóreos nativos y la aparición de taxa exóticos da cuenta de la actividad humana en la cuenca, a su vez que se observa un aumento importante en el aporte sedimentario detrítico. Este cambio marca la transición desde una laguna al actual humedal, y deja en evidencia las relaciones entre la actividad humana y los procesos de superficie como lo son la erosión y escorrentía. En resumen, los resultados reflejan el potencial de identificar en los registros palinológicos y sedimentológicos provenientes de humedales de Chile Central cambios paleoambientales asociados a procesos naturales (e.g. clima) y antropogénicos, dando a su vez cuenta de la naturaleza retrodictiva de los métodos y aproximaciones utilizados en estudios de esta naturaleza.

Palabras clave: Chile Central; Bío-Bío, lluvia de polen, teledetección, transición Holoceno medio



Colombia's amazing Quaternary History: Climate, Flora, Páramos and Man

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Anticipating on the Earth' future requires a thorough understanding of the past. High tropical mountains act as a laboratory-setting where past and ongoing 'experiments' with climate-driven environmental change

can be studied. In this talk we explore the development of the Andean flora and we show the long pollen records of climate change from the deep sedimentary basins of Bogotá and Fúquene. The anatomy a glacial-interglacial cycles hints to drivers and operating mechanisms and sets the scene how climate-driven environmental conditions and biodiversity in high mountains has changed in the past. In a 10-minutes video Sky Islands we present the flickering connectivity system (FCS), a proposed mechanism to explain the stunning high biodiversity in the páramos of the Northern Andes. Altitudinal shifts of vegetation belts in the young profiled northern Andes, at millennial to orbital time scales (41 and 100 kyr), cause multiple events of iso-

lation and connection of gene pools. Each mountain range has a characteristic profile with a cordillera-specific history as a consequence. For example, the FCS explains why the páramo of the Western Cordillera is less biodiverse as the páramo of the Eastern Cordillera. This video presentation also gives hints for potential changes in the distribution of páramo during the next centuries. Pollen records are museums of changes in plant assemblages in deep-ecological time. With 60-yr between samples in the 284,000-yr long Fúquene record the composition of mountain forest is monitored some 3 times within the life cycle of its constituents. Resolution is reaching ecologist's detail of permanent-plot data potentially opening a new field of relevant research questions to be addressed. As is the case with climate conditions, current taxonomic forest composition is of relatively short duration also. Realizing that non-analog plant associations and non-analog climates dominated in the past, hypothesis development should better include this aspect. Although present phytosociological relationships reflect an ephemeral aspect of vegetation, such studies are helpful to infer taxon's used niche space. Pollen records potentially allow to infer the unused niche space also. An understanding of plant's genetically constrained niche space, consisting of a used (today) and an unused (e.g. under glacial conditions) niche space, allow plants to respond to climate change by niche tracking. Genetic plasticity is within the total niche space. In relation to current climate change paleoecologists refrain from using the term 'adaptation' as the niche space of a plant is a very conservative character in deep-ecological/geological time. Documenting and understanding past and future changes in distribution areas, and fragmentation and connection of gene pools, is helpful in developing current conservation strategies and anticipating the future. The relevance of a good understanding of past ecological conditions is demonstrated with

Kyoto Protocol-driven measurements. Recent carbon sequestration in the páramos of Ecuador, Colombia and Venezuela with Mexican pine destroyed much of this precious ecosystem while measurements were politically advertised as adequate and sustainable. Understanding of mountain dynamics during the Quaternary should be better used in the societal and political arena.

References

Hooghiemstra H, Sarmiento-Pérez G, Torres Torres V, Berrio J-C, Lourens L., Flantua SGA 2022. 60 years of scientific deep drilling in Colombia; the north Andean guide to the Quaternary. *Sci Drilling* 30, 1-15.

Pérez-Escobar OA, Zizka A, Bermudez MA, Hoorn C, Hooghiemstra H, Pennington RT, Antonelli A, Chomicki G 2021. The Andes through time and the evolution and distribution of Andean floras. *Trends Plant Science* 26, 1-15.

Mottl O, Flantua SGA, Bhatta KP, Felde VA, Giesecke T, Grimm EC, Haberle S, Hooghiemstra H, Ivory S, Kunes P, Williams JW 2021. Global acceleration in rates of vegetation change over the past 18,000 years. *Science* 372, 860-864.

Nogué S, Santos AMC, Birks HJB, Björck S, Castilla-Beltrán A, Connor S, De Boer EJ, Hooghiemstra H, et al. 2021. The human dimension of biodiversity changes on islands. *Science* 372, 488-491.

Flantua SGA, O'Dea A, Onstein R, Giraldo C, Hooghiemstra H 2019. The flickering connectivity system of the north Andean páramos. *J. Biogeogr.* doi: 10.1111/jbi.13607.

Hooghiemstra H, Flantua SGA 2019. Colombia in Quaternary: an overview of environmental and climatic change. In: Gómez-Tapias J (editor), *The Geology of Colombia Book, Vol. 4 Quaternary*, pp. 33-84. Servicio Geológico Colombiano.

Torres V, Hooghiemstra H, Lourens LJ, Tzedakis PC 2013. Astronomical tuning of long pollen records reveals the dynamic history of montane biomes and lake levels in the tropical high Andes during the Quaternary. *Quat Sci Rev* 63, 59-72.

González-Carranza Z, Hooghiemstra H, Vélez MI 2012. Major altitudinal shifts in Andean vegetation on the Amazonian flank show temporary loss of biota in the Holocene. *The Holocene* 22, 1227-1241.

Groot MHM, Bogotá RG, Lourens IJ, Hooghiemstra H et al. 2011. Ultra-high resolution pollen record from the northern Andes reveals rapid shifts in montane climates within the last two glacial cycles. *Clim Past* 7, 299-316.

Bogotá-A RG, Groot, MHM, Hooghiemstra H et al. 2011. Rapid climate change from north Andean Lake Fúquene pollen records driven by obliquity: implications for a basin-wide biostratigraphic zonation. *Quat Sci Rev* 30, 3321-3337.

Moscol-Olivera MC, Hooghiemstra H 2010. Three millennia upper forest line changes in northern Ecuador: pollen records and altitudinal vegetation distributions. *Rev Palaeobot Palynol* 163, 113-126.

Bakker J, Moscol-Olivera M, Hooghiemstra H 2008. Holocene environmental change at the upper forest line in northern Ecuador. *The Holocene* 18, 877-893.

Comparative analysis of anthropogenic versus climatic influences on the Late Holocene vegetation dynamics in the Northern Neotropics: a palynological approach from Lake Izabal, eastern Guatemala



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The deterioration of forest communities around the world threatens the sustainable supply of ecosystem services that plants afford to humans and nature. These processes are associated with anthropogenic and climatic forcing at different time scales. The main goal of this study is to understand how

tropical vegetation responded to these two sources of variability. Here, we present palynological data from Lake Izabal, eastern Guatemala, spanning the last 1,300 cal yr BP based on extrapolation of five 14C dates of woody debris in the sediments. Analysis of the relative abundances of pollen reveal distinct alternations between herbaceous and forest associated vegetation groups. These alternations have been evaluated at spatio-temporal scales spanning major anthropogenic and climatic events such as the apogee and demise of the Maya Civilization, the Medieval Climate Anomaly, Little Ice Age, and the Great Dying. The Lake Izabal vegetation responses have been compared with other proxy records within the northern Neotropics to ascertain the regional factors that drive the variability in vegetation patterns. Inferences from this work potentially provide scientific and societal clues for assessing how and why species are preferentially distributed in their current localities.

Keywords: Pollen, herbaceous taxa, forest taxa, MCA, LIA, Maya Civilization



Early Pleistocene Atlantic Forest dynamics in southeastern Brazil

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Located in the eastern part of Brazil, the Atlantic Forest is one of the most diverse forests in the world, containing high levels of endemism along a latitudinal gradient from 3°S to 30°S. In addition, the influence of the Atlantic Ocean, polar air masses, and monsoon circulation make the area a unique place for regional and global paleoclimatic research. Here we present a new record, the COL17c, located in the Colônia basin in São Paulo, Brazil (23°S, ca. 700 m a.s.l). The record has 115 m of overlapping sediment cores, spanning the first 50 m depth from the basin. We have analyzed the deepest 6 m of COL17c to reconstruct climatic and vegetation changes of the southern tropics during the 40-kyr glacial-interglacial cycles dated between 1.5 and 1.3 Myr. COL17c was analyzed using a multi-proxy approach that included pollen, diatoms, biomarkers, charcoal, and X-Ray fluorescence scanning.

We found that meridional temperature differences regulated the input of moisture at the latitude of Colônia, differentiating glacial and interglacial forest types. The Atlantic Forest was composed of evergreen forest taxa (i.e., *Ilex*, *Myrsine*, *Myrtaceae*, *Podocarpus*) during interglacials. Conversely, the expansion of grasses, herbs, and semideciduous forest taxa (i.e., *Alchornea*, *Celtis*, *Bignoniaceae*) characterized the glacial periods. During glacial and interglacial periods *Araucaria Forest* was continuous and expanded at 1.4 Myr, concomitant with an early Pleistocene cooling. Regional fires were observed with low frequencies and did not play a role in shaping vegetation dynamics in our record.

Keywords: Araucaria, 41 kyr world, subtropical front, Southern Hemisphere



Holocene palynological records of hydroclimate variability in the southeastern United States

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Recent flooding and drought events in the southeastern United States (US) have caused billions of dollars in economic losses, and anthropogenic global warming is anticipated to cause significant alterations to the regional hydroclimate. The drivers of hydroclimatic variability in the southeastern US are poorly understood, in large part because there are few regional high-resolution records of Holocene paleoclimate. This research project examines a suite of proxies from lake sediment cores in northern and southern Alabama and Georgia in order to identify the timing, magnitude, and spatial variability of precipitation patterns in the Holocene. The goal of the project is to define whether these patterns are predominantly driven by the Pacific North American (PNA) pattern, the North Atlantic Oscillation (NAO), the El Niño-Southern Oscillation (ENSO), or some combination thereof? Modern correlations between mean annual precipitation and these climate oscillations indicate that different spatial patterns of precipitation can be used to identify which of these climate oscillations were predominantly responsible for changing precipita-

tion in the earlier Holocene. Particular focus will be given to sediments deposited 4000 years before present, 2000 years, and during the “Medieval warm period” and “Little ice age”.

Cored sediments from four lakes (Buck Pond, Hanna Pond, Halls Pond, Pigeon Marsh) are currently being analyzed for radiocarbon dating, sedimentology, geochemistry, and palynology. Pollen and plant spore assemblages are being used as a paleoclimate proxy to reconstruct mean annual precipitation, but also mean annual temperature, and the temperature of the coldest and warmest months. Paleoclimatic reconstruction will utilize the Climatic Amplitude Method and other methods.

Initial palynological results from Buck Pond sediments, ranging from approximately 250 to 5,100 years before present, reveal pollen assemblages consistently dominated by *Pinus* and *Quercus* pollen, suggesting a broadly similar paleoenvironment from the mid-Holocene to present, as observed in the field in late 2021 during drilling. Pollen from aquatic vegetation is also present, mainly *Myriophyllum* (water milfoil) and *Nuphar* (water-lily). Less abundant terrestrial pollen and plant spores in the assemblage include *Alnus*, *Amaranthaceae*, *Asteraceae*, *Carya*, *Caryophyllaceae*, *Myrica*, *Poaceae*, *Ulmus*, and others. Non-pollen palynomorphs in the assemblages include fungal spores, lacustrine algae, freshwater dinoflagellates, and palynomorphs of unknown affinity. Palynological sample processing and analysis is currently in progress, to be followed with statistical and paleoclimatic investigation and integration with sedimentological and geochemical results.

Keywords: Holocene, southeastern United States, paleolimnology, paleoclimatology, Pacific North American Pattern, El Niño Southern Oscillation



Climate history of southwest Morocco: Impacts on vegetation

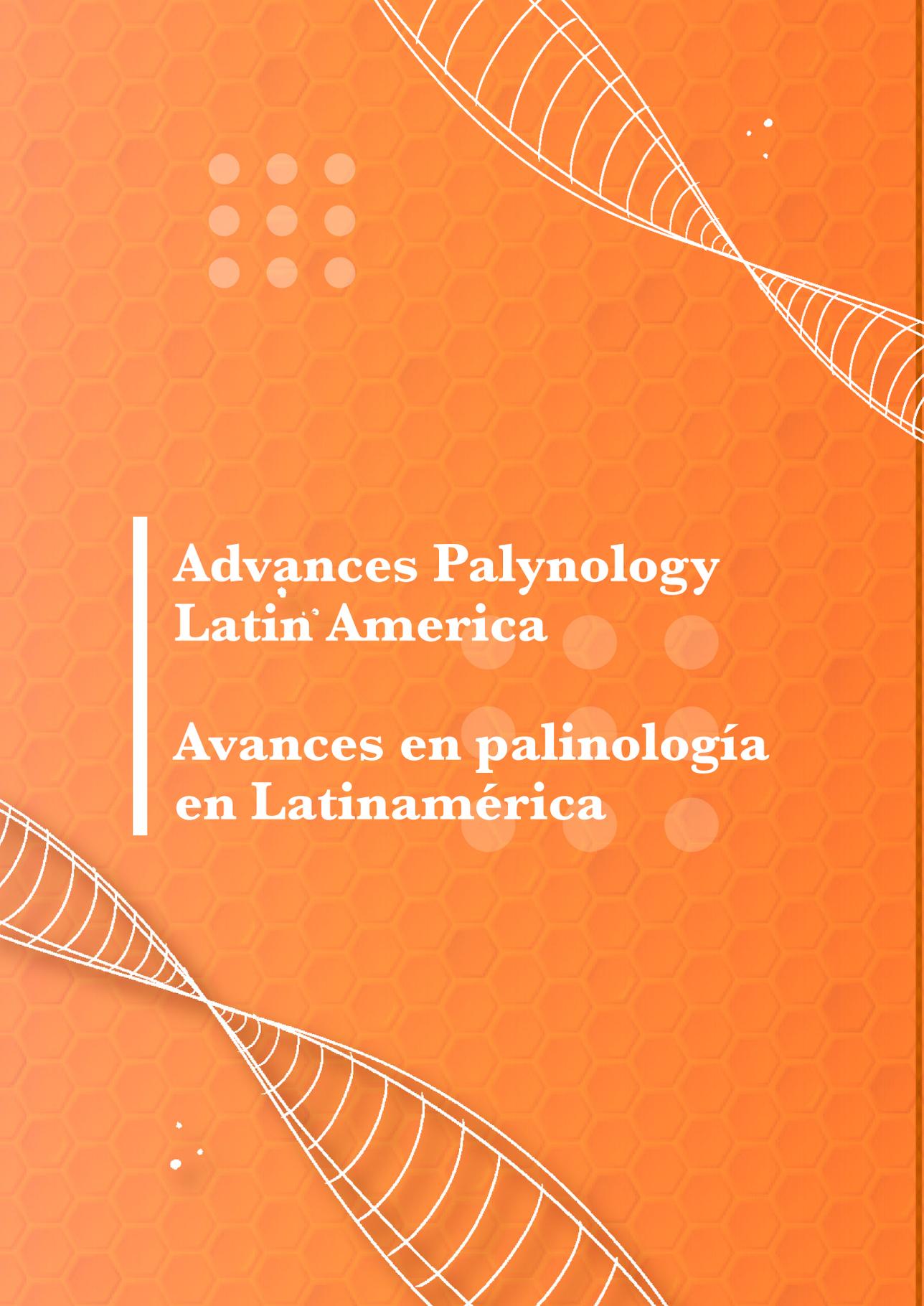
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Terrestrial signals in marine sediment archives are frequently used for paleoclimate reconstructions to understand past human–climate–environment interactions. Southern Morocco is presently subject to severe droughts, desertification and land degradation, and is likely to face increased climate variability and socio-economic stress in the future. In this study, we used palynological data from two high-resolution marine sediment cores collected off Agadir in southwest Morocco. The modern pollen data was then utilized to interpret the high resolution pollen record, in combination with published XRF element ratios, deuterium and carbon isotope data (δD and $\delta^{13}\text{C}$) from plant waxes in a marine sediment core, and high resolution stable isotopes ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) from speleothem records. The main objective is to evaluate the impact of past climate changes on

the vegetation, and to reconstruct the vegetation history during the last 2000 years in the region. The results show that the rapid increase of population in southern Morocco caused land and vegetation degradation due to the expansion of pastoralism and agriculture, especially at the beginning of the Arab invasion of North Africa. Furthermore, the reconstructed pollen-based vegetation in our marine record suggests an interplay of climate and anthropogenic effects on the landscape. Furthermore, we observed that deciduous oaks occurred in more humid forests of the Mediterranean vegetation zone, whereas a decline in deciduous oak pollen percentage indicates drier conditions. The increase of herbaceous taxa might suggest an increase in human impact on the landscape leading to a sparse vegetation cover and subsequently increased erosion.

Keywords: Pollen, climate change, Human impact, Vegetation change, Southern Morocco



**Advances Palynology
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Stingless bee *Melipona beecheii* food storage in suburban areas: when pollen type matter

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In the Yucatan peninsula, Mexico, meliponiculture is considered a legacy of the ancient Maya culture, and stingless bees honey and other products are well recognized for their nutritional and medicinal properties. Nevertheless, the growing urbanization, habitat degradation, and the loss of interest in peasants' descendants force the meliponiculture to suburban areas, where older people and women can manage the bees. Here we present the pot-pollen palynology of a “jobón”, the traditional beekeeping method used by Mayan communities in the Yucatan peninsula, after 15 years of un-managed bee colonies. Our results show the *Melipona beecheii* pollen preferences, foraged

in sub-urban secondary vegetation older than 25 years. Few pollen types composed the majority of pollen storage, showing the potential for beekeeping in sub-urban environments. Weekly pollen loads samples are being collected to compare them with stored pollen and to know whether the collected pollen is the preferred pollen in the area or it is a survival strategy when other common pollen types are unavailable. The findings would allow a better understanding of how *Melipona beecheii* manages their pollen reserves in sub-urban areas and how Mayan beekeepers can improve the pollen sources around the meliponary.

Keywords: *Melipona beecheii*; stingless bee pot-pollen, sub-urban Meliponi-culture, Native bees' palynology



Can fluorescence be helpful to discriminate between indigenous taxa of Carboniferous age from those reworked of Mid-Upper Devonian rocks?

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Terrestrial spores and pollen grains and phytoplankton of fresh- to marine water environments may exhibit bright yellow to weak orange, red and brown colors of autofluorescence. When fluorescence is good usually associated to well- preserved specimens, it is useful for their morphologic characterization, whereas the lack of fluorescence reveals preservational effects linked to taphonomic history. Concerning the recycling of palynomorphs deposited in a new active sedimentary cycle due to erosion of previous sedimentary rocks, they are useful in deciphering base-level variation, diastrophism, and provenance. Their recognition must be based on accurate taxonomic identification and more probable stratigraphic range. In this work, autofluorescence of palynomorphs is analyzed in samples of the Late Famennian of USA bearing indigenous *Retispora lepidophyta* and compared with samples from the Carboniferous of Bolivia and northern Argentina in which indigenous and Devonian reworked taxa (including *R. lepidophyta*) are found together. Standard palynologic method is applied using HCl (25%) and HF (40%), distilled water for neutralization of residues, and 10 µm and 25 µm meshes for sieving. The effect of oxidation on fluorescence is also tested, and for this purpose selected residues were oxidized with HNO₃ (3 minu-

tes) and ammonia. Another objective is to compare the performance of fluorescence in slides mounted with different media (e.g. jelly-glycerin, Trabasil NR2, Cellosize/Entellan, Canadian Balsam, Norland NOA60, glycerin sealed with paraffin, and water for temporary slides). The microscopic analysis was performed using a light microscope Leica DM500 bearing a fluorescence device (LED lamp, filter block for fluorescein ca. 450 nm). Pictures of palynomorphs were taken with an Amuscope 14 Mp video camera and its software. This study revealed that *R. lepidophyta* exhibit autofluorescence colors from yellow to orange up to black (canceled) independently of its origin (indigenous or reworked, I-R). Also, in general, from the slides analyzed herein, phytoplankton species yielded lighter colors with higher intensity than monosaccate pollen grains and spores, in this order and beyond their I-R nature. The results confirm previous studies in which parameters such as the original composition of the exine of terrestrial and aquatic palynomorphs, as well as their source and taphonomic history affect autofluorescence. Moreover, I-R palynomorphs do not exhibit significant changes of fluorescence in slides mounted with non-oxidized and oxidized portions of the same residue. Concerning the performance of different mounting media for fluorescence analyses,

the present comparison confirms that glycerin is one of the best media, non-fluorescent Cellosize and Norland (permanent slides), and water (temporary slides). The jelly-glycerin is a very used medium for mounting permanent slides in many countries due to its cheap, and easy to get and prepare, although

it has green color of fluorescence, higher than that of Trabasil. Despite their fluorescence, the main trouble is that many or most palynomorphs are not adhered to the upper surface of the coverslip, so their fluorescence is not well-observed or is hidden by both media.

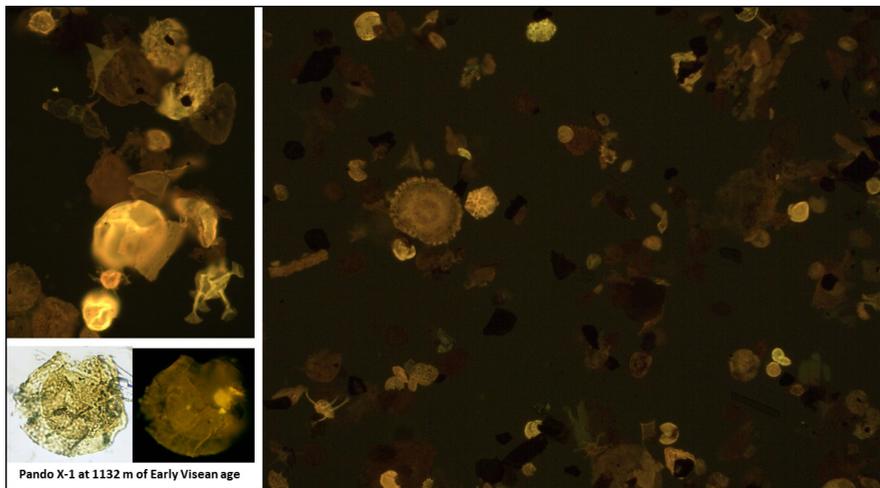


Figure. Fluorescence color exhibited by phytoplankton and spores like *Retispora lepidophyta* (lower left, x100 magnification), which are mostly reworked from Devonian strata. Sample from the Pando X-1 (core at 1132 m depth, slide mounted with Cellosize/Entellan), Early Visean in age.

Keywords: Autofluorescence, indigenous and reworked palynomorphs, mounting media, palynologic methodologies



The UPLA pollen reference collection. Achievements and challenges

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The University of Playa Ancha (UPLA) pollen reference collection is the result of a collective work between science, arts and community. The collection was created under the supervision of the VALPL Her-barium of the University of Playa Ancha, and today has 67 modern pollen samples from representative plant species of Central Chile sclerophyllous ecosystems living in La Campana-Peñuelas Biosphere Reserve, Chile – UNESCO. The samples represent local populations of trees and herbs, geographically identified and mapped, collected during its flowering seasons. Laboratory analyses include digital photography of acetolysed pollen grains at different views and z levels, obtained with an optical microscope Cytation 5. Also, SEM images were obtained with a Hitachi SU 3500, providing new and relevant information for

a more accurate pollen characterization but also giving us the keys into arts of nature. During the pandemic and quarantine, one of the laboratory activities was compile the data in a pollen catalog, and simultaneously the design of an exposition. Online workshops were conducted, in order to share with local communities the experience of discover the beauty of pollen grains and create local pollen landscapes and collections from representative ecosystems or locations. Finally, the recent invitation to collaborate in scientific-social initiatives by means the analysis of corbicular pollen from apiaries located in Central Chile (30°-38° S), represent a new challenge for the laboratory but also an opportunity. Also the construction of a digital platform to make accessible the palynological collection to the community in general.

Keywords: pollen Digital and SEM photography, La Campana-Peñuelas UNESCO Biosphere Reserve, Central Chile sclerophyllous ecosystems, University of Playa Ancha



Palinoteca UPLA. Logros y desafíos

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En el presente poster, presentamos los resultados y experiencias tras la creación y puesta en marcha de la Palinoteca de la Universidad de Playa Ancha (Palyno-UPLA). Entre los productos se destaca la digitalización de muestras polínicas mediante un microscopio óptico de última generación (Cytation 5) e imágenes SEM (Hitachi SU 3500). Las muestras corresponden a especímenes representantes de la flora de Chile Central (n=67) las cuales fueron obtenidas durante diferentes campañas de terreno coincidentes con los periodos de floración de diferentes poblaciones de especies nativas. Así también, se han incorporado muestras provenientes del Herbario VALPL de la Universidad de Playa Ancha. Adicionalmente, se ha comenzado trabajar con polen corbicular de colmenares también presentes en Chile Central, con el objetivo de caracterizar su origen

botánico. Finalmente, durante la pandemia se realizaron diversas actividades centradas en la difusión y que pretendieron vincular a la comunidad con la labor que se realiza en el laboratorio. Para esto, se realizaron talleres online en la cuales se invitó e instruyó a la comunidad como realizar colectas fin de crear palinotecas que representaran la flora local. El resultado fue alentador, por cuanto participo un número importante de personas de diferentes edades y no vinculadas necesariamente al quehacer científico, dando cuenta del interés general de las comunidades en referencia a capturar la belleza de los granos de polen. En la actualidad se trabaja en la creación de una plataforma digital que permita poner a disposición del público en general de las imágenes y datos referentes a la colección palinológica.

Palabras clave: palinoteca, Chile Central, SEM, comunidad y territorio



Approach to the morphology of spores of the genus SPHAGNUM in high Andean forests

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Palynological studies in plants have focused mainly on pollen morphology in angiosperms. On the other hand; the study of propagative structures in bryophytes is somewhat more scarce. Worldwide, only four studies of spores for the Sphagnaceae family are known, due to the fact that their importance has been focused on the ecology and taxonomy of the gametophyte, leaving aside one of the structures that is also very important for these studies and of which other aspects can be inferred in various areas; among which is paleoecology. For this reason, this research project aims to describe the morphology of the spores of the genus *Sphagnum*. For which field trips were made to the Agroparque Los Soches, Une and La Paz. Once the samples were treated, the Erdtman acetolitic technique was performed; In addition, the plates were assembled and, later, the description of the spores was carried

out using a microscope with a 1000x objective for the measurements and observations of the characters. The spores of this genus have a triplet-shaped lesion, some have the presence of the perispore, others have escabrada ornamentation on the exine and; two characters not previously mentioned by the authors known as Kyrto-men and Labrum were found. In addition, the size of these structures ranges between 20 and 30um. From the above it is concluded that the morphological diversity of the spores is highly differentiated in the different morphotypes collected, for this reason these studies allow knowing the species to which they belong with the description of said structures, and in this way they attribute to the study of spores fossils in different sediments.

Keywords: *Sphagnum*, espora, trilete, kyrto-men, polar



Aproximación a la morfología de esporas del género SPHAGNUM en bosques alto andinos

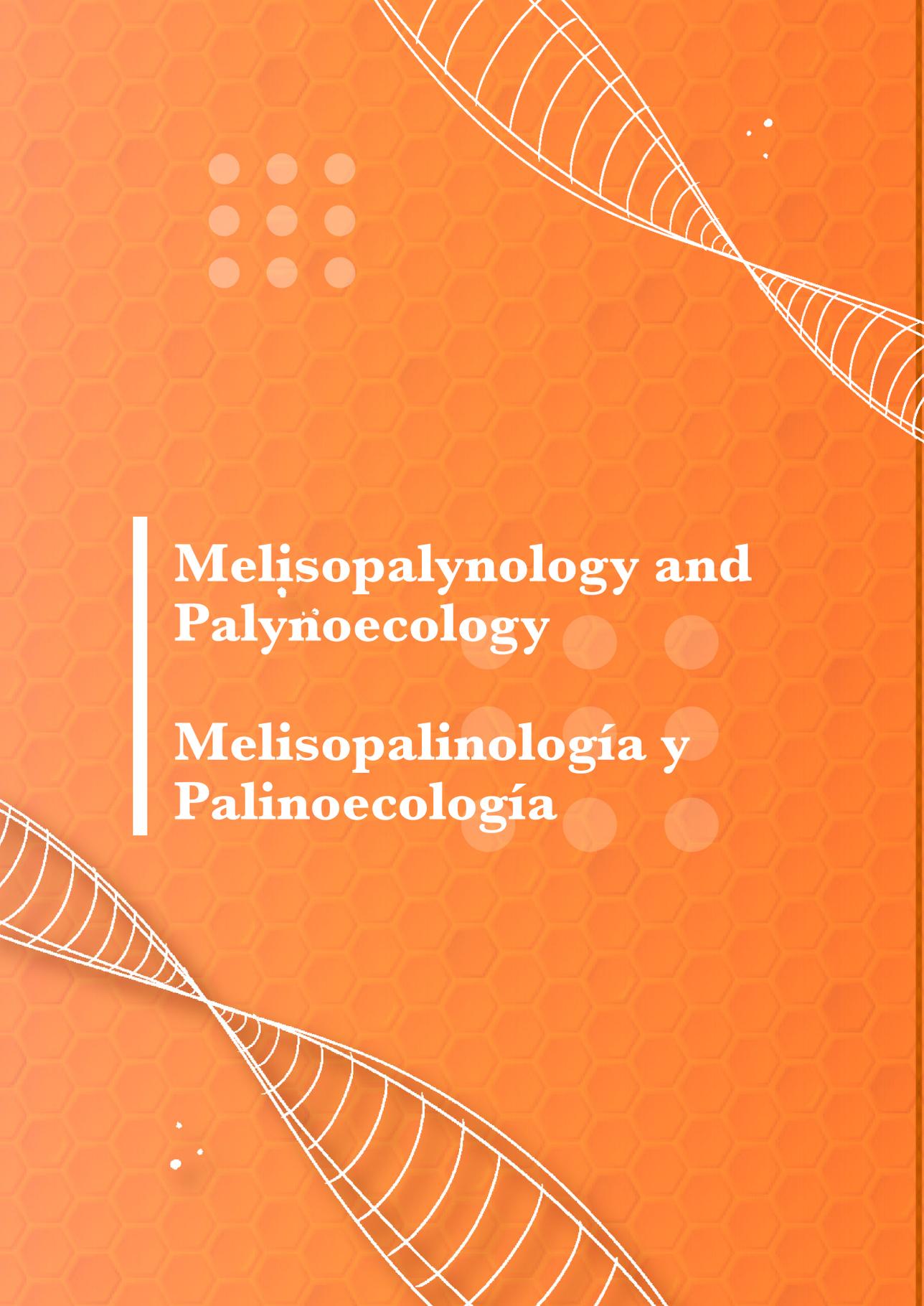
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Los estudios palinológicos en plantas se han enfocado principalmente en la morfología del polen en angiospermas. Por otra parte; el estudio de estructuras propagativas en briofitos es un tanto más escaso. A nivel mundial se conocen a penas cuatro estudios de esporas para la familia Sphagnaceae, debido a que se ha enfocado su importancia en la ecología y taxonomía, del gametofito, dejando de lado una de las estructuras también muy importantes para estos estudios y de las cuáles se puede inferir otros aspectos en diversas áreas; entre las que se encuentra la paleoecología. Por tal motivo este proyecto de investigación tiene como objetivo describir la morfología de las esporas del género *Sphagnum*. Para lo cual se realizaron salidas de campo al Agroparque los Soches, Une y La paz. Una vez las muestras fueron tratadas se les realizó la técnica acetolítica de Erdtman; además se hizo el montaje de

las placas y, posteriormente se realizó la descripción de las esporas utilizando para las mediciones y observaciones de los caracteres un microscopio en objetivo de 1000x. Las esporas de este género cuentan con una lesura en forma de trilete, algunas cuentan con la presencia del perisporio, otros tienen ornamentación escabrada en la exina y; se encontró dos caracteres no mencionados anteriormente por los autores conocidos como Kyrto-men y Labrum. Además, el tamaño de dichas estructuras oscila entre las 20 y 30µm. De lo anterior se concluye que la diversidad morfológica de las esporas es altamente diferenciada en los diferentes morfotipos colectados, por tal motivo estos estudios permiten saber la especie a la que pertenecen con la descripción de dichas estructuras, y de esta forma atribuyen al estudio de esporas fósiles en diferentes sedimentos.

Palabras clave: *Sphagnum*, espora, trilete, kyrto-men, polar



**Melisopalynology and
Palynoecology**

**Melisopalinología y
Palinoecología**



Melissopalynology without acetolysis: the pros and cons of enzymatic and KOH-based processing techniques

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Melissopalynology is an established science in much of the world and reliant upon traditional, acetolysis-based processing techniques for extraction of easily-recognized pollen from honey samples. This technique is advantageous in that it results in relatively

rapid results, however, can be highly destructive to fragile pollen, and has a relatively high risk-assessment associated with it. Plant biologists and palynologists explored multiple less-risky and less-damaging methods in the early 2000's, however, no direct comparison was made for honey samples. This comparison was completed in collaboration with Vaughn Bryant and students in 2017-2018 and is presented here for the first time. Enzymatic methods using cellulase and pectinase are safer and less destructive, but do not always produce clean preparations. These preparations can be improved through judicious short-term use of a 5% KOH treatment. Use of 10% KOH treatment alone sometimes results in exine damage. In both cases, prepared grains are generally somewhat smaller than those prepared using acetolysis.

Keywords: Enzymes, Cellulase, Pectinase, KOH, Melissopalynology



Pollen analysis of honey from the Peruvian Amazon

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Melissopalynology is useful to determine the floral content and the geographical origin of honey. The great botanical diversity of the Amazon allows bees to produce honey that has an important value in the Peruvian culture. However, pollen analysis and labels that provide information on honey content

are scarce; therefore, people do not know what types of honey they are consuming. For this reason, we carried out a melissopalynological study to analyze the pollen content of 14 samples of honey from Selva Alta and Selva Baja of the Peruvian Amazon. A total of 40 pollen types from 28 families were identified and most of the samples were multifloral. Pollen from Fabaceae, Asteraceae and *Citrus* was very frequent, while *Myrciaria dubia*, *Trema* and *Paullinia* were frequent in the samples. *Bombax*, *Gouania* and *Mimosa* pollen were rare in the samples. Pollen concentration values per 10 g of honey ranged from very rich to very poor. Most of the floral sources identified in honey are related to taxa that are traditionally used for medicinal purposes. Bioactive compounds

in the nectar of these plants may be producing the “healthier” properties that people associate with Amazonian honeys in Peru. This pollen study provides important in-

formation on the floral preferences of the bees and honey content, which can be used by traditional beekeepers and the public in general.

Keywords: melissopalynology, pollen, honey, Peru, Amazon



Análisis del contenido polínico de mieles de la Amazonía peruana

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El análisis melisopalinológico es útil para determinar el contenido floral y el origen geográfico de la miel. La mega diversidad botánica de la Amazonía permite que las abejas produzcan miel de gran valor en la cultura peruana. Sin embargo, los análisis de polen y las etiquetas que brindan información sobre el contenido de miel son escasos; por lo tanto, las personas no saben qué tipos de miel están adquiriendo y consumiendo. Por esta razón, realizamos un estudio melisopalinológico para evaluar el contenido polínico de 14 muestras de miel de Selva Alta y Selva

Baja de la Amazonía peruana. Se identificaron un total de 40 tipos de polen de 28 familias y la mayoría de las muestras fueron multiflorales. El polen de *Fabaceae*, *Asteraceae* y *Citrus* fue muy frecuente en las muestras, mientras que *Myrciaria dubia*, *Trema* y *Paullinia* se encontraron frecuentes en las muestras. El polen de *Bombax*, *Gouania* y *Mimosa* fue poco frecuente en las muestras. Los valores de la concentración de polen por 10 g de miel variaron de muy rico a muy pobre. La mayoría de las fuentes florales identificadas en la miel están relacionadas con taxones que se utilizan tradicionalmente con fines medicinales. Los compuestos bioactivos del néctar de estas plantas pueden estar produciendo las propiedades “más saludables” que las personas asocian con las mieles amazónicas en Perú. Este estudio de polen proporciona información importante sobre las preferencias de origen floral de las abejas y sobre el contenido de miel, que pueden utilizar los apicultores tradicionales y el público en general.

Palabras clave: melisopalinología, polen, miel, Perú, Amazonía



Pollination ecology and effect of invasive species *Elaeagnus angustifolia* on honey bee foraging behavior

Authors: Sophie Warny^{a,b}, Joshua Campbell^c, Natalie West^c

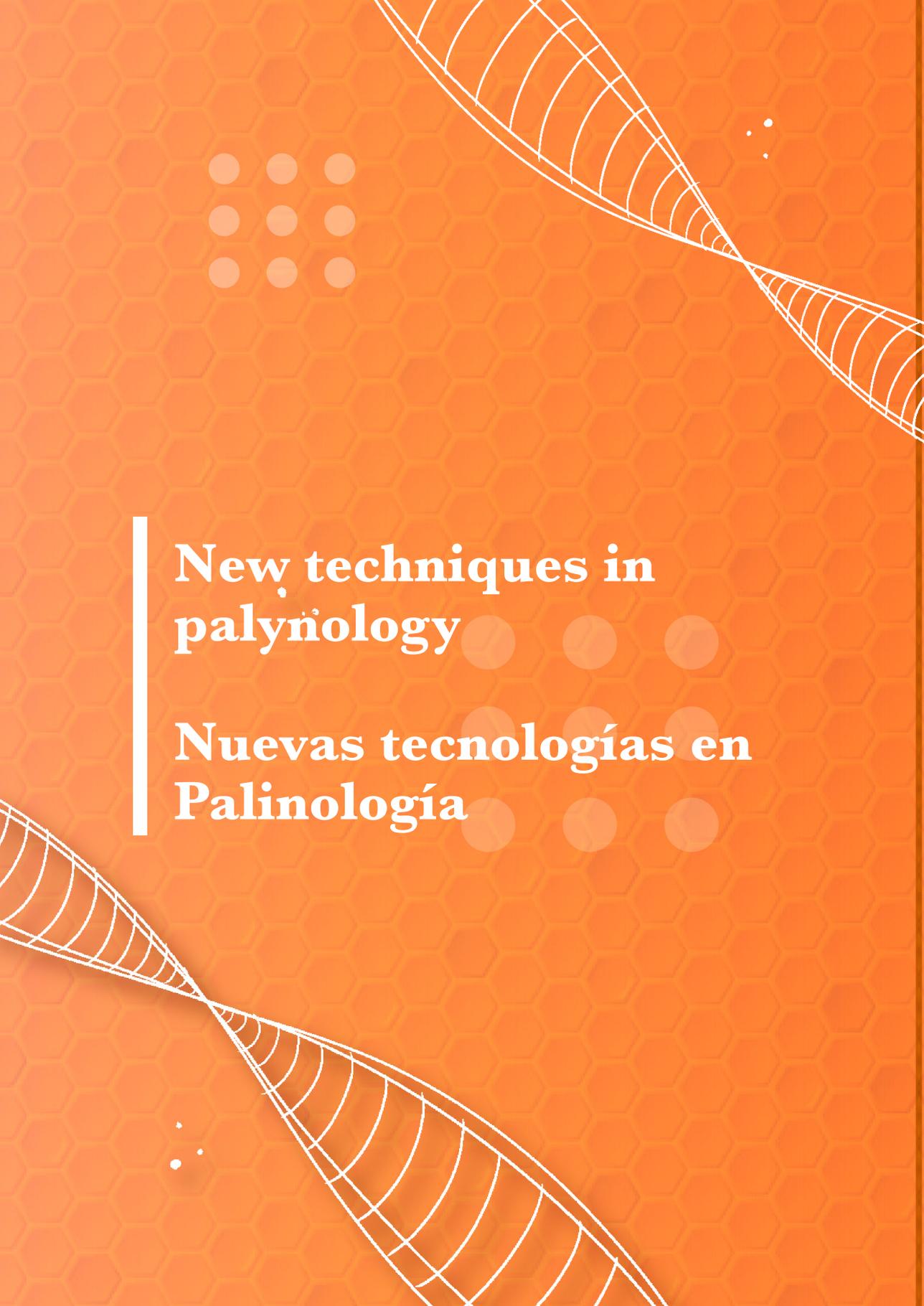
Affiliation: ^aDepartment of Geology and Geophysics, Louisiana State University, Baton Rouge, LA, USA; ^bMuseum of Natural Science, Louisiana State University, Baton Rouge, LA, USA; ^cPest Management Research Unit, USDA ARS NPARL, Sidney, MT 59270 USA

Here we present the results of a pollination and palynological study designed to understand pollinator foraging behavior in a rural area in Montana that is characterized by a strong presence of freely occurring and planted specimens of *Elaeagnus angustifolia* L., the Russian olive tree. Despite the commonality of Russian olive within the western half of the United States, its pollination ecology has not been explored. We conducted (1) an insect exclusion experiment, (2) timed flower visitor observations, and (3) honey bee corbicular pollen analysis. The insect exclusion experiment demonstrated that Russian olive seed production is substantially increased via pollen transport by insects. During floral visitor surveys, honey bees (*Apis mellifera*) were the dominant floral visitor, comprising over 80% of all insect visitation to Russian olive flowers. We collected 75 honey bee foragers and removed corbicular pollen between June 10 and 25 2021, from four different sites, located north and south of Sidney, Montana. Results indicate that, *Elaeagnus angustifolia* is by far the most abundant type of pollen fo-

raged by the bees throughout the study area, at all four sites, most of the days, most of the times targeted. Other types foraged include Chenopodiaceae/Amaranthaceae, *Plantago*, Poaceae, *Rubus occidentalis*, *Salix*, Asteraceae (ragweed type), *Berberis*, *Juniperus*, *Quercus*, and *Trifolium/Melilotus*.

Our data suggests that honey bees are highly attracted to Russian olive flowers, exhibit flower constancy, and act as a main pollinator. It is worth noting that *Elaeagnus angustifolia* and *Apis mellifera* are both Eurasian in origin; thus, it is possible that the honey bee may be the plant's natural pollinator. It is also clear that, during Russian olive bloom periods, honey bees may be poor pollinators of other simultaneously blooming crops or native plants. The minimal flower visitation by other insects suggests that Russian olive is not attractive to native insects and, thus, provides minimal resources to native pollinators.

Keywords: Palynology, corbicular pollen, foraging, honey bees, entomology



**New techniques in
palynology**

**Nuevas tecnologías en
Palinología**



RGraphCor: a tool to perform Graphic Correlation

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RGraphCor is an intuitive toolkit built in R (a language and environment for statistical computing and graphics) that we have developed to perform Graphic Correlations, a well known biostratigraphic method. In 1986, Kenneth Hood developed a program in MS-DOS named GraphCor to perform Graphic Correlation, that he maintained during many years and now it is available to the public at no cost. Unfortunately, the software hardly runs in the modern computing systems, therefore, we decided to replicate GraphCor in a modern platform that runs within the R environment, compatible with the most widespread operative systems (IOS and PC), and it is open-source and cost-free.

The package consists in six main functions:

1. `graphcor`: Correlates and plots two stratigraphic sections and their content.
2. `gc_screen`: Displays an html plot to easily explore the data.
3. `reloc`: Try and compares different lines of correlation (LOC).
4. `gc_extend`: Extends the ranges of occurrences of the events in the reference section.
5. `border_rm`: Detects and marks in the plot events too close to the limits.

6. `gc_summary`: Summarizes the information from Composite Sections.

RGraphCor also includes additional functions to assist the users to formatting their data to optimize the analyses and avoid errors.

The software allows the use of different formats for the input, and it is capable to correlate events from different sources such as cores, drillings, and outcrops with different measurement units (e.g. feet and meters) and temporalities (comparing wells with outcrop sections). The final output is an automatically adjusted composite section that is ready to be compared with new sequences, making the process accumulative. Thus, a master stratigraphic sequence can be built by iteratively feeding it with different sequences to include more and more relevant stratigraphical events, and spanning wider time periods, always preserving the original data.

We hope this package will facilitate and promote the application of the powerful biostratigraphic method that is the Graphic Correlation.

Keywords: graphic correlation, biostratigraphy, line of correlation, composite section.



Generative models as a novel tool for image generation and modeling of palynological datasets

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With the increasing implementations of machine learning algorithms, data analytics processes in geosciences have been transformed; several classification and segmentation algorithms becoming staple in current geological workflows, however, the potential impact of generative architectures is not yet fully explored, with some recent seminal publications hinting at possible uses of these architectures, such as super-resolution, classification and interpolation of under-represented images in a dataset.

In this work, the results obtained from a generative model using adversarial neural networks (GANs) trained with pollen samples is explored. The StyleGAN2 architecture was used, given the state-of-the-art results of this architecture and its derivatives and the robust framework in place for the interpretation of the model, we performed the training with a set of over seven thousand images of open-source pollen samples divided into six genera: *Astelia*, *Citrus*, *Lepto*, *Myrsine* and *Passiflora*.

The model was evaluated using the Fréchet Distance, FID Score, between the synthetic

and real images respective activations when processed by the InceptionV3 architecture, reaching a 15.8 FID for unconditional generation of images at 64x64 px resolution. We use this size with the aim of both allowing quick prototyping between conditional and unconditional generation, varying dataset size, diversity and gathering enough images for the GAN model to be viable and to allow for a quick replication of our results within the academic community. The limitations of this approach being the high quantity of images required, in the order 10^3 - 10^4 samples, and high-end Graphical Processing Units (GPU) requirements for training higher resolution models.

With this work, a first step into generation of synthetic images for data augmentation, modeling, and visualization of pollen specimens is taken, with the use of the latent space generated by the trained network, and the associated styles found in the datasets allowing for explorations such as style transfer, interpolation, and truncation of the generated samples, which could further improve image analysis and experimentation within palynological workflows in the future.

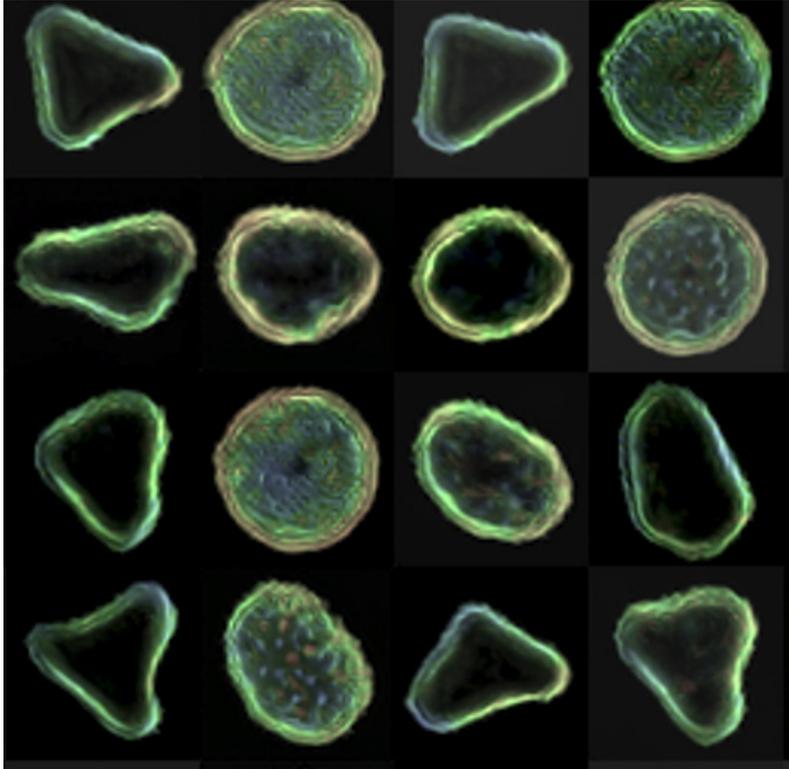


Figure 1: Random sample of images generated by the model.

Keywords: Generative models, Image analysis,
Pollen, Machine Learning



Digital Palynology

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The study of pollen and spores started more than a century ago and provides the fundamental basis to understand vegetation changes through time, date sedimentary rocks through biostratigraphy, and model plant evolution among many other applications. Since its origin, palynology has relied on the manual count of pollen and spores 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 to pollination biology and honey production.



Palynology and outcrop analogue studies for reducing uncertainty of reservoir heterogeneity in carbon capture and storage

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Carbon capture and storage (CCS) is an option for reducing emissions to the atmosphere. Provisional conclusions from palynology and outcrop analogue studies suggest that these two techniques combined can contribute to understanding and predicting geological heterogeneity in subsurface formations. The use of these techniques shows how science developed to understand

oil and gas extraction can be re-invented to help in the injection and underground management of CO₂.

CO₂ will be injected as far as possible in geological conditions that encourage slow migration, dissolution and precipitation, and/or stratigraphic trapping. The balance they may be sought is one between injecti-

vity and presence of enough heterogeneity to facilitate solubility trapping. An example is the Sleipner CO₂ storage facility, the longest running facility for CO₂ storage. Repeat seismic surveys alongside specially tuned seismic has detected layers of rock with high CO₂ saturation – where the CO₂ has accumulated below thin sub-seismic mudstone layers creating bright spots within the reservoir. In the Utsira, mudstone layers could be seen as problems for injection – perhaps making less of the reservoir available to injection, but also have proved useful in slowing down upward migration allowing more time for reactions to take place dissolving CO₂ and leading to more long term storage through carbonation. Thus the low permeability layers (baffles) promote ‘solubility trapping’ leaving the overlying seal (the physical trap) to do less of the work of confining the CO₂.

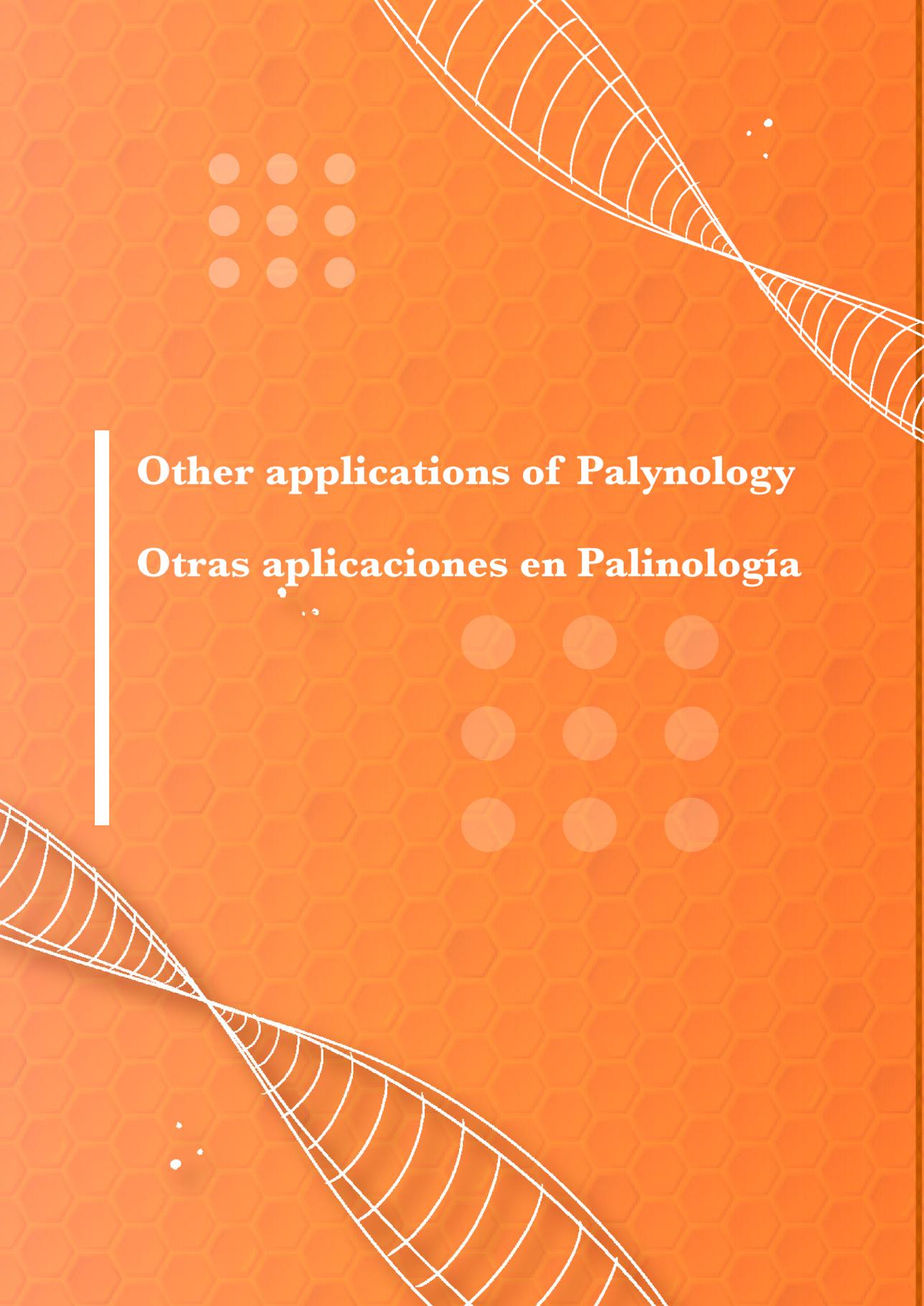
Recent use of palynology in understanding the geometry of mudstones has been developed through study of the Upper Permian fluvial Umm Irna Formation. This formation is 70m thick and outcrops for 40 km north to south along the Jordanian Dead Sea coast. Around 30 individual mudstone units within the Umm Irna Formation, both large and small, were sampled for their spores and pollen with the objective of determining whether mudstone lateral persistence (baffle continuity) could be predicted by palynological content. Overall the argillaceous units revealed pollen and spores that varied a lot but generally fell into two categories. The first group was found in laterally persistent argillaceous units like migrating point bars or flood deposits associated with the main river channels. This was high in diversity, containing a wide variety of Permian pollen and spores that probably represent a regional snapshot of the vegetation on the floodplain and the higher ground around.

The second assemblage from smaller argillaceous units like oxbow and channel plugs was of lower diversity with high proportions of one or two local palynomorphs, and also the spores of green algae (mainly zygospores) that usually indicate water bodies that are drying up.

The reason for this distinction is not completely clear, and more work needs to be done on other similar fluvial successions both ancient and modern, however it seems likely that the different assemblages relate to the way that palynomorphs are transported. Although saccate palynomorphs (e.g. *Falcisporites*, *Alisporites*, *Taeniaesporites*) can be distributed by wind, their main transport is by flowing water. Thus a depositional environment more closely associated with an active river channel that drains a large hinterland through its network of tributaries is more likely to contain a diverse assemblage of palynomorphs. Those associated with abandoned channels, particularly where a waterbody is drying up is more likely to contain palynomorphs like zygospores (e.g. *Quadrisporites*; where green algae start to dry up) and purely local palynomorphs from plants very close to the water body – possibly growing just around it.

The distribution and lateral continuity of mudstone baffles will be obvious in outcrop, but the key is transferring what has been learned from the outcrop to the subsurface. If detailed palynology work is done, preferably on core on fairly closely spaced boreholes, it should be possible to distinguish a horizontal baffle in a borehole from a narrower mudstone unit with less baffle potential. This could be very useful in providing information on geological heterogeneity in advance of CO₂ injection in CCS projects.

Keywords: palynology, heterogeneity, carbon capture and storage



Other applications of Palynology

Otras aplicaciones en Palinología



Monitoring Air quality in the Permian Basin during Covid-19 and West Texas drought

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Air quality is an ever-increasing issue in the United States. Air pollution is one of the leading causes of lung and heart disease, especially in vulnerable populations. The advent of Covid-19 in late 2019 and a severe drought beginning in West Texas in early 2020 and still ongoing has created unusual circumstances with regard to air quality and public health in the Permian Basin. Our study has been monitoring airborne Pollen, Spores, other organically derived particles (e.g. plant trichomes and phytoliths), Volatile Organic Compounds (VOCs), SO₂ and Particulate Matter (1, 2.5, and 10-micron PM). The pandemic caused a ripple effect throughout the oil field that eventually led to halting of many oilfield operations while at the same time increasing flaring of natural gas. Although there were increases in the release of VOCs, especially methane, during this time our fixed monitors detect no notable increase. This phenomenon is attributed

to highly local nature of flaring and methane plume emissions. As severe drought has developed over the last two years, pollen and spores have decreased in abundance caused by the reduction in plant growth and flowering due to the drought. Pumpjack pads and the lack of vegetation has exposed more barren ground in the region leading to an increase in airborne particulate matter. Although daily averages of PM are at acceptable EPA levels, days with wind speed above 10 knots (a common event in the Permian Basin), can cause severe dust events, which last only a few hours, that are well above acceptable levels of PM. These events can cause acute distress in people with respiratory disease. Although our regional air quality may be characterized as good, there are severe episodic events for airborne dust and proximity to oil field operations can also significantly affect people sensitive to VOCs and SO₂.

Keywords: pollen, spores, VOCs, SO₂, particulate matter, oilfield operations, air pollution, flaring



Palynology in O&G Industry Venezuela, 1938 -2000

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The Oil Industry was expanding very fast in several regions of the world during the first part of the XX Century. Teams of field geologists were surveying sedimentary basins where oil seeps had been reported. They were looking for the right geological conditions to find major oil reservoirs, but many of them were in terrestrial sections.

A story tells that in 1934 a petroleum geologist working pre Quaternary sections in the U.S. found it very difficult to correlate some of them because neither (micro)paleontology nor lithological methods provided sufficient detail to work the correlation of some terrestrial sections.

Samples from Mexico were first assessed for pollen and spores in 1938 in Dr. R. Potonie's laboratory in Germany, and samples from Venezuela and Malaysia were assessed by Dr. F. Florschütz in his laboratory in The Netherlands in 1939. The reports from both of them with encouraging results sparked Shell's interest in palynology as an oil and gas exploration tool. At the same time, Standard Oil was starting its research in palynology in its California laboratory. Then came WWII started and brought all this research activity to a halt. But as soon as WWII ended, the interest of both corporations for palynology returned.

So, in Venezuela, by the mid-'40s, the Caribbean Petroleum Co., later Shell de

Venezuela, and the Lago Petroleum Co., Standard Oil de Venezuela, and later Creole Petroleum Corporation, started their research in palynology in their Maracaibo and Caracas laboratories, respectively devoting important resources to further advance in its development. All was very confidential.

For exploratory and operational reasons, in Venezuela, Shell's early palynological studies' initial focus was in the Paleocene to Oligocene sections of the Maracaibo Basin. As a consequence, the palynological Eocene - Paleocene zonation was already in extensive use in the company's concessions well before 1955, as demonstrated when Kuyl et al. 1955 published the first known palynological correlation of sections around Lake Maracaibo Basin. This palynological zonation's main objective was to correlate the rich oil-bearing fluvio-deltaic sand intervals of the prolific Misoa Formation.

By the 1950s, more paleontological laboratories with palynology sections opened in the country, e.g., the Mene Grande Oil Company laboratory and the Texas Oil Company (Texaco) laboratory. During the 1960s, the new palynological laboratory of the Corporación Venezolana del Petróleo (CVP) started operations.

On December 31st, 1975, all concessions were reverted to Venezuela's government. As of that date, the properties, plants, equipment, and paleontological laboratories, among other aspects of the foreign con-

cession companies, became the property of Venezuela's State. By the early 1980s, only three companies (Lagoven, Maraven, and Corpoven) and one Research Institute (INTEVP) prevailed. All of them had active and prolific palynological laboratories in operation. In 1997, December 31st, a new change in the corporative structure of the Venezuelan Oil Industry took effect with the merger of the three companies into one major corporation under the name of Petroleos de Venezuela S.A., and their geological - paleontological laboratories became one

under the umbrella of PDVSA Exploration, with regional laboratory units in the East, West, and Caracas. The paleontological laboratory of INTEVEP remained independent after the merger. Palynology continued to thrive in Venezuela during 1978 -2000. The story we tell in this paper is to honor those brave palynologists whose love for science and adventurous spirit helped develop palynology as a key to finding the energy resources that supported the development of our modern society, not only in Venezuela but in the world.



In the photo, Palynologist Mrs. Estella Bradley de DiGiacomo identifying pollen and spores from the Maracaibo Basin, circa 1960.



Preliminary analysis of non-pollen palynomorphs: An experimental research work with forensic implications (La Picada, Entre Ríos, Argentina)

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Mycology contributes as a discipline to several others but its application in forensic science has been increasing. From working with postmortem intervals, trace evidence, and soil profiles are evident we need to intensify experimental research to use fungi in forensic contexts. We present the first experimental work at a hypothetical crime scene tracing the site of human remains' deposition in a protected area (relatively low spiny trees, shrubs, and an understory of herbaceous plants) near a creek in La Picada location (Entre Ríos) focusing on non-pollen palynomorphs (NPP), particularly fungi. The floral composition and climatic regime of the study site correspond to a shrubby forest with grassland and ferns under a subtropical-temperate climate. The samples were taken during the spring from sediment from

the trail chosen to conduct the experiment, soil accumulated in the sole of the shoes, and with the tape method from a subject's shoulders, thighs, and ankles after walking 1 hr on the trail. The samples were processed following standard protocols used in forensic palynology adapted for this experiment. The NPPs identified were fungal spores as more abundant followed by thecate amoebas, diatoms, and nematodes. Fungal spore traits and ecology correlated with the vegetation of the study site and NPPs' general ecology were useful to delimitate the site of study regarding its climate and floral composition. Sediments held a higher species richness of fungal spores and other NPPs commonly found in soil, litter, and wood remains (*cf. Sphaerodes*, *Glomus* sp., *Tetraploa aff. aristata*, *Bispora aff. antennata*, *Criconeoides* sp., *cyst cf. Lecythium asini*, among others). Samples from ankles, thighs, and shoulders showed less fungal richness but correlated with those growing over the vegetation present at the study site roughly at the same height in the walking path with more fungal species growing on trees and bushes (*Meliola* sp. *cf. Venturia*, *Melanomma* sp., *Drechslera/Bipolaris*, among others). So far, these results showed that fungi correlate with local floral composition and regional climate being valuable tools with forensic applications. Although, there's a need to continue working on this kind of experimental research using NPPs as reliable proxies for a concrete application in forensic sciences like elucidating the crime scene.

Keywords: Fungi, fungal ecology, NPP, forensic science

Análisis preliminar de palinomorfos no polínicos: una investigación experimental con implicancias forenses (La Picada, Entre Ríos, Argentina)



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La micología contribuye como disciplina a varias otras, pero su aplicación en la ciencia forense ha ido en aumento en los últimos años. A partir del trabajo con intervalos post-mortem, evidencia de rastros y perfiles de suelo, es evidente que es necesario intensificar la investigación experimental para usar hongos en contextos forenses. Se presenta el primer trabajo experimental en una hipotética escena del crimen que rastrea el sitio de depósito de restos humanos en un área natural protegida cerca de un arroyo en la localidad de La Picada (Entre Ríos) centrándonos en palinomorfos no polínicos (PNP), particularmente hongos. La composición floral y el régimen climático del sitio de estudio corresponden a un bosque xerófilo caducifolio abierto relativamente bajo, con un estrato arbustivo pobre y un sotobosque de plantas herbáceas bajo un clima subtropical-templado. Las muestras se tomaron durante la primavera del sedimento del sendero elegi-

do para realizar el experimento; así como suelo acumulado en la suela de los zapatos y con el método de la cinta de los hombros, muslos y tobillos sobre la ropa de un sujeto después de caminar 1 hora por el sendero. Las muestras se procesaron siguiendo protocolos estándar utilizados en palinología forense adaptados para este experimento. Los PNP identificadas fueron las esporas de hongos como las más abundantes, seguidas de teca de amebas, diatomeas y nematodos. Las características de las esporas fúngicas y la ecología correlacionada con la vegetación del sitio de estudio y la ecología general de los PNP fueron útiles para delimitar el sitio de estudio en cuanto a su clima y composición floral. Los sedimentos contenían una mayor riqueza de hongos y otros PNP que se encuentran comúnmente en el suelo, la hojarasca y los restos de madera (cf. *Sphaerodes*, *Glomus* sp., *Tetraploa* aff. *aristata*, *Bispora* aff. *antennata*, *Criconemoides* sp., *quiste* cf. *Lecythium asini*, entre otros). Las muestras de tobillos, muslos y hombros mostraron una menor riqueza de hongos, pero se correlacionaron con los que crecen sobre la vegetación (en árboles y arbustos) presente en el sitio de estudio aproximadamente a la misma altura en el sendero (*Drechslera/Bipolaris*, *Melanomma* sp., *Meliola* sp, cf. *Venturia*, entre otros). Hasta el momento, estos resultados mostraron que los hongos se correlacionan con la composición floral local y el clima regional, siendo herramientas valiosas con aplicaciones forenses. Sin embargo, existe la necesidad de continuar trabajando en este tipo de investigación experimental utilizando los PNP como representantes confiables para una aplicación concreta en ciencias forenses para esclarecer la escena del crimen.



Contribution to the
pollen morphology
in *Bauhinia* L. and
Schnella Raddi species
(Cercidoideae, Fabaceae)
from forest patches in
Southeastern Brazil.

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Cercidoideae has a wide geographic distribution in Brazil, with its most representative genera *Bauhinia* and *Schnella*. The present study aimed to describe the pollen morphology of *Bauhinia* and *Schnella* from forest fragments in southeastern Brazil and to contribute to the morphology description of these genera and species of Cercidoideae. The description of the pollen morphology of 21 species was carried out, being 13 species of *Bauhinia* and eight species of *Schnella*. Pollen materials were obtained from exsiccates deposited in Brazilian herbaria. Pollen grains were acetolyzed, measured ($n = 25$) and photographed to obtain qualitative and quantitative data. Quantitative pollen grain data were examined by descriptive and multivariate analysis. The pollen grains of the studied species showed variation in size (medium to very large), shape (oblate to oblate spheroidal or prolate), type and detail of ectoaperture (3-porate, 3- or 5-colpate,

3-colporate, angulaperturate, planaperturate or fossaperturate, very short to very long and narrow to very large ectoaperture, tapered or rounded at the polar ends, membrane of the ectoaperture with ornamentations or not, with or without margo, constricted or not) and endoaperture (lolate, circular, or lolate endoaperture, costate or not), exine ornamentation (areolate, striato-reticulate, microreticulate heterobrochate or homobrochate, and reticulate heterobrochate or homobrochate ornamentation) and types of suprategal elements (with bacula, clavae, gemmae and verrucae, or without suprategal elements). Quantitative data, mainly diameter measurements, allowed the separation of the *Bauhinia* and *Schnella* genera in the multivariate analysis. From the data obtained and the pollen variations observed in the species already analyzed, we can describe Cercidoideae and *Bauhinia* and *Schnella* genera as eurypalinos.

Keywords: Palynology, *Phanera*, Cerrado, Eurypalynous.



Paleodrainage Evolution of Northern South America and its Impact on Exploration Success in the Guyana Basin

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Since 2015, the Guyana Basin has become one of the most exciting hydrocarbon provinces in the world and a key asset in ExxonMobil's portfolio thanks to oil discoveries in the Stabroek Block, offshore Guyana. New evidence indicates that uplift in the Northern Andes played a significant role in the sedimentary history of the Guyana Basin. Recognition of Devonian and Andean palynoflora within thick Messinian to recent mass transport complex (MTC) deposits in the Guyana Basin attest to their distant provenance, and comparable palynology results from industry wells in the Amazon Fan (Hoorn et al., 2017) suggest a shared history. Modern sedimentation on the Guianas shelf is dominated by long- and along-shore bypass of fine-grained Amazon River derived sediment, and little material makes it into the deep-water Guyana Basin at present. The sudden and voluminous late Miocene onset of MTC accumulation in the Guyana Basin and contemporaneous

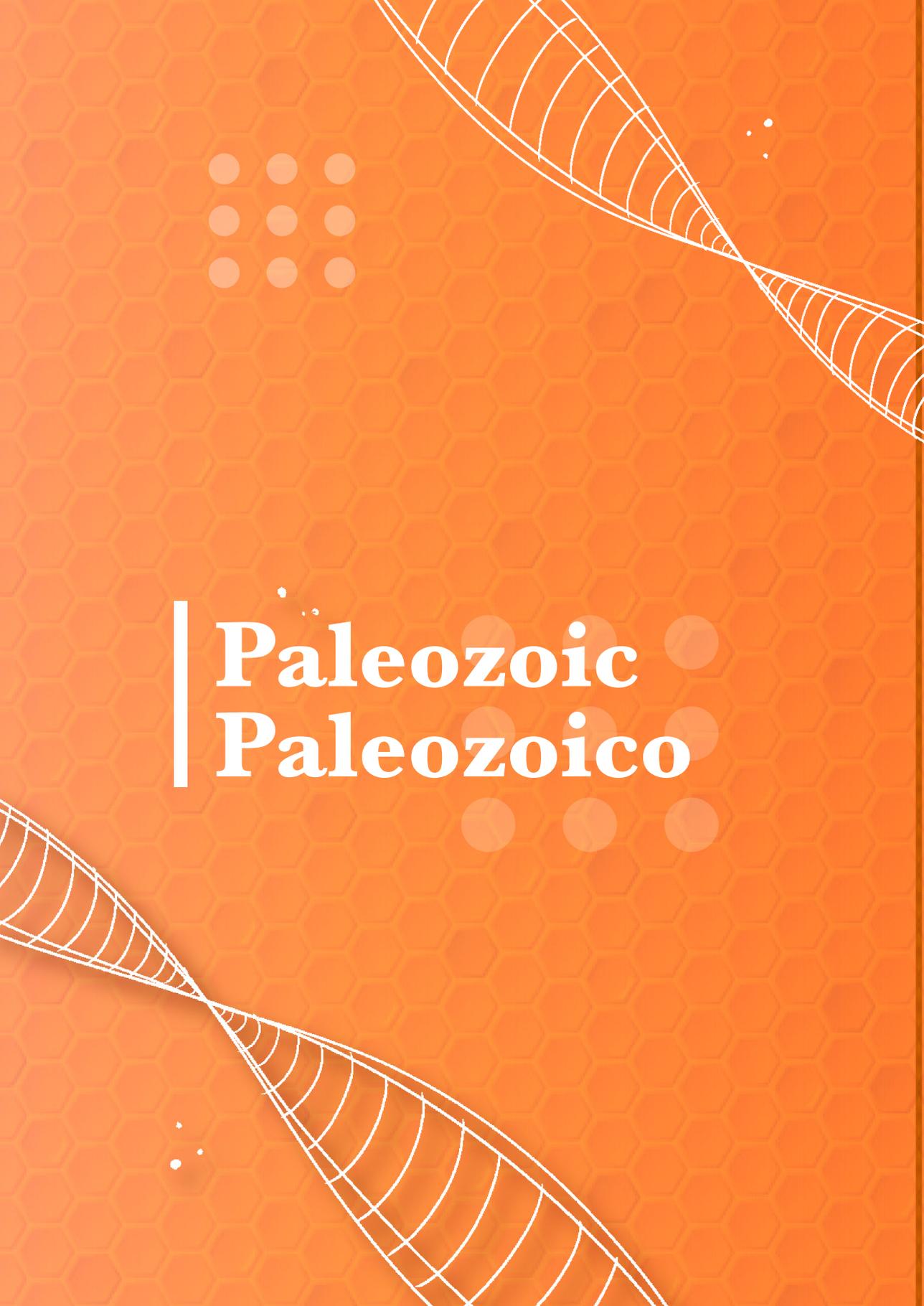
growth of the Amazon Fan is temporally consistent with continental-scale drainage reorganization that occurred onshore that connected Andean sedimentation to the Atlantic margin for the first time. We hypothesize that MTC sedimentation was triggered by sudden availability of large volumes of fine-grained sediments to the Guianas margin coupled with Neogene high frequency and high amplitude sea level fluctuations (Milankovitch scale cycles) that allowed rapid accumulation of unstable sediment at the shelf-slope break. Frequent, possibly semi-continuous, slope failures led to thick MTC accumulations in the Guyana Basin down-dip. Our preliminary analysis indicates that without the combination of these factors, sedimentation rates in the Guyana Basin would have remained low throughout the Neogene and the basin-wide hydrocarbon system evolution would have been dramatically different.

Keywords: Palynology, *Phanera*, Cerrado, Eurypalynous.



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**Paleozoic
Paleozoico**



Defining the Siluro-Devonian boundary in the Lower 'Old Red Sandstone', U.K. with a preliminary spore biozone

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The near continuous terrestrial fluvial succession of the Siluro – Devonian Lower 'Old Red Sandstone' of the Anglo-Welsh Basin, U.K., yields abundant vertebrate and plant remains alongside diverse and well-preserved dispersed spores. Previous workers succeeded in erecting regional and global biostratigraphic zones using these fossils, especially in the Early Devonian. The latest Silurian and Earliest Devonian (Přídolí – earliest Lochkovian), however, remains problematic given the paucity of suitable sampling horizons. Where possible, we have systematically investigated the palynological record from this time slice and revealed a diverse and well-preserved assemblage of

dispersed cryptospores and miospores, comprising some 200 species in 43 genera, from several sites across the Welsh Borderlands and south Wales, U.K. These sites shed new light on the problematic Earliest Devonian and Přídolí spore biozones and go some way towards constraining the Siluro – Devonian boundary of the region. However, problems persist with (1) correlating the biozones with the type section in Klonk, and (2) suitable sampling horizons in the Anglo-Welsh Basin, the latter being neatly encapsulated in one borehole by some 700m of red, unsamplable mudstones, leaving a considerable portion of the Přídolí unexamined.

Keywords: Biostratigraphy, Old Red Sandstone, Palynology, biozones, Silurian-Devonian boundary, terrestrial



Early Devonian palynomorphs from the Cerrezuelo Formation, Norte Basin, Uruguay

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This contribution describes the presence of Devonian organic-walled microfossils in the subsurface of the Norte Basin (Uruguay) from continuous rock cores (borehole) from the drilling of Cardozo Chico E-1. The Devonian sedimentary rocks in the Paraná and Chaco Paraná basins (PCPb) are characterized as an almost complete transgressive-regressive cycle that progressively increases thickness from East to West.

The Devonian basin configuration shows provenance areas located to the east and a marine embayment to the west. In the southeastern region of the PCPb area, Devonian outcrops are only recognized in Uruguay and these deposits rest unconformably on the Precambrian basement. Devonian sediments in Uruguay are grouped in the Durazno Group, subdivided, from base to top, into the Cerrezuelo (140 m), Cordobés (90 m) and La Paloma (35 m) formations. Outcrop distribution in the basin indicates the presence of erosional and structural limits. Studies on facies associations, micro and macrofossil associations, paleocurrents and provenance, allow to interpret the Devonian sediments as deposited in a marine basin with Neoproterozoic provenance areas located to the East. Recently, stratigraphic wells (Achar E-1 and Cardozo Chico E-1)

drilled in the Uruguayan area (Tacuarembó Department) of the basin confirmed the shallow marine to tidally-influenced littoral depositional conditions for the upper Cerrezuelo Formation. The presence of black shales, with high organic matter contents, in the Cordobés Formation section penetrated in those wells suggests a paleogeography with restricted oceanic communication that led to the amplification of tidal processes in this sector of the basin.

Samples analysed in the present contribution correspond to the basal part of Cardozo Chico E-1 well, belonging to the Cerrezuelo Formation and possibly, its transition to the Cordobés Formation. In relation to the sedimentation paleoenvironment, along the interval of almost 60 m thickness repeated variations can be observed in the palynological content from clearly continental, to marine or brackish environment as is the case of a level dominated by *Quadrisporites* spp. Among the spores represented in the samples the more important taxa are *Dictyotriletes emsiensis*, *D. marshallii*, *D. subgranifer*, *Emphanisporites rotatus*, *Knoxisporites riondae*, *Cymbohilates baqaensis*, *C. heteroverrucosus*, *Retusotriletes maculatus*, *R. triangulatus*, *Brochotriletes* aff. *B. tennellus*, *Synorisporites papillensis*, *S. verrucosus*, *Dyadospora murusattenuata*, *Latosporites*

ovalis, *Scylaspora costulosa*, *Dibolisporites* spp. Among the recorded paleomicroplankton taxa are *Gorgonisphaeridium granatum*, *Pyloferites escobaides*, *Polyplanifer turbatum*, *Pterospermopsis* sp., *Quadrisporites horridus*, *Q. variabilis*, *Schizocystia pilosa*, *S. saharica*, *Tunisphaeridium tentaculaferum*, *Triangulina* spp., *Winwaloewsia distracta*, and the chitinozoan *Ramochitina magnifica*.

According to the stratigraphic distribution of the organic-walled paleomicroplankton, chitinozoan and mostly of miospores, the age suggested for the analysed interval is late Pragian-early Emsian, which is in agreement with the age assigned in previous publications for this interval. *Ramochitina magnifica*, *Knoxisporites riondae*, *Dictyotriletes* and *Cordobesia* species are commonly present in Devonian sediments from Uruguay. Correlation with other Gondwana and peri-Gondwana associations can be made based in elements in common. *Schizocystia pilosa*, *S. saharica*

and *Winwaloewsia distracta* first appear in the Lochkovian but extend upwards into the Emsian. *Ramochitina magnifica* is commonly recorded in late Pragian-early Emsian sediments from Brazil (Ponta Grossa Formation), as well as in Argentina (p.e. upper Caburé and lower Rincón formations). *Cymbohilates bakaensis* is known from Pragian of Saudi Arabia and Tunisia. Other relevant taxa in common with Pragian-Emsian associations from Jauf Formation in Saudi Arabia are *Brochotriletes foveolatus*, *B. tenellus*, *Cirratriletes diaphanus*, *Dictyotriletes emsiensis*, *D. subgranifer*, *Latosporites ovalis* and *Scylaspora costulosa*. *Dictyotriletes subgranifer* and *D. cf. D. richardsonii* are recorded respectively in the late Pragian-early Emsian of the Jaicós (Paraná Basin) and Ponta Grossa (Paraná Basin) formations of Brazil. Other elements in common with the Ponta Grossa Formation are *Distaverrusporites steemansii*, *Knoxisporites riondae*, and *Cordobesia* spp.

Keywords: Pragian, Emsian, Gondwana, peri-Gondwana, paleomicroplankton, miospores, palynostratigraphy



The impact of land plants on Earth systems: a palynological, palaeobotanical, and geochemical perspective

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The diversification and spread of terrestrial plants was one of the most profound changes in the history of Earth. Plants affect Earth's climate and the global hydrologic cycle through evapotranspiration and by altering planetary albedo. They also alter the landscape; they have transformed river morphologies and the distribution of mud in sedimentary systems. While it is long accepted that the evolution of terrestrial plants had considerable impact on Earth systems, there are still widely varying views about the extent to which the emergence of land plants increased global productivity, drove atmospheric oxygenation, and altered the global marine redox landscape. The goals of this project are to connect and evaluate the effects of plant evolution on the marine redox record through palynology, paleobotany, and geochemistry.

Sampling efforts focus on stratigraphic successions spanning the Silurian-Devonian transition, specifically the Road River Group and McCann Hill Chert, as sampled on the Tatonduk River and McCann Hill type section, Alaska, USA. These successions provide an exceptional opportunity to characterize both marine and terrestrial processes across the Silurian-Devonian transition and to explore the impact of land plant evolu-

tion on Earth systems. The interbedded limestones, shales, and cherts of these units record slope deposition on the northwestern margin of Laurentia, likely spanning the basal Silurian through Middle Devonian. The generation of palaeobotanical and palynological records from these successions will be used to track changes in plant diversity. If palynomorph and plant macrofossil diversity and abundance changes in tandem with shifts in geochemical redox tracers this will allow for the detailed, high-resolution linkage of plant evolution and marine geochemistry through the Silurian-Devonian interval. Alternatively, lack of coupled change would suggest that hypothesized linkages likely require revision. The specific hypotheses to be tested is that plants increased nutrient delivery to the oceans, causing locally anoxic water columns to become sulfidic. This will be tested by analysis of iron speciation and Mo/U ratios. The geochemical and paleobotanical data from the Tatonduk River and McCann Hill successions will provide well-calibrated records of redox change through the Silurian-Devonian transition, directly connected to palaeobotanical records, and thus the best test to date of whether terrestrial evolution is temporally associated with redox changes in the marine realm.

Keywords: early plants, geochemistry, oxygen, redox records



Palynology of the Lower Devonian (upper Emsian) of the Holy Cross Mountains, Poland

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The active Bukowa Quarry located in the northern part of the Holy Cross Mountains (Poland) provided a new exposure of the Lower Devonian deposits. Numerous plant macrofossils preserved as carbonaceous compressions, adpressions occurred alongside a differentiated assemblage of palynomorphs. According to the palynostratigraphy, the age of the fossiliferous sequences is the narrow Pro. Zone within the AP Zone of the douglastownense-eurypterota Miospore Zone, which corresponds to the upper part of the Emsian. Based on the palynofacies analysis the depositional environment is

thought to be shallow water/alluvial. The palynomorph assemblage contained fresh water organisms and rich association of the terrestrial components. Numerous microfossils include filamentous green algae, arthropods, terrestrial fungi-like filaments, nematophytes and abundant land plants. Scolecodonts and acritarchs are much rarer the same suggesting limited marine influence. This diversified assemblage shows the complexity of the early Devonian environments and provides the new insight into examined time interval.

Keywords: palynostratigraphy, palynofacies, marginal marine, miospores,



Mesozoic
Mesozoico



An integrated palynology and heavy mineral based correlation scheme for the Triassic Skagerrak Formation, Central North Sea, U.K

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Triassic fluvial successions from the Skagerrak Formation located in the U.K. Central North Sea (CNS) constitute a high-pressure- high-temperature (HPHT) play that provides important primary and secondary hydrocarbon-bearing sandstone reservoir intervals. Over the past decade there has been considerable renewed interest within these deeply buried Triassic successions as a result of the North Sea Basin reaching so-called super mature status. The Skagerrak Formation across the CNS is typically subdivided using the J-member lithostratigraphic system into six alternating sandstone and mudstone members. Although, latest studies indicate that these members show considerable lateral and vertical heterogeneity with regard to composition, reservoir quality and provenance at differing scales. In this work, an integrated approach to correlating the CNS Skagerrak Formation using palynology and heavy mineral analysis (HMA) has been applied to allow the varying spatio-temporal distribution of members to be investigated. Traditionally, CNS Triassic successions are widely regarded as being barren, however recent work utilising a refined processing te-

chnique has proven that palynological yields can be recovered allowing recognisable biozones to be established. High-resolution heavy mineral analysis enables variations in provenance throughout sandstone-dominated intervals to be recognised and divided into heavy mineral units that can be correlated across wells. This study extends the newly established biozonation scheme into unstudied wells from areas of development interest and succinctly combines it with intra-member scale variations in provenance identified using HMA. The combined dataset has been subject to statistical analysis that allows for a direct quantitative comparison between the differing data types. This study aims to contribute to our understanding of ancient distributive fluvial systems with different and/or mixed provenance through time. Whilst permitting key questions to be investigated regarding the source-to-sink configuration of the CNS Basin during the Triassic as well as refine our understanding of the different sediment sources that enabled deposition of the Skagerrak sandstone reservoir intervals.

Keywords: Triassic, provenance, heavy minerals, palynology, Central North Sea



Biostratigraphy and Palynology of Triassic Sediments in the Norwegian North Sea

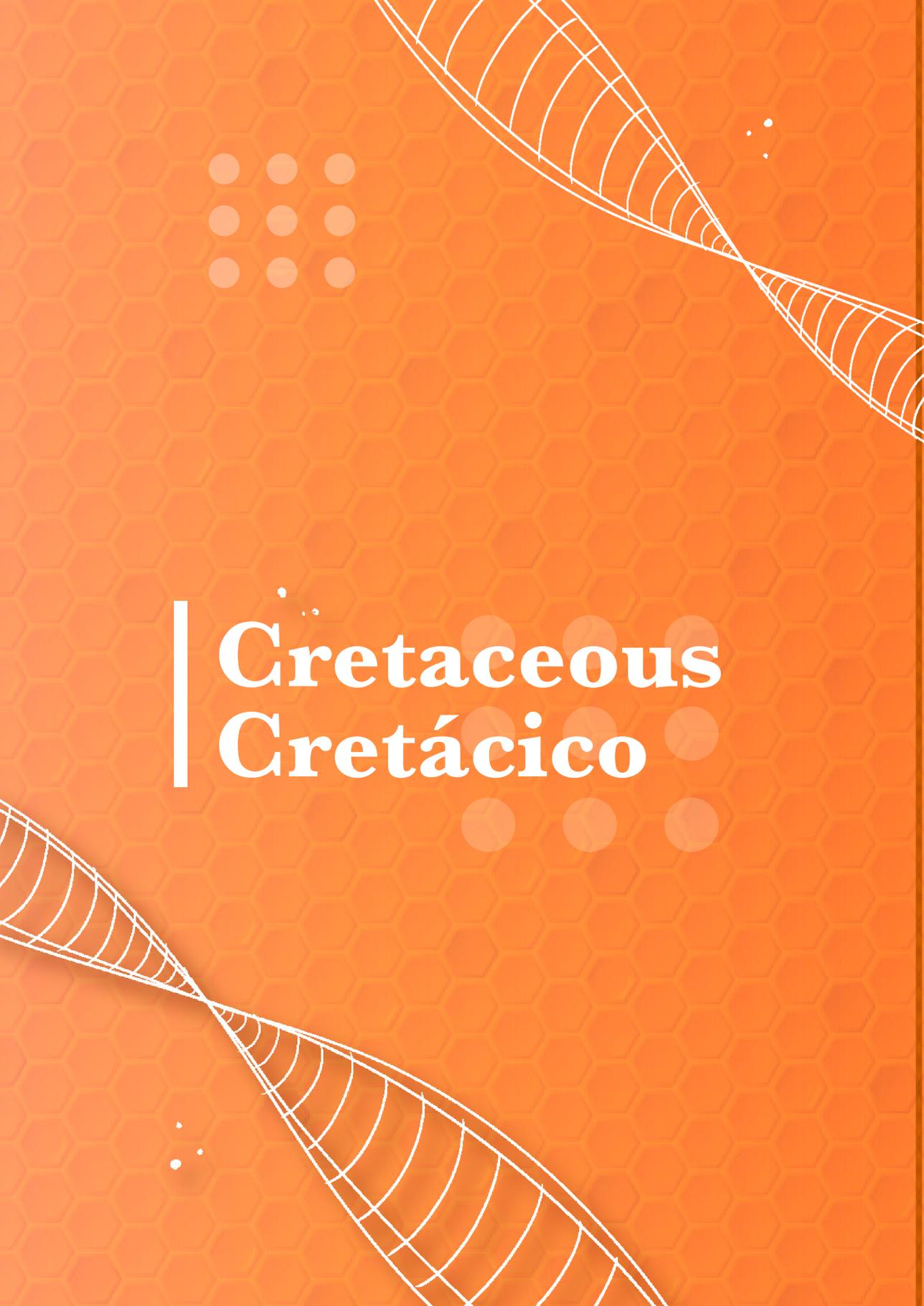
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The Central North Sea and the Northern North Sea has significant hydrocarbon potential in the form of the Triassic Skagerrak Formation and the Hegre Group, respectively. They represent a sequence of continental sediments that were deposited in a climate-driven distributive fluvial system. The Skagerrak Fm is one of the last major targets for exploration as a high pressure-high temperature play (HPHT). The Triassic was previously unattractive as a target due to its burial depth, but the mature nature of existing, shallower fields has made the Triassic a priority in recent years. There has been a struggle to connect regional scale lithologies and biostratigraphy with localised studies within the North Sea fields. Issues with correlation in the region include; a lack of reliable biostratigraphic information, heterogeneous lithostratigraphy, the varying influence of salt tectonics, unconformities and erosion, and partial Triassic well penetrations. Much of the Triassic sediments of the Central and Northern North Sea

are dominated by the continental red-bed facies and are often barren or contain limited diagnostic biostratigraphic material. It is these red beds that are the primary target for hydrocarbon reservoirs. By conducting an in-depth palynological investigation of Triassic Strata within the Norwegian North Sea, this study aims to reconstruct palaeoenvironmental conditions, as well as construct a biostratigraphic-based correlation framework within the Norwegian Sector of the Central and Northern North Sea. This project involves extending an existing biostratigraphic correlation scheme developed for the Triassic Skagerrak of the Central North Sea (UK and Norwegian sectors) into the northern sectors of the Norwegian Sea. This is achieved by using a targeted sampling strategy (focused on fine-grained sediments) in combination with modern palynological acid processing techniques in order to allow for a high-resolution palynological framework to be developed for use across both UK and Norwegian sectors.

Keywords: Triassic, palynology, biostratigraphy, North Sea, Skagerrak, red-beds, correlation



Cretaceous Cretácico



Early Cretaceous palynology of the Scotian Margin (Atlantic Canada)

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Biostratigraphic studies of Mesozoic–Cenozoic strata along the Scotian Margin began in the early 1970s, with the works focusing on zonation schemes for separate disciplines. Subsequent studies over the past 25 years, however, have evolved into an event stratigraphic approach, with the publication of significant multidisciplinary event-stratigraphic frameworks that combined palynologic with micropaleontologic and nanofossil events, as well as seismic horizons. Extensive taxonomic treatments of Late Cretaceous and Cenozoic palynomorphs from the Scotian Margin were also undertaken, but did not encompass the Triassic to Lower Cretaceous interval. We are thus developing a comprehensive event-stratigraphic scheme for this earlier interval on the Scotian Margin based on palynology, integrated with paleoenvironmental changes and sequence stratigraphy. In addition to detailed taxonomic and event stratigraphic studies, we also aim to investigate the impact of varying paleoenvironmental conditions, including brackish environments and global stress events (e.g. Oceanic Anoxic Event 1a). Our main focus is on conventional cores (e.g. Panuke B-90, Cohasset A-52 and Alma K-85), aiming to develop a composite Lower Cretaceous section to avoid problems with down-hole sample contamination (caving). Nevertheless, we are also using cuttings from

deeper wells that penetrate pre-Cretaceous strata (e.g. Argo F-38, Bittern M-62, comprising a Triassic to Paleogene succession) to provide a broader context. The sedimentary facies and trace fossils at the base of the Panuke B-90 core indicate a transition from a shoaling marine to a mainly fluvial-estuarine setting, followed by a transgressive cycle through the Upper Mississauga Formation that culminates in normal marine environments again near the base of the overlying Naskapi Member (Logan Canyon Formation). This trend is supported by initial palynologic results from the base of the Upper Mississauga Formation that suggest a marginal marine depositional setting based on: abundant foraminiferal test linings and acritarchs, including *Leiosphaeridia* and *Nummus*; common records of the prasinophyte *Pterospermella*; presence of the freshwater alga *Schizosporis*; and low species richness and abundance of dinoflagellate cysts, with common *Subtilisphaera* spp. Furthermore, there is a general trend up section of increasing dinoflagellate cyst richness and abundance, with frequent occurrences of the areoligeraceans *Circulodinium distinctum* and *Tenua* spp., the ceratiaceans *Muderongia* spp. and *Pseudoceratium* spp., *Cribroperidinium* spp., *Druggidium rhabdoreticulatum*, *Kiokansium* spp., *Kleithrisphaeridium* spp. and *Oligosphaeridium* spp. (Plate I); the dinoflagellate cyst

assemblage indicates a neritic depositional setting. Terrestrial palynomorphs, such as the pollen *Araucariacites australis*, *Cerebropollenites macroverrucosus*, *Clavatipollenites* sp. and *bisaccates*, as well as the spores *Cicatricosisporites* spp., *Concavissimisporites* spp., *Deltoidospora* spp., *Dictyophyllidites* spp., *Gleicheniidites senonicus* and *Ruffordiaspora* spp. (Plate I), are also abundant and support a relatively proximal position for this well during the middle Early Cretaceous. These assemblages from the

lower part of the Panuke B-90 core (Upper Mississauga Formation) are typical of the Early Cretaceous, most probable Barremian. An Aptian age is expected for the overlying Naskapi Member based on previous studies and the presence of age-diagnostic ammonites such as *Deshayesites* sp. Ongoing work on this Lower Cretaceous core and coeval successions will contribute to a comprehensive event-stratigraphy framework for the Scotian Margin.

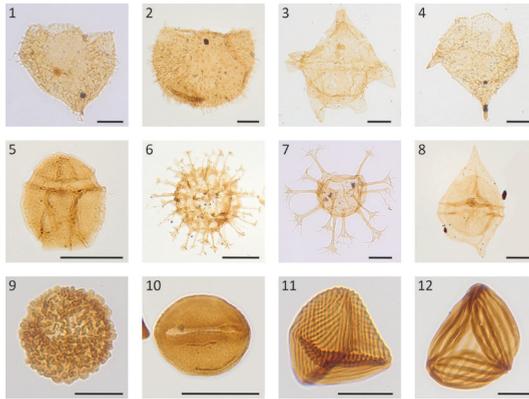


Plate I. Early Cretaceous dinoflagellate cysts and terrestrial palynomorphs from the Panuke B-90 core, Scotian Basin. The scale bar in all photographs represents 20 μm . 1. *Circulodinium distinctum*, sample P41403. 2. *Tenua anaphrissa*, sample P41398. 3. *Muderongia* sp. cf. *M. asymmetrica*, sample P41403. 4. *Pseudoceratium pelliferum*, sample P41403. 5. *Druggidium rhabdoreticulatum*, sample P41398. 6. *Kiokansium unituberculatum*, sample P41398. 7. *Oligosphaeridium* “complexpulcherrimum”, sample P41403. 8. *Subtilisphaera perlucida*, sample P41403. 9. *Cerebropollenites macroverrucosus*, sample P41400. 10. *Clavatipollenites* sp. Sample P41398. 11. *Cicatricosisporites* sp., sample P41400. 12. *Ruffordiaspora* sp., sample P41400.

Keywords: dinoflagellate-cys , Early Cretaceous, pollen, Scotian Margin, stratigraphy, spores



Evidence of a Pre-Albian Equatorial Humid Belt in the Southern Hemisphere

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Current view of the Gondwana Supercontinent suggests that it was dominated by arid environments during the Early Cretaceous. According to the so-called Supercontinent Effect, extreme temperatures and low humidity levels characterized the interior of the continent in pre-Albian times. This results from reconstructions of Cretaceous climatic zones that propose the establishment of a proto-Intertropical Convergence Zone (proto-ITCZ) or a Humid Equatorial Belt from the Albian. However, the large amount of data for these climatic reconstructions in the Northern Hemisphere and the little work carried out in the Southern Hemisphere (for example, Northeast Africa, Brazil and Colombia) tend to bias paleoclimatic interpretations. Recent work suggests that relatively humid climates occurred in the tropical landscapes of Gondwana in the late Aptian. Two hypotheses suggest distinct mechanisms as responsible for the appearance of humid conditions in these tropical contexts: the main marine transgressions resulting from the initial opening of the South Atlantic and the latitudinal displacement of the Equatorial Humid Belt (or proto-ITCZ). Based on evidence from palynological, ich-

nological and sedimentological data at low latitudes, this work aims to explain the onset of humid conditions at tropical latitudes in South America and Africa during the Aptian, suggesting the triggering mechanism. We analyzed sixty-five core samples from the São Luís Basin (Brazilian Basin), corresponding to equatorial paleolatitudes in the Aptian–Albian. Around 40 g of sediment were processed using standard methods for palynology; and up to 300 palynomorphs were counted for each sample. Comparison between these new data on the sporomorph genera richness with those published from African and South American basins allowed us to define a representative map of the variation of palynoflora in the Gondwana Supercontinent. For paleoclimatic interpretation, we used four indicators: palynological assemblages, sporomorph genera richness, relative abundance of reworked palynomorphs, and changes in sedimentary facies. We used principal component analysis (PCA) and the chi-square test to compare the proportions of pollen grains and spores between indicators of humid and arid paleoclimates. We grouped the result of sedimentary facies and ichnofabrics into four facies associations: epicontinental siliciclastic marine delta; siliciclastic restricted epicontinental sea; mixed restricted epicontinental sea; and epicontinental hypersaline sea. We recovered a diverse and abundant palynoflora with a dominance of gymnosperms, such as *Classopollis* spp., *Araucariacites* spp. and *Callialasporites* spp., and fern spores, *Cicatricosisporites* spp., *Leptolepidites* spp. and *Crybelosporites* spp., occurring at different stratigraphic levels in the studied succession. The shift in palynoflora to elements with humid climate preferences is reflected in the abrupt change from mixed to siliciclastic sedimentation (indicating greater fluvial input), increase in the relative abundance of reworked Paleozoic palynomorphs, and increase in the richness of genera of pollen grains and spores.

Principal component analysis clearly shows correlation between the genus *Classopollis* and hybrid sedimentation, while the genera *Araucariacites*, *Cicatricosisporites* and trilete spores are associated with siliciclastic sedimentation. Regarding marine palynomorphs, we recorded a peak in dinoflagellate cysts (genus *Subtilisphaera*). However, given increased humidity precedes this peak, we interpret that the first major marine transgression event associated with the proto-South Atlantic Ocean was not the main driver of late Aptian humid climates. Our data suggest that the southward shift of the Equatorial Humid Belt was coeval with variations in Earth's thermal asymmetry during the Ap-

lian, when inter-hemispheric temperature gradient substantially decreased. Previously published simulations of general circulation models have shown the relationship between Earth's thermal asymmetry and atmospheric circulation patterns, which corroborates the hypothesis that the latitudinal displacement of the proto-ITCZ would be the mechanism causing the inception, yet in the Aptian, of the Equatorial Humid Belt in the low latitudes of South America and Africa.

Keywords: Aptian, palynology, ITCZ, Gondwana



Evidencia de un Cinturón Ecuatorial Húmedo Prealbiano en el Hemisferio sur

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La visión actual del Supercontinente de Gondwana sugiere que este fue dominado por ambientes áridos durante el Cretácico Inferior. Según el llamado Efecto Supercontinente, las temperaturas *extremas* y los bajos niveles de humedad caracterizaron el inte-

rior del continente en épocas pre-albianas. Esto resulta de reconstrucciones de zonas climáticas del Cretácico que proponen el establecimiento de una Zona de Convergencia proto-Intertropical (proto-ITCZ) o un Cinturón Ecuatorial Húmedo a partir del Albiano. Sin embargo, la gran cantidad de datos para estas reconstrucciones climáticas en el Hemisferio Norte y los pocos trabajos realizados en el Hemisferio Sur (por ejemplo, el noreste de África, Brasil y Colombia) tienden a orientar las interpretaciones paleoclimáticas. Aun así, trabajos recientes, sugieren que climas relativamente húmedos acontecían en los paisajes tropicales de Gondwana a finales del Aptiano. Dos hipótesis han sido sugeridas como responsables de la aparición de condiciones húmedas en estos contextos tropicales: las principales transgresiones marinas resultantes de la apertura inicial del Atlántico Sur y el desplazamiento latitudinal del Cinturón Húmedo Ecuatorial. Basado en evidencia de datos palinológicos, icnológicos y sedimentológicos en bajas latitudes,

este trabajo tiene como objetivo explicar el inicio de las condiciones húmedas en latitudes tropicales de América del Sur y África durante el Aptiano, sugiriendo el mecanismo detonante. Se analizaron 65 muestras de núcleos de la Cuenca de São Luís (cuenca brasileña) correspondiente a las paleolatitudes ecuatoriales en el Aptiano–Albiano. Se procesaron alrededor de 40 g de sedimento usando el método estándar para palinología y se contaron hasta 300 palinomorfos por cada muestra estudiada. La comparación de estos nuevos datos de riqueza de géneros de esporomorfos con otros similares ya publicados de cuencas africanas y sudamericanas nos permitió definir un mapa representativo de la variación de la palinoflora en el supercontinente de Gondwana. Para la interpretación paleoclimática, utilizamos cuatro indicadores: asociaciones palinológicas, riqueza de géneros de esporomorfos, abundancia relativa de palinomorfos reelaborados y cambios en las facies sedimentarias. El análisis de componentes principales (CP) y la prueba chi-cuadrado fueron usados para comparar las proporciones de granos de polen y esporas, entre los indicadores de paleoclima húmedo y árido. El resultado de las facies sedimentarias y las icnofábricas se agruparon en cuatro asociaciones de facies: delta marino silicilástico epicontinental; mar epicontinental restringido siliciclástico; mar epicontinental restringido mixto; y mar hipersalino epicontinental. Se recuperó una palinoflora diversa y abundante con un dominio de gimnospermas, como *Classopollis* spp., *Araucariacites* spp. y *Callialasporites* spp., y esporas de helechos, *Cicatricosisporites* spp., *Leptolepidites* spp. y *Crybelosporites* spp., ocurriendo en diferentes niveles estratigráficos

en la sucesión estudiada. El cambio en la palinoflora a lo largo de la sección a elementos con preferencias climáticas húmedas se refleja en el cambio abrupto de sedimentación mixta a silicítica (lo que indica un mayor aporte fluvial), un aumento en la abundancia relativa de palinomorfos paleozoicos reelaborados y un aumento en la riqueza de géneros de granos de polen y esporas. El análisis de componentes principales muestra claramente una correlación entre el género *Classopollis* y la sedimentación híbrida, mientras que los géneros *Araucariacites*, *Cicatricosisporites* y esporas triletes están asociados con la sedimentación siliciclástica. En cuanto a los palinomorfos marinos, registramos un pico de quistes de dinoflagelados (género *Subtilisphaera*). Sin embargo, como los indicadores de humedad ocurren antes de este pico, interpretamos que el primer gran evento de transgresión marina asociado con el proto-Océano Atlántico Sur no fue el principal impulsor de la humedad en el final del Aptiano. Nuestros datos sugieren que el desplazamiento del Cinturón Ecuatorial Húmedo hacia latitudes más meridionales fue coetáneo con las variaciones en la simetría térmica del planeta durante el Aptiano, momento en el cual, el gradiente de temperatura inter-hemisférico disminuye sustancialmente. Simulaciones de modelos de circulación general han demostrado la relación entre la simetría térmica de la Tierra y los patrones de circulación atmosférica, lo que corrobora la hipótesis de que el desplazamiento latitudinal de la proto-ZCIT sería el mecanismo causante del surgimiento, aún en el Aptiano, de la Faja Ecuatorial Húmeda en las bajas latitudes de América del Sur y África.

Keywords: Aptiano, palinología, ITCZ, Gondwana



Aptian palynoflora of the Cerro Negro Formation, Snow Island, Antarctic Peninsula

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This work presents a study of the palynoflora of an outcrop located on Snow Island, in the Antarctic Peninsula. The Cerro Negro Formation is mainly composed by volcanosedimentary rocks containing fossilized plants deposited in a fluvio-lacustrine environment. The objective of the study was to document the Aptian palynoflora of Snow Island. The material studied (26 samples) was collected by the PALEOANTAR team during the 35th Antarctic Operation (OPERANTAR XXXV) and processed (40 g) following the standard technique for palynological analysis. In each sample, up to 300 palynomorphs were counted through transmitted-light optical microscopy. Diversity (Shannon-Wiener), dominance (Simpson) and equality

(Evenness) indices were applied to the palynoflora data through the PAST Software. A total of 5,504 specimens and 43 taxa were identified. Sporomorphs are abundant, prevailing representatives of ferns, lycophytes and bryophytes (33 species), followed by coniferous pollen grains with seven species. In terms of abundance and frequency in the analyzed section, the following spores stand out: *Ceratosporites equalis*, *Baculatisporites comauensis*, *Biretisporites* spp., *Cicatricosisporites* spp., *Cyathidites australis*, *C. minor*, *Deltoidospora hallii*, *Foraminisporis asymmetricus*, *Ischyosporites* spp., *Leiotriletes* spp., *Muricingulisporis annulatus*, *Ornamamentifera* spp., *Psilatriletes radiatus*, *Sotasporites elegans*, *S. triangularis*, *triletes*, *Undulatisporites pannuceus*, and *Verrucosisporites* spp. Among the conifers: *Alisporites bilateralis*, *Araucariacites* spp., *Podocarpidites* spp. and *Vitresisporites* spp. The described palynological association is very similar to the macroflora registered in the Lower Cretaceous of the South Shetland Islands, Antarctica. The section can be divided into two parts, the basal portion (up to ~3.9 m) characterized by a clastic facies association with predominance of mudstones, where the highest rates of diversity and equality of palynoflora are found. The upper portion (from ~3.9 m to the top ~30 m) is characterized by an pyroclastic facies association with the triletes group as dominant palynoflora. These results show a change in the behavior and preservation of the palynoflora towards the top of the section, which may be directly related to the incidence of subalkaline continental-arc rhyolitic volcanism, which occurred in the region during the Aptian. [CNPQ 407670/2013, 442677/2018-9].

Keywords: Aptian, palynoflora, Antarctica



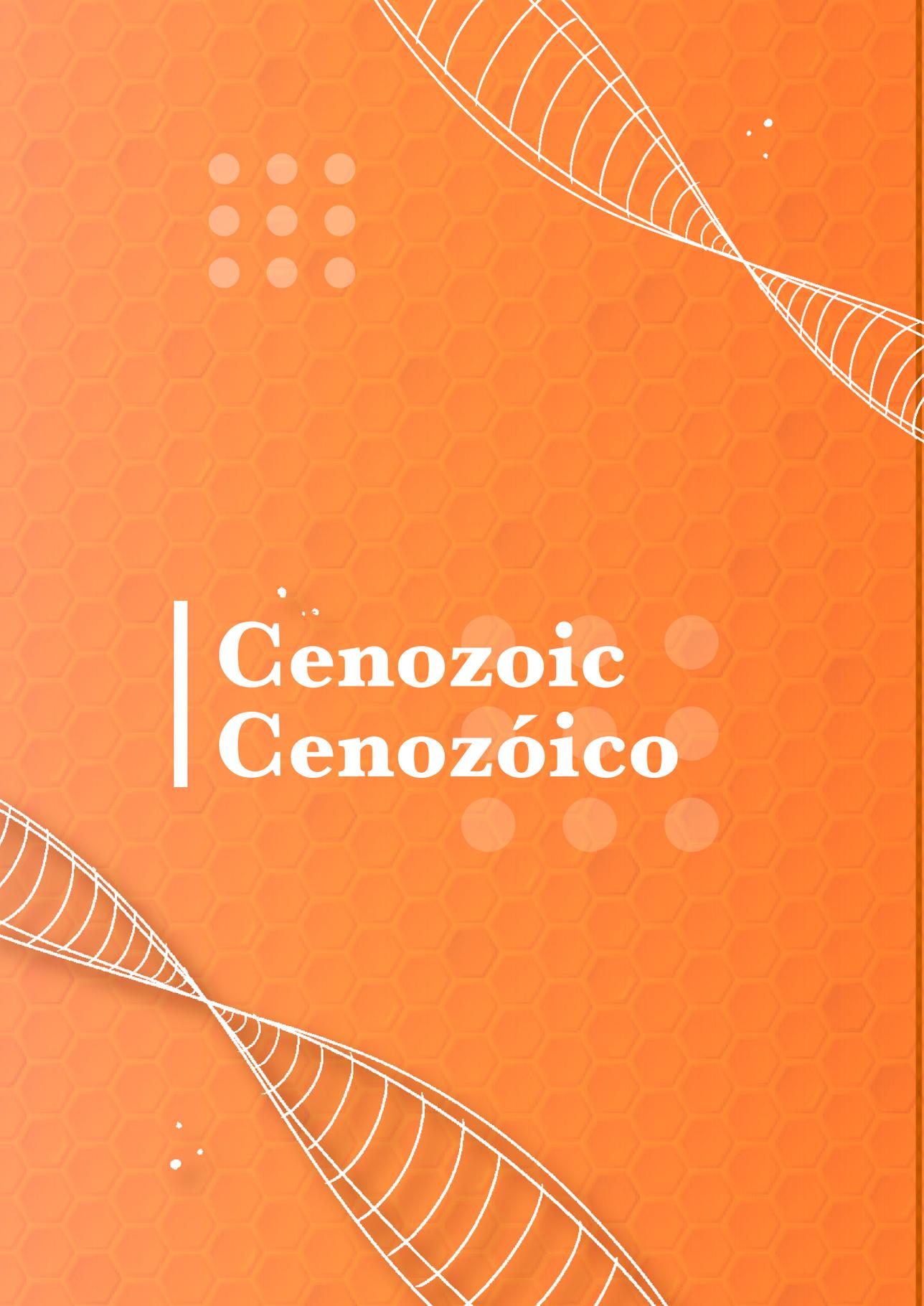
Palinoflora del Aptiano de la formación Cerro Negro, Isla Snow, Península Antártica

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Este trabajo presenta un estudio de la palinoflora de un afloramiento localizado en la Isla Snow, en la Península Antártica. La Formación Cerro Negro es compuesta principalmente por rocas volcanosedimentarias, conteniendo plantas fosilizadas, depositadas en un ambiente fluvio-lacustre. El objetivo del trabajo fue documentar la palinoflora del Aptiano de la Isla Snow. El material estudiado (26 muestras) fue colectado por el equipo PALEOANTAR, durante la 35ª Operación Antártica (OPERANTAR XXXV) e procesadas (40 g) utilizando la técnica estándar para análisis palinológica. En cada muestra fueron contados hasta 300 palinomorfos a través de microscopía óptica de luz transmitida. Fueron aplicados en los datos de la palinoflora, índices de di-

versidad (Shannon-Wiener), dominancia (Simpson) e igualdad (Evenness) a través del Software PAST. Fue posible identificar un total de 5,504 especímenes y 43 taxones. Los esporomorfos son abundantes, predominando los representantes de helechos, licofitas y briofitas (33 especies), seguidas por granos de polen de coníferas con siete especies. En términos de abundancia y frecuencia en la sección analizada, se destacan los siguientes esporos: *Ceratosporites equalis*, *Baculatisporites comaumensis*, *Biretisporites* spp., *Cicatricosisporites* spp., *Cyathidites australis*, *C. minor*, *Deltoidospora hallii*, *Foraminisporis asymmetricus*, *Ischyosporites* spp., *Leiotriletes* spp., *Muricingulisporis annulatus*, *Ornamentifera* spp., *Psilatriletes radiatus*, *Sotaspores elegans*, *S. triangularis*, *Triletes*, *Undulatisporites pannuceus* y *Verrucosisporites* spp. Entre las coníferas: *Alisporites bilateralis*, *Araucariacites* spp., *Podocarpidites* spp. e *Vitresisporites* spp. La asociación palinológica descrita es muy semejante a la macroflora registrada en el Cretácico Inferior de las Islas Shetland del Sur, Antártica. La sección puede ser dividida en dos partes, la porción basal (hasta ~3.9 m) caracterizada por una asociación de facies clástica con predominando de lodolitas, donde se presentan los mayores índices de diversidad e igualdad de palinoflora. La porción superior (desde ~3.9 m hasta el tope ~30 m) es caracterizada por una asociación de facies piroclástica con el grupo de los triletes como palinoflora dominante. Esos resultados muestran un cambio en el comportamiento y en la preservación de la palinoflora en dirección al tope de la sección, que puede estar directamente relacionado a la incidencia del volcanismo riolítico subcalcalino de arco continental, ocurrido en la región durante el Aptiano. [CNPQ 407670/2013, 442677/2018-9].



Cenozoic **Cenozóico**

Evolución del Sistema Pebas durante el Mioceno: una dinámica regida por el levantamiento Andino, los cambios en el nivel del mar y fuerzas astronómicas



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Durante el Mioceno (>23-11 Ma), en la Amazonia occidental se desarrolló el extenso humedal llamado “Lago Pebas”. La ocurrencia de dicho sistema ha ayudado a explicar parte de la biogeografía actual de la biota de los bosques amazónicos al “favorecer” o “impedir” el desarrollo de especies; sin embargo las causas de derivaron en su existencia no son plenamente comprendidas. Por mucho tiempo se ha propuesto que han sido la dinámica topográfica, el levantamiento andino y los avances marinos periódicos los principales controladores de la acumulación de sedimentos. Mas recientemente se ha sugerido que cambios cíclicos orbitales deben ser incluidos en la explicación de la dinámica del sistema Pebas.

Nuestra investigación se enfocó en el estudio de los sedimentos pertenecientes a la Sección Los Chorros (27,2 m; Rio Amazonas, Colombia) para identificar y caracterizar la presumida ciclicidad en el sistema Pebas durante Mioceno. Para esto, integramos datos litológicos, palinológicos, malacológicos y geoquímicos desde el enfoque de secuencias estratigráficas.

La evaluación de las secuencias bioestratigráficas señalan que la sucesión de sedimentos de la Sección Los Chorros refleja ocho series (ciclos) de paquetes de inundación-relleno influidos por los oblicuidad (41 k-años) que ocurrieron durante el periodo entre ~14.5 y ~13.8 Ma. Cada paquete inicia con una fase rápida de inundación inicial, muy influenciada por condiciones marinas durante la máxima expresión, la cual es seguida por una fase larga regresiva de relleno. El estudio palinológico permitió diferenciar la vegetación local, asociada a pantanos, de la vegetación regional cuyo origen se relaciona, ya sea, a los bosques Amazónicos no inundables de tierras bajas y/o a los bosques Andinos. La geoquímica de los sedimentos confirmó las fuentes locales y regionales de los sedimentos. A lo largo de la sección la evidencia de la influencia marinas se muestra intermitentemente. Los periodos de influencia marina son cortos y están reflejados por máximos en el polen de manglar (i.e. *Zonocostites ramonae* = *Rhizophora mangle*; *Z. costamaxilalongporatus* cf. *R. racemosa*) junto con restos de foraminíferos, dinoflagelados y moluscos costeros, y la disminución episódica en los biomarcadores de origen terrestres. Durante la posterior inundación, las condiciones lacustres imperaron y se vieron reflejadas por el desarrollo de algas (i.e. *Botryococcus* y *Pediastrum*), helechos flotantes (*Azolla*) y asociaciones de moluscos que señalan condiciones oligotróficas y eutróficas alternantes. El polen identificado igualmente permitió indicar la presencia de pantanos de palmas de Mauritiinae (i.e.

Grimsdalea magnaclavata y *Mauritiidites franciscoi*, aff. *Lepidocaryum/Mauritia*) acompañados de pastizales inmersos en una matriz propia de un bosque húmedo tropical diverso. Finalmente el polen identificado sugiere que la altitud alcanzada por los Andes (Cordillera Oriental Colombiana) estuvo en el orden entre 1000 y 3500 m s.n.m. y albergó especies de protoparamo (i.e. *Byttneripollis rugulatus* = *Polylepis-Acaena*, *Psilatriteles* aff. *pe-*

ruanus = *Jamesonia*, *Cyathidites typicus* = *Cyathea*, *Hamulatisporis* aff. *Huperzia polycarpus*, *Tetraletes* aff. *Sphagnum*).

De nuestra investigación se concluye que los cambios en la composición de la biota en el sector occidental de los bosques Amazónicos durante el Mioceno Medio estuvo controlado tanto por mecanismos geológicos como astronómicos.

In the Miocene (>23-11 Ma), the large wetland “Pebas Lake” developed in the western Amazonia. Its occurrence helped to explain current biogeographical models of the Amazonian biota, either by “favoring” or “hindering” certain species development. However, the causes that promoted its existence are not well understood. It has been proposed that the dynamic topography together with the Andean uplift and eustasy played a fundamental role in sediment deposition. More recently, orbital forcing has been proposed as another driver to be included to explain the Pebas system dynamic.

Our investigation focused on a multi-proxy analysis of sediments belonging to Los Chorros Section (27,2 m; Amazon River, Colombia) to identify and characterize the presumed cyclicity associated to the Pebas system during the Miocene. We integrated lithological, palynological, malacological and geochemical data from a sequence biostratigraphic perspective.

The biostratigraphic sequence evaluation indicates that the main sediment succession at Los Chorros Section is composed of eight flood-fill packages influenced by obliquity cycles (41 ka) between ~14,4 and 13,8 Ma. Each cycle started with a rapid initial flood with marine-influence condition, followed by a longer regressive infill phase. Palynological analysis allowed to differentiate lo-

cal vegetation associated to wetlands from regional vegetation, such as non-flooded Amazonian Forest or/and Andean Forest. Sediment geochemistry supported those local and regional sources of sediments. Along the record, marine influences are intermittent. Periods with marine influence are short-lived and related with maxima of mangrove pollen (i.e. *Zonocostites ramonae* = *Rhizophora mangle*; *Z.* “*costamaxilalongporatus*” cf. *R. racemosa*) together with foraminiferal test lining, dinoflagellate cysts, coastal mollusk species and an episodic decline in terrestrial biomarkers. During the flooding phase, lacustrine conditions prevailed and were reflected by occurrences of algae (i.e. *Botryococcus* and *Pediastrum*), floating ferns (*Azolla*) and mollusk assemblages that reflect alternating oligotrophic and eutrophic conditions. Pollen accumulation also indicates Mauritiinae palm wetlands development (i.e. *Grimsdalea magnaclavata* and *Mauritiidites franciscoi* aff. *Lepidocaryum/Mauritia*) mixed with grasses within a diverse tropical wet forest. Also, palynology suggests that the Andes (Eastern Cordillera of Colombia) reached between ~1000 and ~3500 m a.s.l and hosted protoparamo species (i.e. *Byttneripollis rugulatus* = *Polylepis-Acaena*, *Psilatriteles* aff. *peruanus* = *Jamesonia*, *Cyathidites typicus* = *Cyathea*, *Hamulatisporis* aff. *Huperzia polycarpus*, *Tetraletes* aff. *Sphagnum*).

Our investigation allows to conclude that biota composition changes during the Middle Miocene in the western sector of Amazon were controlled by geological and orbital forcing mechanisms.



Neogene palynology of the Lake Izabal Basin, Guatemala

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The Lake Izabal Basin is a deep and asymmetric pull-apart basin developed along the strike-slip North American and Caribbean plate boundary. This basin has accumulated a thick sediment cover (~4 km) since the late Miocene (~12 Ma). We report here the palynological analysis of 13 ditch-cutting samples spanning 650 m of mudstones from an industry well drilled in the eastern side of the basin in 1993. Outcrop observations correlated to industry seismic profiles indicate that the studied interval corresponds to the lower part of the Pliocene Herreria Formation and the uppermost part of the

Keywords: Amazonas, palinología, secuencia estratigráfica, incursiones marinas.

late Miocene Carboneras Formation We counted 2804 palynomorphs and identified 40 taxa including 27 angiosperm pollen, 8 pteridophyte spores, 2 gonyaulacoid dinoflagellate cysts, 2 algae and 1 gymnosperm pollen. The palynological assemblage is characterized by the abundance of *Laevigatosporites tibuiensis* and *Psilatriteles* spp., as well as the continuous presence of *Echiperiporites akanthos* (Alismataceae), *Malvacipolloides maristellae* (Malvaceae), *Monoporopollenites annulatus* (Poaceae), *Pediastrum simplex* (Hydrodictyaceae), *Podocarpites* spp. (Podocarpaceae) and *Rhoipites hispidus* (unknown affinity). The lowermost 150 m of the studied cuttings are restricted to the Tortonian based on the last occurrence of *Bombacidites nacimientoensis* (Malvaceae-Bombacoideae) at 1200 m and the extrapolation of a 12-My-old tuff deposited during the initial infill of the basin.

Keywords: Central America, pollen, spores, dinoflagellate cysts, Miocene, Pliocene



Palynological record of mangroves and sea level changes during the Miocene in the Colombian Caribbean

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The Colombian Caribbean has a sedimentary record ranging from the Upper Cretaceous to recent times. It has a wide variety of geological studies that have been supported by hydrocarbon exploration companies. Micropaleontology has mainly focused on the evaluation of marine deposits using calcareous microfossils. In contrast, there

is a few paleoecological and paleoenvironmental data from terrestrial palynological analyses, including pollen and spores. The ANH-Los Pájaros-IX stratigraphic well was drilled in the northern sector of the San Jacinto fold belt (CPSJ) by the Agencia Nacional de Hidrocarburos (ANH). It is a 1344' (410m) thick sedimentary succession, composed of greenish-gray mudstones, sandstones, conglomerates, and some coal beds. In the fine-grained deposits an abundant and well-preserved association of terrestrial and marine palynomorphs has been identified, such as: *Chicoriacidites longispinosus*, *Clavainaperturites microclavatus*, *Crassiectoapertites colombianus*, *Crassoretitriletes vanraadshooveni*, *Echiperiporites akanthos*, *Echiperiporites estelae*, *Echitricolporites spinosus*, *Fenestrites spinosus*, *Grimsdalea magnaclavata*, *Malvacipolloides maristellae*, *Multimarginites vaderhammenii*, *Nijsenosporites fossulatus*, *Perforitricolpites digitatus*, *Zonocostites ramonae* and *Tuberculodinium vancampoae*. This association indicates a middle-late Miocene age. Some levels of gray mudstones and coal beds present abundant percentages

of *C. vanraadshoovenii* (*Lygodium microphyllum*, an invasive fern from continental wetlands and coastal areas) and *Z. ramonae* (*Rizophora*, a tree abundant in the most waterlogged parts of the mangrove ecosystems). In addition, other stratigraphic levels present high frequencies of *G. magnaclavata* and *Mauritiidites franciscoi* var. *minutus* (morichal palms), which allows to interpret fluvial and coastal marsh environments in estuaries or tidally dominated deltas. The presence of dinoflagellates, foraminifera, escolocodons, *Botryococcus* sp., *Azolla* sp., among others, indicates fresh to brackish water in shallow marine environments. Statistical analyses (e.g., DCA, DFA) reveal a correlation between presence and abundance of some palynomorphs and the sedimentary environment. Thus, variations in palynomorph assemblages allow to interpret changes in shoreline configuration and/or relative sea level, highlighting at least two intervals of shallow marine environments and a general marine regressive trend towards the top of the studied sequence.

Keywords: Palynology, Colombian Caribbean, Mangroves, Shallow marine, Middle-Late Miocene.



The palynology of the Red Sea Basin, SE Sudan

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This paper presents the first palynological results from subsurface strata of Red Sea Basin, succession of intercalated sandsto-

nes and mudstones in eastern Sudan marl and evaporites.

Although the recovered palynomorphs are overwhelmingly of terrestrial origin, rare brackish water dinoflagellates cysts, freshwater algae and fungal spores were encountered. Based on the stratigraphic distribution of selected pollen and spores from two exploration wells, three informal Assemblage palynozones from late Oligocene to early Pliocene are proposed. The identified zones, in ascending order, are: Assemblage Zone I (Late Oligocene to Early Miocene),

Assemblage Zone II (Middle Miocene) and Assemblage Zone III (Late Miocene to Early Pliocene). The assigned ages are based on stratigraphic positions and a series of first down hole appearances of key species such as *Bombacacidites noremii*, *Bombacacidites nacimientoensis*, *Malvacearumpollis estelae*, *Margocolporites Vanwijhei*, *Corsinipollenites jussiaeensis*, *Cicatricosisporites dorogensis*, *Tricolpites neogenicus*, *Laevigatosporites javanicus*, *Verrucatosporites usmensis*, *Bombacacidites noremii* correspond to Assemblage Zone (I). *Polypodiaceoisporites simplex*, *Pteridacidites africanus*, *Polypodiaceoisporites tumulatus*, *Polypodiisporites speciosus*, *Polypodiaceoisporites vancampoi*, *Polypodiaceoisporites simplex*, Assemblage Zone (II). *Osmundacidites cf. inaequalis*,

Matonisporites rarus, *Chenopodipollis chenopodiaceoides*, *Chenopodipollis microporatus* are characteristic for Assemblage Zone (III). The palynoforal and bontical affinities give an indicator for paleoclimate and paleoenvironment where Low land forests Swamps herbs fobs, Open aquatic environment (*Pediastrum Lacustrine*) demonstrate during Late Oligocene to Early Miocene, the existence of *Dennstaedtiaceae* family indicate the tropical to subtropical to tropical temperate, this suction is overlain by coastal and swamps vegetation *Schizeaceae* which pointed to tropical paleoclimate during the Mid Miocene. Moving to late Miocene to Early Pliocene the tropical or subtropical to aired climate prevailed as have been indicated from grass vegetation.

Keywords: Palynology, upper Paleogene, Neogene Red Sea Paleoenvironment and Paleoclimate



Multi-proxy evidence of Caribbean-sourced marine incursions in the Neogene of Western Amazonia, Brazil.

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The timing of continental-scale marine flooding events in Western Amazonia during the Neogene is still an unsolved question. Despite broad proxy-based evidence of such events, the pathways and duration of late Miocene marine incursions remain controversial. We provide coupled calcareous and organic microfossil and geochemical data from six onshore cores from Neogene sequences of the Solimões Basin, Brazil. Our records support minor marine influence in the early Miocene (23.0, 21.1, 18.6, and 16.3 Ma), middle Miocene (14.9, 13.7, and 12.9 Ma) and early Pliocene (4.7, 4.2–4.1, and 3.8 Ma), and conspicuous marine incursions in the late Miocene (11.1–8.8 Ma) suggested by the consistent presence of salinity-indicative microfossils and geochemical data. Our findings challenge the view of major marine incursions in the early and middle Miocene in the studied area. We propose for the first time a new late Mioce-

ne incursion (LMI) event as the main marine flooding event in Western Amazonia during the Neogene. These onshore records are compared with three offshore cores from the Atlantic and Pacific Oceans. The similarity between microfossil assemblages of the Solimões Basin and the Caribbean Sea, and evidence of increased runoff from the Ori-

noco river drainage system, strongly suggest the Caribbean Sea as the primary source area of the marine incursions, supporting a Venezuelan seaway. We further show for the first time the potential linkage between Neogene marine incursions (mainly the LMI) into the Solimões Basin and major disturbances in the global carbon cycle.

Keywords: Western Amazon, Neogene, marine microfossils, Miocene



Evidencia de incursiones marítimas con origen en el Caribe en el Neógeno de la Amazonía Occidental, Brasil

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El momento de los eventos de inundaciones marinas a escala continental en la Amazonía occidental durante el Neógeno continúa siendo un problema sin resolver. A pesar de la amplia evidencia basada en proxy de tales eventos, las rutas y la duración de las incursiones marinas del Mioceno tardío siguen siendo controvertidas. Proporcionamos datos de microfósiles (de pared orgánica y calcáreo), y geoquímicos de seis núcleos te-

restres de secuencias neógenas de la cuenca de Solimões, Brasil. Nuestros registros respaldan una menor influencia marina en el Mioceno temprano (23.0; 21.1; 18.6 y 16.3 Ma), Mioceno medio (14.9; 13.7 y 12.9 Ma) y Plioceno temprano (4.7; 4.2-4.1 y 3.8 Ma), y se observaron incursiones marinas evidentes que fueron registradas al final del Mioceno (11.1-8.8 Ma) sugerido por la presencia constante de microfósiles indicativos de salinidad (un quiste de dinoflagelados, palinoforaminíferos, foraminíferos planctónicos y ostrácodos marinos) y datos geoquímicos. Nuestros hallazgos desafían la visión de grandes incursiones marinas del Mioceno temprano y medio en el área de estudio. Este trabajo propone por primera vez un nuevo evento de incursión del Mioceno Tardío (LMI) como el principal evento de inundación marina en la Amazonía Occidental durante el Neógeno. Los registros encontrados en la Amazonía occidental se comparan con tres núcleos offshore en los océanos Atlántico y Pacífico. La similitud entre los grupos de microfósiles de la cuenca de Solimões y el mar Caribe, y la evidencia de un aumento del caudal del sistema de drenaje del río Orinoco, sugieren fuertemente que el mar Caribe es el área de origen principal

para las incursiones marinas, lo que sustenta un mar venezolano (Fig. 1). También mostramos por primera vez el vínculo potencial entre las incursiones marinas del Neógeno

(principalmente LMI) en la cuenca de Solimões y las principales perturbaciones en el ciclo global del carbono.

Palabras clave: Amazonía Occidental, Neógeno, microfósiles marinos, Mioceno



Middle Miocene (Serravallian) wetland development in central England

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The Miocene was identified as an interval of interest in the recent IPCC AR6 report as a geological analogue for middle-late 21st century anthropogenic climate change. The Brassington Formation, Derbyshire, is the most extensively studied of three onshore UK sites that contains a Miocene-age fossil flora. Previous palynostratigraphy has identified that the Kenslow Member is diachronous in age. Of the outcrops that still exist, the Kenslow Top Pit outcrops are dated to the Tortonian, whilst the Bees Nest outcrop is dated to the Serravallian. The Serravallian is an interesting interval to investigate terrestrial environments of northwest Europe - against a background of global tem-

perature declines and increased aridity, the regional climate of northwest Europe remained warm and humid, likely caused by the Atlantic Meridional Oceanic Circulations. Despite this regional significance, the Serravallian Kenslow Member has only ever been studied using plant palynology from grab samples. Here we present the first continuous sequence of palynology through the Serravallian Kenslow Member at Bees Nest Pit.

Reconstruction of two identified pollen zones showed a mixed mesophytic forest with an evolving wetland palaeoenvironment. Through high-resolution sampling, it has been possible to explore the changing wetland ecology. We propose a fallen tree influenced the depositional environment and created a forest hollow, which allowed for limited lignite preservation. Co-existence approach-based palaeoclimate reconstructions produced ranges of Mean Annual Temperature (15.7-18.4 °C) and Mean Annual Precipitation (1096- 1372 mm) with no variations across the stratigraphy outside of uncertainty ranges, inferring a relatively short depositional period. Overall, the sequence shows the impact of a flat latitudinal temperature gradient in the North Atlantic during this time interval.

Keywords: Serravallian, climate change, pollen, vegetation, warm temperate, British Isles, Europe



Volkheimerites
labyrinthus, a new striate
angiosperm pollen
from the Paleogene of
Patagonia, Argentina

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The profile containing the specimens of the new angiosperm pollen grain crops out at Quebrada Barone (43°50'30"S and 67°54'25"W), in the Cañadón Carbón area, Chubut Province (Patagonia, Argentina). The sedimentary sequence is approximately 12 m thick, composed of finely laminated shales interbedded with siltstones and fine sandstones. Fourteen samples were collected for palynological analysis but only one had relevant palynological content (good preservation and number of grains). The remaining samples were rich in organic matter (amorphous and opaque phytoclasts) but devoid of palynomorphs. The sample level is located 8.5 m above the upper beds of the underlying Lonco Trapial Formation. The detailed description of this new angiosperm taxon expands the knowledge of the Paleocene palynofloral diversity in Patagonia. Combined light (LM) and high-resolution scanning electron microscopy (SEM) analyses were done to provide a detailed description of the 24 specimens of *Volkheimerites labyrinthus* gen. et sp. nov. (Fig. 1. A–D). The generic epithet honors Dr. Wolfgang Volkheimer (1928–2018; Fig. 1. E), a renowned German-Argentinian palynologist who carried out vast research in Mesozoic and Cenozoic basins from Argentina, and who first illustrated specimens of this species from another locality,

leaving them with an open assignment. The specific epithet refers to the characteristic labyrinthine pattern of the ornamentation.

The grain is oblate with circular-subcircular outline in polar view; semicircular to ellipsoidal in equatorial view; without defined aperture. Medium to large in size (25.5–55 µm). The presumed distal face is striate, with the muri forming a labyrinthine or dichotomous-radiate pattern. The muri are 1–1.8 µm wide in polar view, broad and rounded. The exine is semitectate. Nexine up to 0.8 µm thick. Columellae 0.5–1.5 µm in diameter; irregularly spaced, 0.8–1.8 µm high. Tectum 1–1.8 µm high. The large circular opening on the presumed proximal face corresponds to the thinning of the exine, that is generally torn or absent.

Volkheimerites labyrinthus shares the presence of a coarse semitectate tectum supported by columellae with the fossil genera *Dichastopollenites* (Nymphaeaceae), *Trisectoris* and *Periretisyncolpites* (Schisandraceae), and with some Winteraceae and Annonaceae species, but differs in having striate-labyrinthine or dichotomous-radiate as opposed to a reticulate ornamentation. *Volkheimerites* is also distinctive by the occurrence of solitary grains (monads) instead of the more frequent presence of tetrads in the Winteraceae family or grains separated into two hemispheres as in *Dichastopollenites*. The large thin area of the exine appears to be morphologically analogous to the proximal thinning of the exine in the monads making up the tetrads as occurs in some Annonaceae species. Despite the morphological traits shared with the described genera and families, *Volkheimerites labyrinthus* could not be assigned a botanical affinity, probably consisting of an extinct taxon not closely related to any extant family.

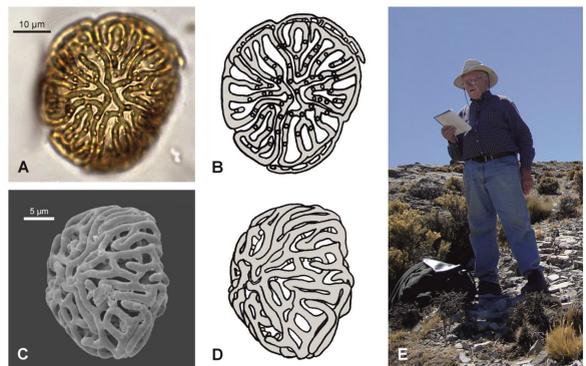


Fig. 1. *Volkheimerites labyrinthus* gen. et sp. nov. A B. Specimen in polar view showing the striate labyrinthine sculpture and cross section of the columellae visible through the muri, A. LM, B. Schematic drawing of A; C D. Specimen in lateral view

showing the characteristic striate labyrinthine sculpture, C. SEM, D. Schematic drawing of C; E. Dr. Wolfgang Volkheimer during fieldwork in 2007 (Neuquén Basin, Argentina). Source: P. Narváez.



Terrestrial palynomorph diversity within the deepwater Wilcox Group, Alaminos Canyon, Gulf of Mexico

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The analysis of marine and terrestrial palynomorphs is often used in the reconstruction of paleoclimates, to narrow down sources of sediment in particular drainage areas, and in building biostratigraphic zonations used in biosteering. Biosteering is a high-resolution biostratigraphic technique that can be critical in the exploration of reservoirs. It involves real-time monitoring during the drilling of a borehole to determine the position of the drill bit within the reservoir interval. Biosteering requires the use of pre-established biozonation schemes constructed from palynofacies. The current project aims at creating such a biozonation for deep wells in the northwestern Gulf of Mexico by building a biozonation using a deepwater well from the Alaminos Canyon block (AC 857#1) donated by Royal Dutch Shell to the Center for Excellence in Palynology (CENEX). This well penetrates the Paleogene Wilcox Group sediments, and while the palynology of the onshore Wilcox Group is fairly well documented, the deepwater palynology is largely proprietary. Preservation of calcareous microfossils, like nannofossils and foraminifera, is also often poor in the deepwater Wilcox Group, but palynomor-

phs are well preserved and should allow the development of a deepwater palynological biostratigraphy with important practical applications in the Gulf of Mexico, in addition to providing paleoclimate and paleobotanical insights. Ditch cuttings from this well with measured depths between 4000 m and 5200 m were processed into 128 samples. Pollen, spore and dinoflagellate cyst assemblages from these samples are currently being identified and tabulated, and the botanical affinities used to reconstruct the paleoclimate. Key species recovered and dominating the assemblages include Intratriporopollenites (Tiliaceae), Betulaceae/Myricaceae types, Caryapollenites (Juglandaceae), and Momipites (Juglandaceae). The dinoflagellate Apectodinium, a classic marker for the Paleocene-Eocene Thermal Maximum, has also been found in the Paleocene samples. Thus far, early Eocene samples appear to have a greater diversity in palynomorphs when compared to the Paleocene samples. The presence, absence, and abundance data of these organic-walled microfossils will be used to construct a biozonation scheme, employing mostly pollen and spores, but also with a limited focus on dinoflagellate events. The palynomorph assemblages observed will be compared to previous onshore palynological studies of the Wilcox Group in order to provide a deeper understanding of these preliminary observed changes in palynomorph diversity. This study will provide one of the first nonproprietary palynological analyses of deepwater Wilcox Group sands, improving stratigraphic control for ongoing and future Gulf of Mexico exploration.

Keywords: Angiosperm pollen grain, Salamanca Formation, Paleocene, Argentina

Keywords: Paleogene, Wilcox Group



Neogene reconstruction of terrestrial environments from the Peruvian Desert

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The Pisco East Basin, located on the central Peruvian coast (12-16°S), has yielded abundant and diverse fossil remains, allowing the study of past coastal-marine faunas and environments. By contrast, the continental settings remain virtually unknown given the lack of evidence. Recent excavations carried out by our group unearthed well-preserved plant remains, including leaf impressions, petrified wood, and pollen assemblages from two Miocene localities associated with the Pisco Fm. These floral remains correspond to the earliest known Neogene evidence of plant communities living along the central Peruvian coast, where a vast hyper-arid desert exists today (i.e., the northern limit of

the Atacama Desert). Fossils were deposited between 12 and 8 million years ago when the Central Andes had lower heights (~2000-2500 masl) and the Earth experienced a greenhouse climatic regime. Newly discovered plant material will be essential for characterizing the composition of ancient floral communities, assessing past climatic conditions, and gaining insights into the evolution of modern xeric landscapes in relation to the Andean uplift, the Miocene greenhouse climate, and the progressive Pliocene cooling. Plant remains are being used as indicators of taxonomic diversity, while fossil leaves are used as estimators of precipitation. Preliminary results indicate the presence of a plant community formed by abundant savanna elements, with diversity patterns higher than those observed in modern xeric biomes at similar latitudes. Our estimates indicate that Miocene precipitation values varied around 500 and 800 mm/yr, which are significantly higher than current values of ~50 mm/yr. These estimates indicate the presence of a wetter and warm coastal climate, suggesting a different hydrological regime along the central Peruvian coast.

Keywords: Atacama Desert, Peruvian coast, Xeric landscapes, Miocene, Pollen



Fungi in a Warmer World: evaluating fungal biodiversity during the Miocene Climatic Optimum in Southern McMurdo Sound

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Fungi play a key role in ecosystems; many are cosmopolitan, but several taxa have distinctive geographical distributions due to climate and host availability. Although they are often overlooked in deep-time palynological preparations, their study in the fossil record is key to better understanding their role in past ecosystems under different climate conditions. Fungal remains are generally deposited close to the source, providing an accurate record of local environmental conditions at the time of deposition. Some fungi have very narrow environmental preferences, such as temperature, humidity, rainfall, and pH. The Miocene Climatic Optimum (MCO) is considered an excellent analogue for future global climate (Steinthorsdottir et al. 2021). Thus, the *Fungi in a Warmer World* (FiaWW) project is developing a global dataset of fungal diversity and distributions from different sites representative of the MCO worldwide.

Here we present the fungal study results from the ANDRILL (Antarctic geologic drilling program) 2A core recovered from the southern McMurdo Sound in western Ross Sea, Antarctica. Marine, freshwater, and terrestrial palynomorphs previously analyzed suggest a relatively short period of time during the peak of the MCO in which the area became suddenly much warmer, with summer temperatures reaching at least 10°C (Warny et al. 2009), and moisture delivery to the Antarctic coast substantially increased (Feakins et al. 2012). Our preliminary results from the ANDRILL 2A newly acquired fossil fungal record show that fossil fungi are low in diversity and vary in opacity and deterioration throughout the MCO. Amerospores are the most common morphotype found, and the presence of fungal spores without septa could indicate local humid conditions. We used the CREST method (Climate Reconstruction Software) to re-evaluate the pollen and spore record to provide new paleoclimatic reconstructions. These new CREST analyses provide a maximum mean annual temperature of 10.3°C and a mean annual precipitation of 1147 mm for the warmest intervals of the MCO. These parameters are consistent with but add precision to the findings published by Warny et al. 2009 (based on the climatic distribution of *Nothofagus*, the most abundant remaining plant during the MCO in the Ross Sea) and Feakins et al. 2012 (based on modeling of hydrogen isotopic data extracted from leaf waxes). Results from this work will aid in determining the impact an increase in global temperatures would have on modern fungi in glacial environments.



Late Oligocene plant communities (San Gregorio Formation) in Baja California Sur, Mexico

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The San Gregorio Formation was deposited while Baja California was attached to the Mexican mainland block. In general, the stratigraphy of the San Gregorio Formation from bottom to top is characterised by three lithofacies: 1) a phosphatic-volcanic conglomerate facies, 2) a tuff unit with diatomaceous and phosphatic facies at different stratigraphic levels and 3) a widely distributed siliceous shale unit with calcareous and phosphorite facies. The San Gregorio Formation was deposited in a shallow-marine environment. Since the sediments exhibit almost no lateral variation, they may have been deposited in a forearc basin with active volcanism during a slow marine transgression. Although the global cooling climate change that triggered the Antarctic continental ice-sheet expansion characterised the greater part of the Oligocene, a climatic warming trend that promoted Antarctic ice reduction has been documented for the late Oligocene (26-27 Ma), during which part of the San Gregorio Formation was deposited. As part of PAPIIT-DGAPA project IN-109920 from Universidad Nacional Autónoma de México, 116 core samples from San Gregorio Formation (core LB1) were processed for palynology using standard methods, 42 of them yielded well-preserved marine and terrestrial palynomorphs. The complete palynological assemblages

were analysed in order to define palynozones, with special emphasis in the analysis of terrestrial palynomorphs, which give important information about plant communities. Marine palynomorphs dominated the associations (e.g. dinocysts, acritarchs and copepod eggs) and allowed us to constrain a late Oligocene age for the San Gregorio Formation in core LB1, based on the occurrence of the dinocysts *Chiropteridium lobospinosum* and *Tuberculodinium vancampoeae*.

Spores and pollen grains, despite being transported from the continent, reflect the composition of plant communities that evolved near the depositional area (coastal vegetation), as well as that of the uplands (regional vegetation). Within the terrestrial assemblages (Figure 1), the dicotyledonae: Anacardiaceae type, *Chenopodipollis* spp., *Brossipollis* spp., Euphorbiaceae type, Fabaceae type, *Quercoidites* sp., Polygonaceae type and Sterculiaceae type were more abundant than monocotyledonae (e.g. *Liliacidites* spp. and *Graminidites* sp.). The analysis of pollen-spore assemblages gave evidence of two temperate highland communities: Pinus forest and cloud forest. Pinus ecosystem was represented at the top of palynozone A, in the middle part of palynozone B, as well as in palynozone C. Cloud forest was relevant in palynozone A, and palynozones C and D. Moreover, representatives of the local semi-arid vegetation (*Brossipollis*, *Chenopodipollis*, *Ephedripites* and *Graminidites*), growing throughout a palaeoaltitudinal gradient from the uplands down to the shoreline, such as chaparral, tropical deciduous forest, coastal grassland and coastal dune also occurred. On the other hand, *Brossipollis* spp. (*Bursera* spp.), *Acaciapollenites* sp., *Margocolporites* spp., *Liliacidites*, *Tubulifloridites*, Cactaceae type and Polygonaceae type, alongside Fabaceae type, Malpighiaceae type, Meliaceae type, Onagraceae (*Corsinipollenites* and *Corsinipollis*), Polemoniaceae type, Polygonaceae type, Rosaceae type, Rubiaceae type, Sterculiaceae type and Tiliaceae type among

others may be part of tropical deciduous forest. Although taxa of this semiarid vegetation were present throughout all core LB1, they were more relevant in palynozone C. Besides, coastal dunes and grassland vegetation represented by *Ephedripites*, *Graminidites* and *Chenopodipollis*, were highly represented in palynozones A, C and D. Additional components of coastal dune flora were Euphorbiaceae type, Labiatae type, Malvaceae type, and Rubiaceae. The abundance of *Chenopodipollis* spp. could be linked to a specific plant association developed in salt marshes similar to the monospecific communities

of Amaranthaceae with high salt tolerance present today in Baja California peninsula ecosystems. Terrestrial taxa richness varied between 5 and 57, the diversity index ranged between 1.2 and 3, and evenness oscillated between 0.4 and 1. Four palynozones were defined after a CONISS statistical analysis of terrestrial and marine palynomorphs. In summary, Amaranthaceae (*Chenopodipollis*), *Bursera* (*Brossipollis*), *Ephedra* (*Ephedripites*) and Gramineae (*Graminidites*) lineages confirm semiarid local conditions during the sedimentation of the SGF.

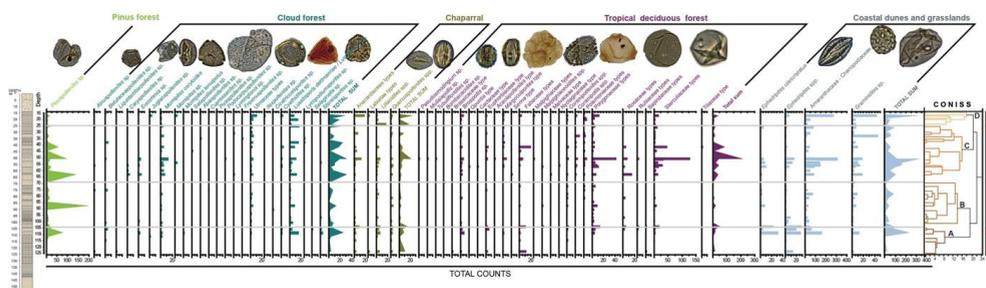
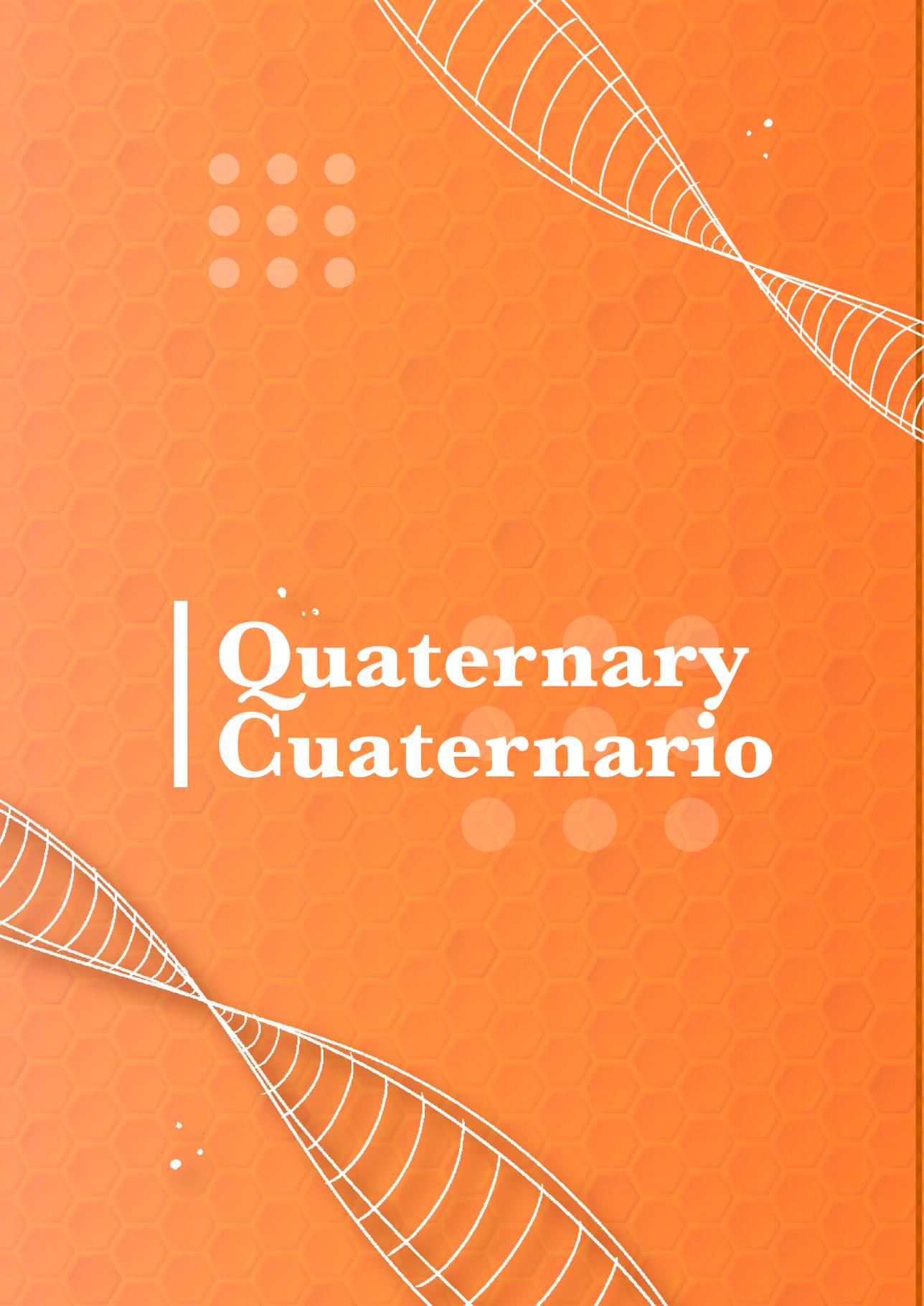


Figure 1. Temperate and semiarid upper Oligocene plant communities. Palynozones are defined from marine and terrestrial assemblages yielded from borehole LB1- San Gregorio Formation.

Keywords: palynostratigraphy, upper Oligocene palynoflora, San Gregorio Formation, Paleogene, semiarid plant communities



Quaternary Cuaternario



Palaeoenvironmental reconstruction of two lost harbors in northern Belgium: Hoeke and Sint Anna ter Muiden

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The extreme flooding of 1134 in northern Belgium led to the incision of a large tidal inlet, the Zwin. Afterwards, man reclaimed the landscape via the massive construction of dikes and canals. The region of Bruges, connected to the sea via a network of outer ports, became a major axis of maritime circulation. However, after its heyday, due to the collapse of the economy and the silting up of the Zwin, the harbors fell in disuse and disappeared. A multidisciplinary project now aims to reconstruct the Roman to Medieval environment in all its aspects. Palynological analysis are carried out to reconstruct the local palaeoenvironment of the disappeared harbors.

At the lost harbor Hoeke, 14 samples were analysed. The pollen record of the peat at the base of the outcrop shows a dominance of tree and shrub pollen (97%), i.e. a regional signal dominated by *Corylus avellana*, *Quercus robur* and *Alnus*. *Sphagnum* is also frequent. In the marine deposits overlying the peat, the tree signal remains dominant (78%), but also saltmarshes taxa (a.o. *Chenopodiaceae*), marine input (a.o. dinocysts) and freshwater input (a.o. *Pediastrum*) is recorded. A natural coastal environment is thus present at Hoeke.

More to the east at Sint Anna ter Muiden, 12 samples from an embankment section

were analysed. The pollen record in the lower clayey fine-grained sand layers holds similar taxa to those recorded in the upper coastal layer at Hoeke. The above-lying slightly clayey silt layer holds a large amount of shells and shell fragments. In addition to coastal taxa and trees from the hinterland, the herbs *Asteraceae liguliflorae* and *Brassicaceae* as well as *Sphagnum* become abundant. Towards the top layer, the number of shells decreases and the signal of herbs increases including a marked presence of anthropogenic taxa (a.o. *Cerealia*-type). These deposits represent clearly an embankment made of clay sods and a waste layer.

In addition, 22 samples from a lower lying waste layer and a subjacent coastal deposit were also analysed. The lower fine-grained coastal sand layer shows a regional signal dominated by *Corylus*, *Quercus* and *Alnus*. Moreover, on the one hand we observe a freshwater signal with the presence of trees (a.o. *Salix*), aquatic plants (*Sparganium* type, *Cyperaceae*) and freshwater algae (a.o. *Pediastrum* and *Mougeotia*). On the other hand, a marine signal is recorded through the presence of trees (*Pinus* and *Saccates*), saltmarshes herbs (a.o. *Chenopodiaceae* and *Plumbaginaceae*), aquatic plants (*Potamogeton* type) and other marine elements (a.o. acritarchs and foram linings). The monolete psilate spores and *Sphagnum* are also abundant. In the upper silty clay layer, the herbs are dominant in the pollen sum (72%) and together with fungal spores indicate the presence of an anthropogenic layer. These samples reflect the evolution from a natural coastal environment to an embanked environment.

Keywords: Roman/Medieval Age periods, tidal inlet, embankment, coastal deposits, palynology, Zwin; Belgium



Evidence of the “Anthropocene” in the Lozoya Valley, Spain

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The high-resolution pollen analysis of a core from a hygro-peat formation of periglacial origin located in the municipality of Rascafría (Valle del Lozoya, Madrid) has allowed us to reconstruct the dynamics of plant communities and the anthropogenic impact of the last 2455 \pm 60 BP. The Holocene pollen records allow us to interpret the transition from more or less forested conditions, characterized by the profusion of pine and oak groves, as well as other elements such as birch, to the progressive installation of an open forest environment and the proliferation of landscape units related to the environment anthropization. A paleo-landscape of perennial grasslands dedicated to transhumant and transterminant livestock activities defines different levels of anthropic pressure. In particular, it has been determined that the first clear events of anthropization and deforestation of the forests of the Lozoya Valley occurred during the III millennium cal. BC and that the current physiognomy of the landscape in the

area is the same since the Middle Ages. Both pollen and non-pollen palynomorphs have been used as diagnostic tools of anthropogenic impact. The pollen records RAS show how the impact of humans on past landscapes was especially important during the Iron Age, giving rise to the predominance of ruderal and anthropozoogenic anthropogenic formations linked to the transterminating livestock movement towards the summer pastures of the high Guadarrama's mountains. The growth of Madrid in the XVII and XVIII centuries A.D. caused the need for a continuous supply of raw materials, wood, granite for the paving of the streets, coal, food and even ice, all of them coming from the mountain areas. At the beginning of the 19th century A.D. it is perceived that the Sierra de Guadarrama has been subjected to continuous exploitation for centuries, forestry and livestock, and that its condition worsens with the need for raw materials and food demanded by the capital, so it becomes imminent to undertake measures for the protection and management of the forest, being in this century when its reforestation takes place. Mentioning precisely these reforestation activities, the pollen diagram of Rascafría clearly shows the increase of *Pinus sylvestris* type, at a date immediately after 50 ± 40 BP, that is, most probably between 1800-1930 cal. AD, coinciding with the reforestation law that started in 1877.

Keywords: Roman/Medieval Age periods, tidal inlet, embankment, coastal deposits, palynology, Zwin; Belgium



Evidencia del “Antropoceno” en el Valle del Lozoya, España

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El análisis polínico de alta resolución de un testigo obtenido en una formación higróturbosa de origen periglacial situada en el término municipal de Rascafría (Valle del Lozoya, Madrid) ha permitido reconstruir la dinámica de las comunidades vegetales y el impacto antrópico de los últimos 2455 \pm 60 BP. Los registros polínicos holocenos permiten interpretar el tránsito desde unas condiciones más o menos forestales, caracterizadas por la profusión de pinares y melojares, así como de otros elementos mesófilos como el abedul, a la instalación progresiva de un medio forestal abierto y la proliferación de unidades de paisaje relacionadas con la antropización del medio. Un paleopaisaje de pastizales vivaces dedicados a actividades ganaderas trashumantes y transterminantes define diferentes niveles de presión antrópica. En particular, se ha podido determinar que los primeros eventos claros de antropización y deforestación de los bosques del Valle del Lozoya ocurrieron durante el III milenio cal. BC y que la fisionomía actual del paisaje en el área es la misma desde la Edad Media.

Los palinomorfos tanto polínicos como no polínicos han sido utilizados como herramientas de diagnóstico del impacto antrópico.

Los registros polínicos de RAS, muestran cómo el impacto del ser humano sobre los paisajes pretéritos fue especialmente importante a lo largo de la Edad de Hierro, dando lugar a la predominancia de formaciones antrópicas ruderales y antropozoógenas vinculadas con el trasiego ganadero de tipo trasterminante hacia los pastos estivales de la alta montaña guadarrámica. El crecimiento de Madrid en los siglos XVII y XVIII d.C. ocasionó la necesidad de un aporte continuo de materias primas, maderas, granito para el empedrado de las calles, carbón, alimentos e incluso hielo, procedentes todos ellos de las zonas serranas. A principios del siglo XIX d.C. se tiene la percepción de que la Sierra de Guadarrama lleva siglos siendo sometida a una explotación continuada, forestal y ganadera, y que su estado empeora con la necesidad de materias primas y alimentos que demanda la capital, por lo que se hace inminente acometer medidas de protección y gestión del bosque, siendo en este siglo cuando se produce su repoblación forestal. Haciendo mención, precisamente, a dichas actividades reforestadoras, en el diagrama polínico de Rascafría se observa muy netamente el aumento de *Pinus sylvestris* tipo, en fecha inmediatamente posterior al 50 ± 40 BP, es decir, con toda probabilidad entre 1800-1930 cal. AD coincidente con la Ley de repoblación forestal que inició en 1877.

Palabras clave: Antropoceno, España, Rascafría, polen, microfósiles no polínicos



Evidence of changes in vegetation and climate during the Late Glacial of northwestern Colombia, based on palynology and X-ray microfluorescence-X.

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The Frontino paramo is located in the northern part of the Western Cordillera of the Colombian Andes, exactly in the municipality of Urrao (Antioquia). Due to its geographical position, in the northwest of South America, it is geostrategic, conserving in itself a diversity of environments, flora, fauna, geomorphology, waters and glacial geology unique to the north of the Andes. Its location allows it to modulate the climate, while being influenced by the meteorology coming mainly from the Caribbean Sea and the Pacific Ocean (Figure 1).

In this research, the reconstruction of the vegetation and climate during the Late Glacial of the paramo is presented. Palynology and microfluorescence (μ XRF) were used to study the sediments recovered from several cores in the Llano Grande wet zone at an altitude of 3460 m. Palynology was studied in the 7.50-12.5 m section of the Llano Grande-2 core (LLG-2), and (μ XRF) in the LLG-5 core (8.50-12.50m). The age model for the Llano Grande Basin was derived from 30 AMS dates of ¹⁴C. According to this model, the time interval studied in this work covers from 16,700 to 11,500 cal years BP.

The vegetation belts and their variations were hired as paleotemperature proxy. In addition, with the use of local aquatic plants, it was possible to obtain a moisture proxy for the basin. μ XRF, particularly of the element titanium (Ti), was used as another moisture proxy, and has a sub-annual resolution.

Results: Using the cluster analysis and knowledge of the ecology of the flora that occurs in the paramo, nine biozones were determined with palynology, based on the reconstruction of the vegetation belts and the productivity of the genetic spectrum with pollen, spores of ferns, fungi and algae (palynomorphs paleoproductivity of the system), at a resolution close to 50 years (every 2 cm).

These results have allowed the paleoenvironmental and climatic reconstruction of the Tardiglacial in northwestern Colombia through the discovery of 5 biozones (Bz) of changes, namely: Biozone 1 (Bz 1) occurs between 16,700 and 16,120 cal years BP. It is approximately equivalent to the Oldest Dryas, and at the level of Colombia, with a part of the Fúquene stadial.

Bz-2 occurs between 16,100 and 14,580 cal years BP. Apparently, this biozone is equivalent to the GS-2 chronozone of the time scale obtained in GICCO5 and, in part, could be located between the Oldest Dryas stadial and the Bølling interstadial for Europe. At the Colombian level, it resembles the Susacá interstadial.

Bz-3 occurs between 14,550 and 13,660 cal years BP. The sedimentary record suggests cool, wet weather conditions. At a global level, Bz-3 could be compared with the GI-1e and GS-2 chronozone of the time scale obtained in GICCO5, and could be located between the transition of the Bølling and Allerød (Older Dryas) interstadials for Eu-

rope. At the level of Colombia, approximately with the La Ciega stadial.

Bz-4 occurs between 13,630 and 12,720 cal years BP. The sedimentary record suggests hot and dry weather conditions. At a global level, Bz-4 could be compared to the interval between the chronozones GI-1a to GI-1d on the GICCO5 scale, and to the transition between the Allerød interstadial and the Younger Dryas (YD) stadial for Europe. At the level of Colombia, with the Guantiva interstadial.

And Bz-5 occurs between 12,700 to 11,500 cal years BP suggests very cold conditions. On a global level, the Bz-5 could be compared to the GICCO5 chronozone Gs-1, and is approximately equivalent to the Younger Dryas (YD). At the level of Colombia, with the Abra stadial. Finally, it can be mentioned that the previous paleoenvironmental reconstruction proposal can be taken into account as a reference and/or comparison framework in the identification of climatic events at the local, regional and global levels.



Figure 1. Geomorphology and environments of the Frontino paramo (Urrao), Antioquia-Colombia (Photo: Monsalve-M 2015)

Keywords: climate change, aquatic and Andean vegetation, paramo, Fe, humidity, palaeoecology, palynomorphs-palaeoproductivity, Ti.

Evidencias de cambios en la vegetación y el clima durante el Tardiglacial del noroccidente de Colombia, basado en palinología y microfluorescencia de rayos X.



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El páramo de Frontino se encuentra en la parte norte de la Cordillera Occidental de los Andes colombianos en el municipio de Urrao-Antioquia. Por su posición geográfica, en el noroccidente de Sudamérica, es geoestratégico, conservando en sí una diversidad de ambientes, flora, fauna, geomorfología, aguas y geología glaciaria única al norte de los Andes. Su ubicación le permite ser modulador del clima, a la vez que es influenciado por la meteorología proveniente principalmente del mar Caribe y del océano Pacífico.

En esta investigación, se presenta la reconstrucción de la vegetación y el clima durante el Tardiglacial del páramo. Se utilizaron la palinología y la microfluorescencia (μ XRF) para estudiar los sedimentos recuperados en varios testigos en la turbera Llano Grande a 3460 m de altitud. La palinología fue estudiada en la sección 7.50-12.5 m del testigo Llano Grande-2 (LLG-2), y la (μ XRF) en el testigo LLG-5 (8.50-12.50m). El modelo de edad para la cuenca de Llano Grande fue derivado de 30 dataciones AMS de ^{14}C . Según este modelo, el intervalo de tiempo estudiado en este trabajo cubre desde los 16.700 hasta los 11.500 años cal AP.

Los cinturones de vegetación y sus variaciones fueron utilizados como proxy de paleotemperatura. Además, con la utilización de las plantas acuáticas locales se permitió obtener un proxy de humedad de la cuenca. La μ XRF, particularmente del elemento titanio (Ti), fue utilizado como otro proxy de humedad, y tiene una resolución subanual. Resultados: Utilizando el análisis de clúster y el conocimiento en la ecología de la flora que ocurre en el páramo, se determinaron con la palinología nueve biozonas, basadas en la reconstrucción de los cinturones de vegetación y la productividad del espectro genético con el polen, esporas de helechos, hongos y algas (paleoproductividad polínica del sistema), a una resolución cercana a los 50 años (cada 2 cm).

Estos resultados, han permitido la reconstrucción paleoambiental y climática del Tardiglacial en el noroeste de Colombia mediante el hallazgo de 5 biozonas (Bz) de cambios a saber: La Biozona 1 (Bz-1) ocurre entre los 16.700 y 16.120 años cal AP. Es aproximadamente equivalente al Oldest Dryas, y a nivel de Colombia, con una parte del estadal Fúquene.

La Bz-2 ocurre entre los 16.100 a 14.580 años cal AP. Aparentemente, esta biozona es equivalente a la cronozona GS-2 de la escala temporal obtenida en GICCO5 y en parte, podría ubicarse entre el estadal Oldest Dryas y el interestadial Bølling para Europa. A nivel de Colombia, se parece al interestadial del Susacá.

La Bz-3 ocurre entre los 14.550 y 13.660 años cal AP. El registro sedimentario sugiere condiciones de clima frío y húmedo. A nivel global, la Bz-3 se podría comparar con la cronozona GI-1e y GS-2 de la escala temporal obtenida en GICCO5, y se podría ubicar entre la transición de los interestadiales Bølling y el Allerød (Older Dryas)

para Europa. A nivel de Colombia, aproximadamente con el estadal La Ciega.

La Bz-4 ocurre entre 13.630 y 12.720 años cal AP. El registro sedimentario sugiere condiciones de clima cálido y seco. A nivel global, la Bz-4 se podría comparar con el intervalo entre las cronozonas GI-1a a GI-1d en la escala de GICC05, y en la transición entre el interestadial Allerød y el estadal Younger Dryas (YD) para Europa. Y a nivel de Colombia, con el interestadial de Guantiva.

Y la Bz-5 ocurre entre los 12.700 a 11.500 años cal AP con condiciones muy frías. A nivel global, la Bz-5 podría compararse con la cronozona Gs-1 de la escala GICC05, y es aproximadamente equivalente al Younger Dryas (YD). Y a nivel de Colombia, al estadal El Abra. Finalmente, se puede mencionar, que la anterior propuesta de reconstrucción paleoambiental puede ser tenida en cuenta como marco de referencia y/o comparación en la identificación de eventos climáticos a nivel, local, regional y global.

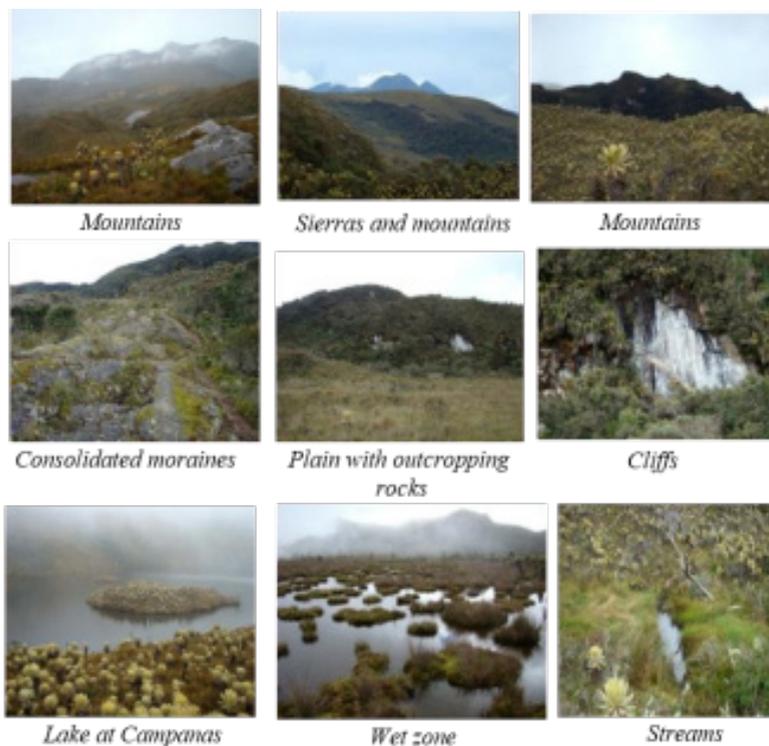


Figura 1. Geomorfología y ambientes del páramo de Frontino (Urrao), Antioquia-Colombia (Foto: Monsalve-M 2015)

Palabras clave: Cambio climático, vegetación acuática y andina, páramo de Frontino (Urrao), Fe; Ti, paleoecología, paleoproductividad polínica.



Pollen morphology of Sanguisorbeae (Rosaceae): comparison with fossil elements from diverse environments

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The Sanguisorbeae tribe, within the Rosaceae family, is a monophyletic clade with two subtribes (Agrimoniinae and Sanguisorbinae) that includes 16 genera. The tribe has a wide distribution in the Andes (*Acaena*, *Margyricarpus*, *Polylepis*, and *Tetraglochin*), with *Polylepis* being the only arborescent genus of the tribe. The diversification of the Andean genera originated from Verruchaena, a southern hemisphere lineage (South Africa, South America) that gave rise to *Acaena* during the late Miocene (~10 million years ago) and after several hybridization events to *Polylepis*, *Tetraglochin*, and *Margyricarpus*.

In Peru, the most abundant and diverse genera of the tribe are *Polylepis* and *Acaena*. *Polylepis* forms forested patches at elevations between 1800-5000 masl, although 94% of the species (n= 18) occur at elevations above 3000 masl. *Acaena*, on the other hand, grows as a shrub/herbaceous plant that inhabits various altitudinal ranges and ecological distribution, including low, medium and high mountain areas. Considering the differences in ecosystem role between *Polylepis* and *Acaena* (i.e., water regulation, carbon se-

questration, and biodiversity maintenance), differences in habits (trees vs. shrubs/herbs) and, in some cases, the associated plant composition (e.g., low montane versus high Andean xeric elements), it becomes key to discriminate the palynological morphology between these genera, in order to improve any (paleo)ecological interpretation based on the palynological record. To date, *Acaena*/*Polylepis* is regarded as a single pollen entity based on morphological characteristics, and is associated with the fossil form *Byttneripollis rugulatus*.

We analyze the pollen morphology of seven genera of Sanguisorbeae (*Acaena*, *Agrimonia*, *Margyricarpus*, *Polylepis*, *Poterium*, *Sanguisorba*, and *Sarcopoterium*) comprising 30 species collected from herbaria. Morphological traits were also compared with two fossil samples from the Pacific coast (~8 Ma) and the Peruvian altiplano (~5-4 Ma). Our preliminary results indicate that it is possible to discriminate between some genera using light microscopy, as the Sanguisorbeae tribe varies from oblate-spheroidal (e.g., *Polylepis*) to prolate (e.g., *Agrimonia*) forms. The exine is thin with ornamentations varying from rugulate, verrucate to striate. The apertures are mostly tricolporate except in *Sanguisorba officinalis* (hexacolporate) and *Margyricarpus* (tetracolporate), with lalongate to circular and pontoperculate pores. *Polylepis* and *Acaena* show high morphological similarity; however, the ornamentation presents particular elements that we consider could be useful to achieve better identifications using high resolution confocal microscopy.

Keywords: *Polylepis*, Pollen morphology, Sanguisorbeae, *Acaena*



Morfología polínica de Sanguisorbeae (Rosaceae): comparación con elementos fósiles de ambientes diversos

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La tribu Sanguisorbeae de la familia Rosaceae, es un clado mono ilético con 2 subtribus (Agrimoniinae y Sanguisorbinae) que incluyen 16 géneros. La tribu tiene una amplia dominancia en los Andes (Acaena, Margyricarpus, Polylepis y Tetraglochin), siendo Polylepis el único género arborescente de la tribu. La diversificación de los géneros altoandinos (i.e. Acaena, Margyricarpus, Polylepis y Tetraglochin) surgen a partir de Verruchae-na, un linaje que se extendió en el hemisferio sur (Sudáfrica, Sudamérica), originando a Acaena en el Mioceno tardío (~10 millones de años) y posteriormente a Polylepis, Tetraglochin y Margyricarpus tras varios eventos de hibridación.

En Perú, los géneros más representativos de la tribu son Polylepis y Acaena. Polylepis habita elevaciones de entre 1800-5000 msnm, aunque el 94% de las especies (18 especies) ocurren en elevaciones superiores a 3000 msnm. En tanto que, Acaena tiene una distribución altitudinal y ecológica más variada, incluyendo áreas de baja, media o alta montaña. Considerando las diferencias del rol ecosistémico entre Polylepis y Acaena (i.e. regulación hídrica, secuestro de carbono y man-

tenimiento de biodiversidad), las diferencias en hábitos de los géneros sudamericanos (i.e. árbol, arbusto y hierba) y en algunos casos la composición vegetal asociadas (e.g. elementos xéricos de baja montaña versus altoandinos), discriminar la morfología palinológica entre estos géneros mejorará las interpretaciones paleoecológicas del registro fósil. A la fecha, las características morfológicas han determinado al grupo Acaena/Polylepis como una única entidad polínica, que se asocia a la forma fósil *Byttneripollis rugulatus*.

Para este fin, se analizaron 7 géneros de Sanguisorbeae (Acaena, Agrimonia, Margyricarpus, Polylepis, Poterium, Sanguisorba y Sarcopoterium) que representan 30 especies colectadas de herbarios. Además, se compararon con dos muestras fósiles procedentes de la costa pacífica (~8 Ma) y el altiplano (~5-4 Ma) peruano. Nuestros resultados preliminares indican que Sanguisorbeae presenta formas obladas-esferoidales (e.g. Polylepis) a proladas (e.g. Agrimonia) y ámbito circular. Las aperturas son tricolporadas excepto en Sanguisorba officinalis (hexacolporadas) y Margyricarpus (tetracolporada), con poros alargados a circulares y pontoperclados.

La exina es delgada con ornamentaciones variando de ruguladas, verrucadas a estriadas. Estos resultados indican que es posible discriminar géneros usando microscopía óptica. Polylepis y Acaena tienen gran similitud morfológica; no obstante, la ornamentación presenta elementos particulares que consideramos podrían ser de utilidad para lograr una mejor identificación usando microscopía confocal de alta resolución.

Palabras clave: Polylepis, Pollen morphology, Sanguisorbeae, Acaena



Palynological characterization of a seasonal desertic ecosystem: the Peruvian Lomas

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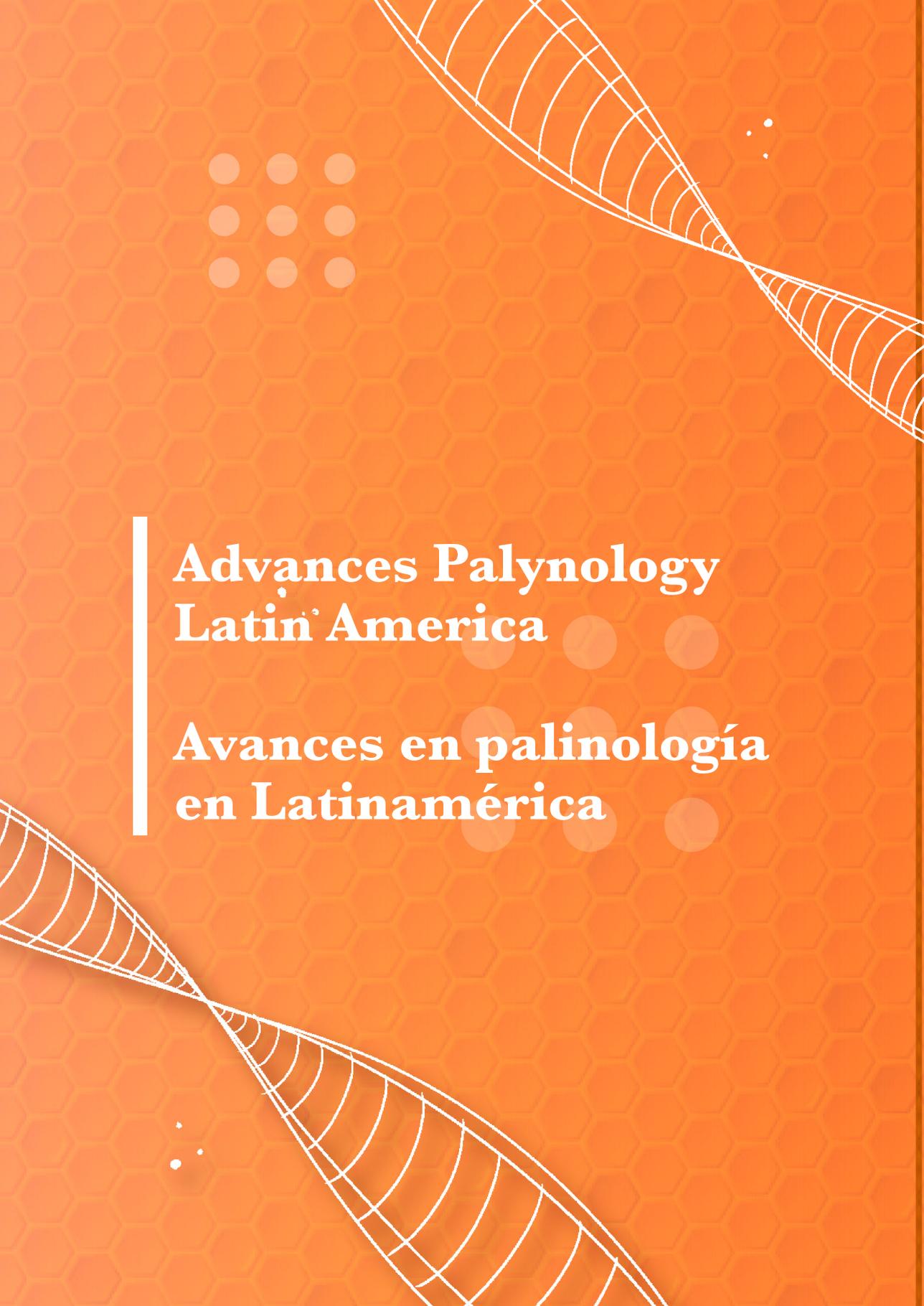
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The Lomas are sui generis biome formations, existing only across the desertic Peruvian-Chilean Pacific coast. They are seasonal in nature with an annual development that depends on the local humidity formed during winter and early spring. Their floristic diversity is high, considering that they belong to the so-called South American Arid Diagonal, and it is dominated by ephemeral vascular plants and abundant endemic species. Although the Lomas serve key ecological services for local and migratory species, they are under threat given the rapid expansion of human activities. Preservation of this biome requires understanding the climatic and evolutionary processes that shaped its modern distribution and ecological traits.

The palynological record offers a unique opportunity to reconstruct their historical evolution and climate-driven changes during Holocene. Unfortunately, there are no palynological catalogues of the Lomas ecosystems (and their endemic species) to date, so generating a reference collection is critical for studying past archives, so that

robust paleoecological and paleoenvironmental interpretations can be established. In this work, we are focused on characterize the modern palynoflora of the two largest and most diverse Peruvian Lomas, the Lachay (11°S) and Atiquipa Lomas (14°S). For Lachay, 146 species of vascular plants, grouped in 124 genera and 52 families, have been registered of which 79% are herbaceous, 17% shrubby, and 3% of woody plants. In the case of Atiquipa, there are 350 registered species, grouped in 237 genera and 78 families, 72% of which are herbaceous, 23% are shrubs and 5% are woody. Lachay has 126 species that are species endemic to the Peruvian Lomas and 11 species that are exclusive of this locality, while Atiquipa has 46 species endemic to the Lomas and 6 of exclusive occurrence at his locality. All palynological material used for building the reference collection come from Herbarium material. This collection will be then used to reconstruct and interpret past vegetation changes observed from two short-cores drilled in each of these Lomas.

Keywords: pollen, Peruvian Lomas, endemic, morphology, diversity.



**Advances Palynology
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Palynologic study of trace fossil assemblages from glaciogenic rhythmites at Melo region, northeastern Uruguay: biostratigraphical and paleoenvironmental approaches

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The ichnofossiliferous-rich glaciogenic sedimentary succession exposed in the Melo region (Cerro Largo County, N Uruguay) attributed to the Ediacaran Tacuarí Formation is also prolific in palynomorphs. Here we discuss the palynology from claystone, siltstone, and fine-grained sandstone deposits from 16 sites in the study area. Trace fossils and sedimentary facies were described in the field, and circa 200 slabs containing ichnofossils were collected for a detailed description on a high-resolution (centimetric) scale. Ichnofossiliferous slabs from each site were processed for palynology at the Instituto Tecnológico de Paleoceanografía e Mudanças Climáticas (UNISINOS University, São Leopoldo, Brazil), and analyzed at the Laboratory of Palynostratigraphy and Paleobotany (CICYTTP-CONICET-ER-UADER, Argentina). Three productive samples were obtained from thin-bedded rhythmites from sites 11, 12, and 13 (from base to top stratigraphic order) exposed at Cañada de Infiernillo.

The three assemblages yielded 89 species composed of 33 spores, 49 pollen grains, 4 chlorophycean algal, a fungal spore, an acritarch, and an indeterminate species, representing a putative Phanerozoic record. Lycophyta (c. 7%-20% of the specimens), Cordaitan, Coniferalean, Glossopteridalean (c. 12%-17%), Corystospermaceae/Peltaspermaceae (5%-8%), Pteridophytes (c. 12%-18%), algal (*Botryococcus*, *Tetraporina*, *Brazilea*, *Quadrisporites*), and other groups (*Deusilites tenuistriatus*, *Portalites gondwanensis*), which together varied from 15% to 32% in the assemblage composition, are the mainly represented botanical groups. Among biostratigraphically important taxa, *Brevitriletes leptocaina*, *B. parmatius*, *B. cornutus*, *Converrucosisporites confluens*, *C. micronodosus*, *Deusilites tenuistriatus*, *Hamiapollenites karroensis*, *Illinites unicus*, *Latusipollenites quadrisaccatus*, *Murospora bicingulata*, *Mabuitasaccites crucistriatus*, *Pakhapites fusus*, *P. ovatus*, *Vallatisporites russoi*, and *Vittatina saccata* are documented. These species compose the record of the latest Pennsylvanian–early Cisuralian *Cristatisporites incons-*

tans-Vittatina saccata (IS) Assemblage Zone of the glaciogenic San Gregorio Formation and other correlated palynozones in South America and elsewhere in Gondwana. Moreover, peaks of abundance and diversity of species of *Cristatisporites*, monosaccate pollen, *Vittatina*, and *Botryococcus* occur in the three samples, and peaks of abundance of *Horriditrites*, *Kraeuselisporites*, *Vallatisporites* occur chiefly in site 13. The thermal alteration index of the palynomorph assemblages indicates an immature phase of oil generation with TAI +1 to -2 (yellow/light orange). Samples of sites 12 and 13 yielded similar palynofacies features, consisting of moderate frequency of tracheids and cuticles (phytoclasts), abundantly well-preserved and highly diverse palynomorphs, and pyrite. These suggest accumulation in a brackish-marginal to inner platform low-energy environment with anoxic bottom waters. A less diverse palynoassemblage with variable degrees of degradation and low frequency of phytoclasts occurs in site 11, possibly deposited under sub-oxic/oxic conditions.

The variable frequencies of plant groups in each sample, based on biological affinities of palynotaxa, indicate a landscape surrounded by fluvial plains and protected areas of rivers and water bodies where Lycophytes were abundant in humid areas, and arboreal forests composed of gymnosperm groups bordering these lowlands. Pteridophytes were mostly part of the understory in forests

and lowlands. This landscape and the relative age indicated by the palynoflora reinforce the Phanerozoic age inferred for the trace fossils. Arthropod trackways, trails, furrows, and resting traces (e.g., *Arborichnus repetita*, *Crescentichnus tesiltus*, *Cruziana problematica*, *Diplichmites aff. gouldi*, *Gluckstadtella cooperi*, *Kingella aff. natalensis*, *Maculichna varia*, *Rusophycus* isp., *Umfolozia sinuosa*) dominate the ichnological assemblage, and insect larva trails and burrows (e.g., *Helminthoidichnites tenuis*). Several of these ichnotaxa are typically found in Late Carboniferous–Early Permian glaciogenic deposits of the Gondwanaland like the Itararé Group in Brazil and the Dwyka Group in South Africa and confirm these rocks were deposited during this age interval. Therefore, the alleged Ediacaran age for the trace fossil assemblage preserved in the deposits of the so-called Tacuarí Formation is not supported by our data. The palynological data presented herein and the structure and composition of the trace fossil assemblage are typical of the Late Paleozoic Ice Age (LPIA) and, more specifically, of the San Gregorio Formation. The reworked nature of the Leiosphaeridia specimens in site 13, based on their light grey color differing from the light-yellow color of the indigenous palynomorphs, and their original preservation in sedimentary beds of the Ediacaran Arroyo del Soldado Group exposed in the study area, indicate that they were eroded from the Ediacaran beds by glaciogenic processes during LPIA.

Keywords: Gondwana ichnostratigraphy, Palynology, Tacuarí Formation, San Gregorio Formation, Carboniferous–Permian, glacial paleoenvironment; Uruguay

Project for the evaluation
of the genetic variability of
Butia yatay in the grassland-
palm ecosystem of the
El Palmar National Park
(Colón, Entre Ríos) and its
adaptation to the climatic
phenomenon ENSO in the
Late Holocene



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In the *Parque Nacional El Palmar* (PNEP), the modern palm *Butia yatay* dominates the landscape of grasslands/palms ecosystems known as “*butiazales*”. This palm that lives between 200 and 400 years offers a delicious fruit used by local producers in the preparation of liquors and preserves with commercial value. In South America, this palm population represents the southernmost extension of humid and temperate savanna ecosystems in Entre Ríos province. Geologic studies performed in this region recognized in the Early Holocene, a semi-arid phase with floods occurred at the beginning and a humid period under tropical conditions during the Middle Holocene, whereas a dry period during the Late Holocene, and Warm Humid Medieval and Little Ice Age are identified. Moreover, in the last 300 years, agricultural exploitation, the repeated burning of grasslands, and the invasion of exotic flora in the park have increased the significant reduction and fragmentation of *Butia* populations. The first palynological study carried out in the park began in 2011 to reconstruct environmental and climatic changes in the Holocene. Records obtained from surface and atmospheric samples

(pollen rain), and comparison with modern flora ecosystems allowed the development of an analogous model of vegetation applicable to the study of soil samples from the Late Holocene, still under study. The first quali-quantitative palynologic study of three cores in three sites of the park allowed the recognition of vegetation changes associated with intervals of higher and lower humidity during the last 500 years (C14 dating). The main cause of this variation was attributed to climatic changes linked to the ENSO phenomenon, confirmed by environmental fluctuations recorded in at least the last 10 years of this study. On the other hand, fossil palm trees provide qualitative evidence for subtropical conditions and frost- and freeze-free winters in the geologic past. This is due to *Butia*'s intolerance to cold weather being the mean cold month minimum temperature (CMMT) to be inferred to 2–8 °C in paleoclimate reconstructions. However, this tolerance varies according to the different organs and stages of life. Seedlings are the least tolerant stage to temperatures below zero, limiting their ability to colonize new environments outside the range of temperatures that are favorable to them. Therefo-

re, it is our hypothesis that we will be able to validate a work methodology to recover the genetic material of *Butia* if preserved in these soil samples and compare it with polymorphisms of interest identified in modern *Butia yatay*. Among the techniques to be used are (1) DNA measurements by flow cytometry to detect individuals with unreduced pollen counts (*Butia yatay* =2n (32c) or 8n) and compare genome size estimates with those of leaf tissue. (2) Polymorphism identifica-

tion by Polymerase chain reaction – Restriction Fragment Length Polymorphism (PCR-RFLP) for *matK* and *rbcL* genes. Although anthropogenic disturbances could have influenced more recent ecological changes of *Butia* communities, the expected variations in their growth and development will be applied as an estimator of environmental stress conditions to consider its adaptive variability to humid and dry periods.

Keywords: Paleopalynology, Genetic, *Butia Yatay*, Paleoclimate.



Listening to Las Lagunas: a long-term disturbance perspective from a conflict zone in Colombia's tropical Andean forest

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Armed conflict can trigger and accelerate deforestation, and when coupled with climate impacts, there is increased potential for further acceleration of biodiversity loss. Andean Tropical Forests have been experiencing conflict and post-conflict scenarios for decades, even centuries. Ultimately, long-term conflict zones create human landscape legacies that can be linked to changes in biodiversity. Here we present a framework that links historical ecology and

biodiversity conservation toward policy making. A study case from Laguna de San Diego (SDL) is provided as an example of how historical land-use changes are linked to violence and climate variability as the main disturbance drivers within these tropical forests. The ecosystems' legacies of violence in Colombia's tropical Andean forests are grouped into three categories as follows: 1. Depletion of wild taxa used for construction materials and food resources, including

the enrichment of grass-, domestic- and invasive-plant species; 2. Simplification of ecosystem's structure and forest fragmentation, and 3. Loss of ecosystem services and nature's contributions to people. Therefore we argue that these conflict zones can be considered unique ecological entities, and provide an opportunity for understanding human-environment dynamics (HED) through time. The history of disturbance in the upper limit of lower Neotropical rainforest Samaná, Colombia, is described through a multi-proxy interpretation of sedimentary, historical, and satellite records spanning the last century (1920 – 2020). SDL record reveals landscape transformation, past disturbance events, and potential biodiversity legacies through high resolution sedimentological (palynological, micro-charcoal) and geochemical (stable isotope) analysis of the top 5-cm-lacustrine sediment cores SDL-Ex1 and SDL-Fc2. Regional changes in precipitation from El Niño/La Niña were evaluated in connection with large magnitude conflict events. We use SDL records to test the hypothesis that disturbances, including warfare, fire, and logging, are keystone processes for shaping the protected area/catchment biodiversity and these impacts are amplified during strong El Niño

Southern Oscillation (ENSO) events. This study demonstrates how disturbance events increased in frequency between 1930 to 1940 and from 1993 to 2003, the latest tandem with observed ENSO variability after the national government put into practice the National Plan of Hydropower Generation and Transmission 1990-2000 (DNP-2.441 –UINF), and armed conflict skyrocketed leading to 13000 displaced people in Samana county. During the last five years, the frequency of deforestation has increased as indicated by satellite (forest loss) and charcoal records, as the effect of the 2016 peace agreement with FARC guerillas expanded into the region. Currently, SDL management plan needs to be updated by the regional environmental authorities, setting up an opportunity to showcase SDL as one of the first regional protected areas with a management plan that incorporates disturbances to improve future projects in this area. We are providing applicable research results to inform decision-making as the returning post-conflict populations accelerate biodiversity loss. Building a bridge between scientists studying Andean Forest ecosystems and management agencies charged with governance provides an opportunity in the Colombian post-conflict era.

Los conflictos armados pueden desencadenar y acelerar la deforestación, y cuando se combinan con los impactos climáticos, existe un mayor potencial de aceleración de procesos de pérdida de biodiversidad. Los Bosques Tropicales Andinos vienen siendo escenarios de conflicto y posconflicto desde hace décadas, incluso siglos. En última instancia, las zonas de conflicto a largo plazo crean legados de paisajes humanos que pueden vincularse a cambios en la biodiversidad. Aquí presentamos un marco que vincula la ecología histórica y la conservación de la biodiversidad con la formulación de políticas. Se proporciona un caso de estudio

de la Laguna de San Diego (SDL) como ejemplo de cómo los cambios históricos en el uso de la tierra están vinculados a la violencia y la variabilidad climática como los principales impulsores de perturbaciones dentro de estos bosques tropicales. Los legados ecológicos de violencia sobre los ecosistemas en los bosques andinos tropicales de Colombia se agrupan en tres categorías de la siguiente manera: 1. Disminución de taxones silvestres utilizados para materiales de construcción y recurso alimentario y el enriquecimiento de especies de pastos, plantas domésticas e invasoras; 2. Simplificación de la estructura de los ecosistemas y fragmen-

tación de los bosques, y 3. Pérdida de los servicios de los ecosistemas y las contribuciones de la naturaleza a las comunidades humanas. Por lo tanto, argumentamos que estas zonas de conflicto pueden considerarse entidades ecológicas únicas y brindan una oportunidad para comprender la dinámica humano-ambiental (HED) a través del tiempo. La historia de la perturbación en el límite superior de la selva tropical neotropical inferior de Samaná, Colombia, se describe a través de una interpretación multiproxy de registros sedimentarios, históricos y satelitales que abarcan el último siglo (1920 - 2020). El registro de La Laguna de San Diego revela la transformación del paisaje, eventos de perturbación pasados y posibles legados de biodiversidad a través de análisis sedimentológicos (palinología, microcarbónes) y geoquímicos (isótopos estables) de alta resolución de los cinco centímetros (5 cm) superiores de los núcleos de sedimentos lacustres SDL-Ex1 y SDL-Fc2. Se evaluaron los cambios regionales en la precipitación de El Niño/La Niña en relación con eventos de conflicto de gran magnitud. Usamos el registro de SDL para probar la hipótesis de que las perturbaciones, incluidas las guerras, los incendios y la tala, son procesos clave para dar forma a la biodiversidad del área protegida/cuenca y estos impactos se amplifican durante los eventos fuertes de El Niño Oscilación del Sur (ENOS). Este estudio demuestra cómo los eventos de perturbación aumentaron en frecuencia

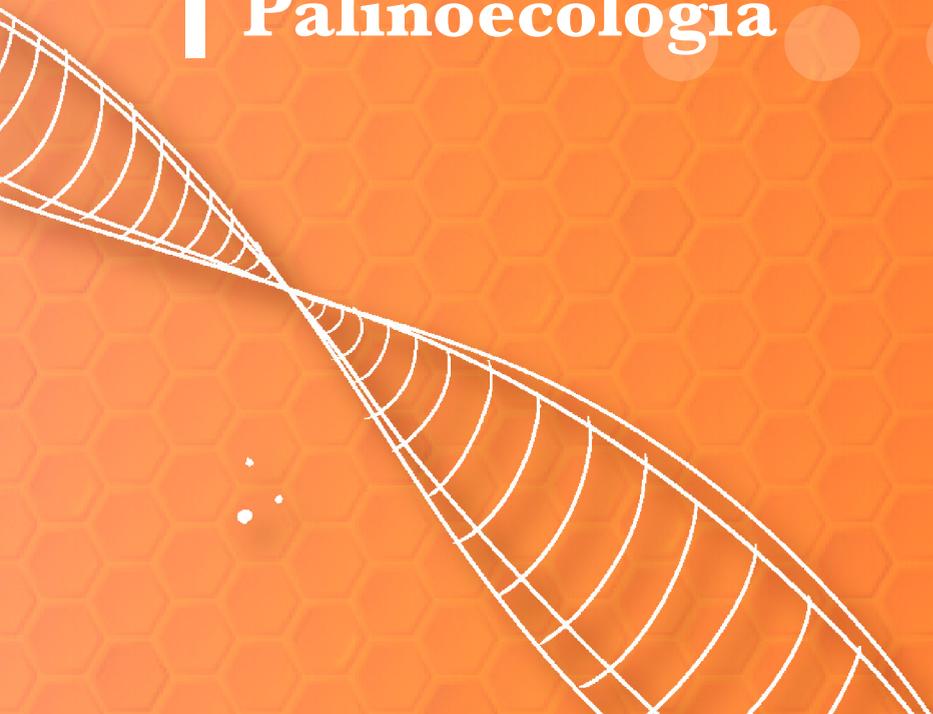
entre 1930 y 1940 y entre 1993 y 2003, el último acoplado con la variabilidad observada del ENOS luego de que el gobierno nacional de Colombia pusiera en práctica el Plan Nacional de Generación y Transmisión de Energía Hidroeléctrica 1990-2000 (DNP-2.441 -UINF), y el conflicto armado se disparara y provocara el desplazamiento de más de 13000 personas en el condado de Samaná. Durante los últimos cinco años, la frecuencia de la deforestación ha aumentado según lo indicado por los registros satelitales (pérdida de bosques) y de carbón, a medida que el efecto del acuerdo de paz de 2016 con la guerrilla de las FARC se expandió a la región. Actualmente, el plan de manejo ambiental de La Laguna de San Diego necesita ser actualizado por las autoridades ambientales regionales, creando una oportunidad para mostrar a SDL como una de las primeras áreas protegidas regionales con un plan de manejo que incorpora perturbaciones para mejorar las futuras acciones de conservación de la naturaleza en esta área. Estamos proporcionando resultados de investigación aplicables para informar la toma de decisiones a medida que los habitantes regresan después del conflicto acelerando la pérdida de biodiversidad. Construir un puente entre los científicos que estudian los ecosistemas del bosque andino y las agencias de gestión encargadas de la gobernanza brinda una oportunidad en la era del posconflicto colombiano.

Keywords: violence, ENSO, Andes, disturbances, palynology, charcoal, isotopes



Melisopalynology and Palynoecology

Melisopalinología y Palinoecología





Palynological, physical and chemical characterization of fresh bee pollen from different geographical areas of Chile

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Corbicular pollen or bee pollen is a mixture of pollen collected from flowers and salivary secretions that the bee kneads into small balls and transports on the third pair of hind legs to the hive. There it is collected by beekeepers with pollen traps before the bees enter through the comb, cleaned and frozen to keep it fresh. It is well known that bee pollen has a high nutritional value, since it contains proteins, carbohydrates, essential amino acids, vitamins and minerals, nutrients used not only by the beehive, but also by man, who increasingly consumes this product as a food supplement. This product is also a powerful antioxidant, with a high content of polyphenols and flavonoids. In this study, the botanical origin of sixteen samples of fresh frozen pollen was determined by palynological analysis applying the Chilean Standard (NCh 3255, 2011) and some physical properties such as moisture and dry weight, and chemical properties such as pH and total phenols were determined.

The results of this study allowed the identification of monofloral, bifloral and multifloral pollens in the different regions and showed that all pollens are in the pH range between 3.7 and 5.8, with humidities less than 22% and with total phenol content between 2.1 ± 1 mg GAE/g pollen and 8.1 ± 2.7 mg GAE /g pollen (*GAE: gallic acid equivalent).

Finally, the determination of physical and chemical parameters, together with the botanical origins identified according to the Chilean Standard (NCh 3255, 2011) allowed the differentiation and valorization of the sixteen pollens coming from different geographical areas of Chile.

Thanks to the beekeeper Leonardo Badani of the company Polen de Monte Badani y Guevara Ltda. for his collaboration with the pollen samples and to the financing of the internal project of the Universidad Técnica Federico Santa María PI-M-2020-30.

Keywords: bee pollen, corbicular pollen, *Apis mellifera*, Total phenols



Caracterización palinológica, física y química de pólenes frescos de abejas de distintas zonas geográficas de Chile

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El polen corbicular o polen apícola es una mezcla de polen recolectado de flores y secreciones salivales que la abeja amasa en pequeñas bolas y transporta sobre el tercer par de patas traseras hasta la colmena. Allí es recogido por los apicultores con trampas de polen antes de que las abejas entren por la piquera, para limpiarlo y congelarlo para mantenerlo fresco. Es bien sabido que el polen de abeja tiene un alto valor nutricional, ya que contiene proteínas, hidratos de carbono, aminoácidos esenciales, vitaminas y minerales, nutrientes utilizados no sólo por la colmena, sino también por el hombre, que consume cada vez más este producto como complemento alimenticio. Producto que, además, es un potente antioxidante, con alto contenido en polifenoles y flavonoides. En este estudio se determinó el origen botánico de dieciséis muestras de polen fresco congelado, mediante análisis palinológico aplicando la Norma Chilena (NCh 3255, 2011) y se determinaron algunas propiedades físicas tales como humedad y peso seco, y propiedades químicas como pH y fenoles totales.

Los resultados de este estudio permitieron identificar pólenes monoflorales, biflorales y multiflorales en las distintas regiones y se logró demostrar que todos los pólenes se encuentran en el rango de pH entre 3,7 y 5,8, con humedades menores al 22% y con contenido de fenoles totales entre $2,1 \pm 1\text{mg GAE/g}$ de polen y $8,1 \pm 2,7\text{ mg GAE/g}$ de polen (*GAE: ácido gálico equivalente). Finalmente, la determinación de los parámetros físicos y químicos, junto con los orígenes botánicos identificados según la Norma Chilena (NCh 3255, 2011) permitieron diferenciar y valorizar los dieciséis pólenes provenientes de distintas zonas geográficas de Chile.

Agradecimientos al apicultor Leonardo Badani de la empresa Polen de Monte Badani y Guevara Ltda. por su colaboración con las muestras de pólenes y al financiamiento del proyecto interno de la Universidad Técnica Federico Santa María PI-M-2020-30.



Palynological assemblage recovered from *Apis mellifera* honeys produced in Santa María Colotepec, Oaxaca coast, Mexico

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Mexico is recognized as the ninth largest honey producer in the world and the thirteenth largest exporter by the end of 2021. The different climatic conditions and botanical resources existing in a region determine the type of honey, as well as its physicochemical and organoleptic properties. The states of Yucatán, Campeche, Veracruz, Guerrero, Quintana Roo and Oaxaca are the main *Apis mellifera*'s honey, royal jelly, propolis and wax producing areas. The present work was carried out on the coast of Oaxaca, which belongs to the Pacific beekeeping region. It is important to point out that this beekeeping activity is carried out in 8 regions of Oaxaca, generating 4,150 tons of honey per year and placing the state in fifth place nationally. One of the main honey-producing areas in the state is the coastal region of Oaxaca, with the contribution of about 150 beekeepers, 32 of which belong to the organization "Mieles Mixtepec S.C. de R.L. de C.V.", and produce 250 tons of honey per year. As for the predominant vegetation type in the area, the original and secondary vegetation of the low deciduous forest, medium-sized forest, transition zones in the highest part

of the pine-oak forest, as well as cultivated areas stand out. These statistics gave the guideline to carry out the present melisopalynological study, with the purpose of complementing the knowledge related to the honey palynological assemblages from the coast of Oaxaca, as well as to characterize them botanically. Thus, they can be typified as "monofloral" when one species dominates with a percentage $\geq 45\%$ and "multifloral, mixed or polyfloral" when three or more species were present with percentages $\geq 10\%$. Multifloral honeys can also be classified as "bifloral" when two pollen types had secondary percentages, "oligofloral" when two or more taxa of a single botanical family dominated with secondary percentages of pollen, and "polyfloral" when three or more pollen types were recorded with secondary percentages. Sampling was conducted in the period November-December 2021 according to their apibotanical calendars established by beekeepers, collecting a total of 7 samples of *A. mellifera* from different apiaries in the municipality of Santa María Colotepec. A total of 250 ml of honey per sample was collected in sterile plastic bottles duly labeled. At the same time, some field observations were made on the flora, and some plants that the beekeepers suggest are the ones that favor production and are of greater importance to them were collected. The plants were determined and a reference collection was made. All honey and plant samples were chemically processed. In the case of honeys, 100 g of honey per sample were processed and the acetolysis technique of Erdtman (1960) was slightly modified by adding a *Lycopodium* clavatum tablet to obtain the absolute amount of pollen grains per gram of honey. The permanent slides with glycerin gelatin were registered and incorporated to the palynological collection of the Paleopalynology Laboratory: Paleopalynology and Actuopalynology, Institute of Geology of the National Autonomous

University of Mexico (UNAM) under the direction of Ph.D. Elia Ramírez-Arriaga. Subsequently, the different pollen types of each sample were described and identified and 500 pollen grains were counted at random to establish the percentages of each taxon, as well as the honey characterization based on the pollen spectrum. In the 7 samples analyzed, 27 pollen types belonging to 11 families were identified, based on the study, 5 monofloral honeys of the Fabaceae family were characterized; 4 dominated by *Mimosa* (>45%) and one by *Diphysa* (>45%). Secondary pollen with a representativeness higher than 10% were *Aeschynomene*, Asteraceae, Gramineae and *Calycophyllum candidissimum*.

um. The diversity index (H') showed a range from 0.67 to 1.78, with a mean of 1.68. Uniformity index values (J') had a variability from 0.26 to 1.77, with a mean of 0.72 (Figure 1). Considering the absolute amount of pollen grains per gram of honey, all the samples belong to group I. Finally, it is important to emphasize that the information generated will be shared with each beekeeper, in order to improve the exploitation of plant resources (nectariferous, nectaropolyniferous and honeydew) and to be able to guarantee the quality of Oaxacan honey for national and international consumption.

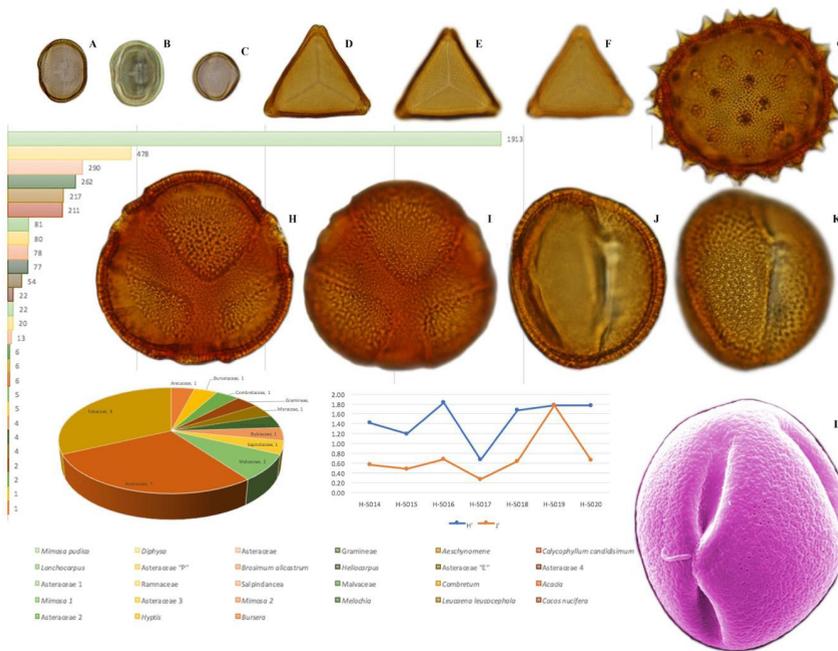


Figure 1. A-B. *Aeschynomene* sp.; C. *Diphysa* sp.; D-F. *Sapindaceae*; G. *Abutilon* sp.; H-I. *Caesalpinia pulcherrima*; J-K. *Coccoloba*; L. *Lonchocarpus* sp. Graphs: The bar graph represents the total pollen counts; the pie chart includes the total taxa per family and the line graph shows the diversity (H') and evenness (J') indices in each sample.

Keywords: Melisopalynology, Oaxaca, *Apis mellifera*, honey characterization, palynoflora.



Conjunto palinológico recuperado de mieles de *Apis mellifera* producidas en Santa María Colotepec, costa de Oaxaca, México

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México es reconocido como el noveno productor de miel a nivel mundial y décimo tercer exportador al cierre del 2021. Las diferentes condiciones climáticas y recursos botánicos existentes en una región determinan el tipo de miel, así como sus propiedades fisicoquímicas y organolépticas. Los estados de Yucatán, Campeche, Veracruz, Guerrero, Quintana Roo y Oaxaca constituyen las principales zonas de producción de miel, jalea real, propóleo y cera de *Apis mellifera*. El presente trabajo se llevó a cabo en la costa de Oaxaca, perteneciente a la región apícola del Pacífico. Es importante destacar, que dicha actividad apícola se desarrolla en 8 regiones de Oaxaca, generando 4 mil 150 toneladas anuales de miel y posicionando al estado como el 5° lugar a nivel nacional. Una de las principales áreas productoras de miel a nivel estatal es la región costa de Oaxaca, con la participación de alrededor de 150 apicultores, de los cuales 32 pertenecen a la organización “Mieles Mixtepec S.C. de R.L. de C.V.” aportando 250 toneladas anuales. Con relación al tipo de vegetación predominante en la zona, destaca la vegetación original y secundaria de la selva baja caducifolia, selva mediana,

zonas de transición en la parte más alta de bosque de pino-encino, así como áreas cultivadas. Dichas estadísticas dieron pauta para realizar el presente estudio melisopolinológico, con la finalidad de complementar el conocimiento relacionado con los conjuntos palinológicos recuperados de las mieles de la costa de Oaxaca, así como caracterizarlas botánicamente. Así, pueden ser tipificadas como “monoflorales” cuando domina una especie con porcentaje igual o mayor al 45% y “multiflorales, mixta o polifloral” cuando tres o más especies se presentaron con porcentajes iguales o mayores al 10%. Las mieles multiflorales pueden también ser catalogadas como “biflorales” cuando dos tipos de polen tuvieron porcentajes secundarios, “oligoflorales” cuando dominan dos o más taxa de una sola familia botánica con porcentajes secundarios de polen y “poliflorales” cuando tres o más tipos de polen se registraron con porcentajes secundarios. Los muestreos se llevaron a cabo en el periodo noviembre-diciembre, 2021 de acuerdo a sus calendarios apibotánicos que los apicultores establecen, recolectando un total de 7 muestras de *A. mellifera* de distintos apiarios en el municipio de Santa María Colotepec. Se colectaron 250 ml de miel por muestra en botes de plástico estériles debidamente etiquetados. Paralelamente se realizaron algunas observaciones de campo sobre la flora, además se colectaron algunas plantas que sugieren los apicultores son las que favorecen la producción y de mayor importancia para ellos. Las plantas fueron determinadas y se realizó una colección de referencia. Todas las muestras de miel y de plantas fueron procesadas químicamente. En el caso de las mieles, se procesaron 100 gr de miel por muestra y se realizó la técnica de acetólisis de Erdtman (1960) ligeramente modificada, agregando pastillas marcadoras de *Lycopodium clavatum* para obtener la cantidad absoluta de granos de polen por gramo de miel. Las laminillas permanentes elaboradas con gelatina glicerizada fueron registradas e

incorporadas a la colección palinológica del Laboratorio de Paleopalínología: Paleopalínología y Actuopalínología, del Instituto de Geología de la Universidad Nacional Autónoma de México (UNAM) bajo la dirección de la Dra. Elia Ramírez Arriaga. Posteriormente, se describieron e identificaron los distintos tipos polínicos de cada muestra y se realizaron conteos de 500 granos de polen al azar para establecer los porcentajes de cada taxón, así como la caracterización con base en el espectro polínico. En las 7 muestras analizadas se identificaron 27 tipos polínicos pertenecientes a 11 familias, en base al estudio se caracterizaron 5 mieles monoflorales de la familia Fabaceae; 4 dominadas por el género *Mimosa* (>45%) y una del género *Diphysa* (>45%). El polen secundarios con

representatividad mayor al 10% se encuentran los géneros *Aeschynomene*, Asteraceae, Gramineae, *Calycophyllum candidissimum*. Los índices de diversidad (H') mostraron un rango de 0.67 a 1.78, con una media de 1.68. Los valores de uniformidad (J') tuvieron una variabilidad de 0.26 a 1.77, con un promedio de 0.72. Considerando la cantidad absoluta de granos de polen por gramo de miel, todas las muestras pertenecen al grupo I. Es importante destacar que la información generada será compartida con cada apicultor, con la finalidad de llevar un proceso de mejora en la explotación de sus recursos vegetales (nectaríferos, nectaropoliníferos y de mielatos) y poder garantizar una miel de calidad oaxaqueña para su consumo nacional e internacional.

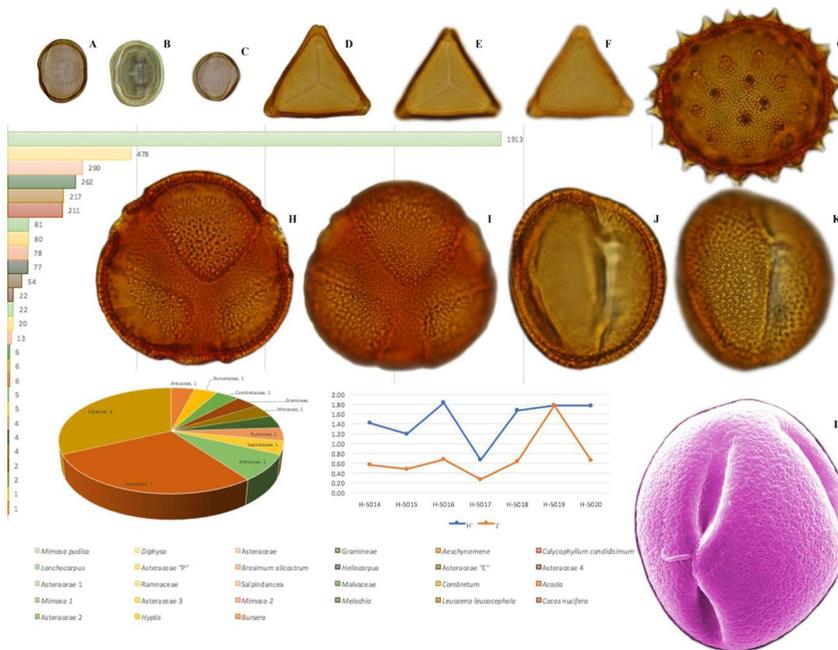


Figura 1. A-B. *Aeschynomene* sp.; C. *Diphysa* sp.; D-F. *Sapindaceae*; G. *Abutilon* sp.; H-I. *Caesalpinia pulcherrima*; J-K. *Coccoloba*; L. *Lonchocarpus* sp. Graphs: The bar graph represents the total pollen counts; the pie chart includes the total taxa per family and the line graph shows the diversity (H') and evenness (J') indices in each sample.

Palabras clave: Melisopalínología, Oaxaca, *Apis mellifera*, caracterización de mieles, palinoflora.



Melisopalynological analysis of honey samples from different types of vegetation and cultivated areas in Veracruz, Mexico

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We studied the floral resources exploited by *Apis mellifera* in different types of vegetation as well as in cultivated areas in order to highlight those native elements or cultivated taxa that are important for honey production in 10 municipalities of the state of Veracruz, since it holds about 23% of Mexico's plant diversity, with about 7,855 plant species for it is considered one of the most diverse states in the country. The main ecosystems are the tropical evergreen forest, tropical sub-deciduous forest, tropical deciduous forest, shrubland, mixed pine-oak forest, oyamel forest, cloud forest, high mountain meadow, mangroves, palm groves and coastal dunes. Unfortunately, in recent decades the vegetation cover has been reduced by more than 70% due to agricultural activities, urban-industrial growth and mining activities. In this context, grasslands cover 45.2% of its surface, following the agricultural areas (5.6%) of corn, sugar cane, papaya, mango and sweet orange. In addition, there are tropical evergreen forest (11.0%), temperate forests (5.2%), shrubland (0.2%), and other types of vegetation (5.5%). A total of 30 *Apis mellifera* honey samples collected at secondary vegetation of temperate forests,

tropical evergreen forest, mangrove, as well as cultivate areas of coffee and citric were characterized melisopalynologically. Each sample was chemically processed (acetolysis) with a *Lycopodium* spore tablet to obtain the absolute number of pollen grains. The permanent slides were incorporated to the palynological collection of the "Laboratorio de Palinología: Paleopalínología y Actuopalínología", Instituto de Geología, Universidad Nacional Autónoma de México. Melisopalynological analyses showed a total of 136 pollen types belonging to 28 plant families. Only 40 taxa were considered important for instance *Ardisia* sp., *Avicennia germinans*, *Brassica* sp., *Bursera simaruba*, *Carica papaya*, *Casuarina* sp., *Cecropia obtusifolia*, *Celtis iguanea*, *Comocladia* sp., *Citrus sinensis*, *Clethra* sp., *Coffea arabica*, *Cordia alliodora*, *Cordia megalantha*, *Dendropanax arboreus*, *Eugenia* sp., *Hedyosmum mexicanum*, *Heliocarpus* spp., *Lonchocarpus guatemalensis*, *Lonchocarpus* sp., *Miconia* sp., *Mimosa pudica*, *Oreopanax xalapense*, *Quercus* sp., *Rhizophora mangle*, *Sambucus* sp., *Spondias mombim*, *Syzygium jambos*, *Tamarindus indica*, Asteraceae taxa among others (Figure 1). After melisopalynological analyses, honey samples were characterized in monofloral, oligofloral and multifloral. The monofloral honey samples were dominated of *Brassica*, *Spondias mombim*, *Rhizophora mangle*, *Citrus sinensis*. Besides, Asteraceae taxa were important in oligofloral honey samples. Likewise, in multifloral honey samples *Lonchocarpus* sp., *Hedyosmum mexicanum*, *Quercus* sp., *Coffea arabica*, *Bursera simaruba*, *Spondias mombim*, among others, were significant. In general, the pollen assemblages showed nectariferous plants and myelate-producing elements, as well as honey enriched with polliniferous taxa. *Apis mellifera* was polylectic, however, selective behavior was observed when visiting a taxon or Asteraceae taxa, being monolectic and oligolectic respectively. In summary, *Apis mellifera* visited native plants and crops. It is important to mention that in cultivated areas, many plants of the

original vegetation are still visited by honeybees to collect nectar resources. Finally, taking into account the absolute amount of pollen grains, honey samples were classified into groups from I to V, with the lowest concentrations (group I) being detected in some monofloral, oligofloral and multifloral samples, while the highest pollen concentrations (group V) were recorded in only two honey

samples (monofloral and oligofloral). We acknowledge Karina Macías, beekeepers from Veracruz, Pronatura Veracruz A.C., Red de Viveros de Biodiversidad, CONABIO consulting on honeys from the Gulf of Mexico and LANGEM-CONACYT.

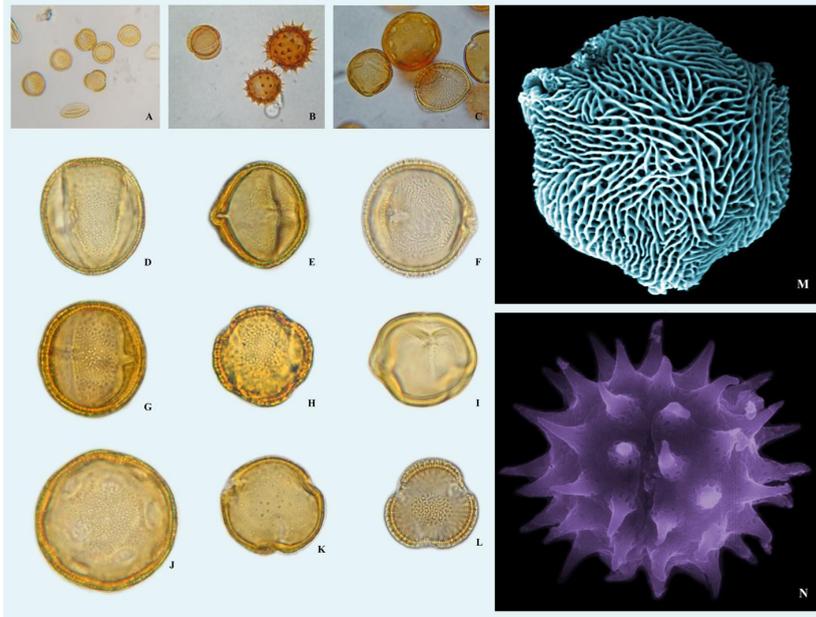


Figure 1. Pollen grains recovered from honey samples produced in Veracruz, Mexico. A. Monofloral honey of *Brassica*, B. Oligofloral honey of *Asteraceae*, C. Multifloral honey (*Quercus*, *Liquidambar*, *Hedyosmum mexicanum*, *Senna*, *Asteraceae*), D. *Coffea arabica*, E. *Oreopanax* sp., F, M. *Bursera simaruba*, G-H. *Citrus sinensis*, I. *Clethra* sp., J. *Liquidambar* sp., K. *Cordia alliodora*, L. *Brassica* sp., N. *Asteraceae*

Keywords: melisopalynology, monofloral, oligofloral, multifloral, honey characterization.



Palynological characterization of the tropical dry forest of northern Bolivar department, Colombia

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Palynology consist of the morphological study of pollen and spores (as well as their dispersion, preservation and applications) present in an ecosystem. Tropical dry forests, despite their category as a critically endangered ecosystem and with 4.5% of their plant species under some threat category, have been little studied with respect to their palynological flora. The objective of this

Keywords: Tropical dry forest, palynology, colombian caribbean, palinotaxonomy, bees, honey



Caracterización palinológica del bosque seco tropical del norte del departamento de Bolívar, Colombia

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La palinología consiste en el estudio morfológico del polen y las esporas (así como su dispersión, preservación y aplicaciones) presentes en un ecosistema. Los bosques secos tropicales, a pesar de su categoría como ecosistema críticamente amenazado y con

project is the palinotaxonomic characterization of plant species present in the tropical dry forest of northern Bolivar department. The material analyzed in this study was collected in localities of Tierra Bomba, Barú and San Jacinto. As preliminary results of the collection, processing and mounting of samples, description of 42 species and 21 families was obtained; which are not reported in current palynological literature available for dry forest in the country; these are among others: 5 Acanthaceae, 2 Asteraceae, 2 Bignoniaceae, 1 Cactaceae, 2 Cappara-ceae, 2 Combretaceae, 2 Convolvulaceae, 1 Cordiaceae, 1 Ehretiaceae, 9 Fabaceae, 1 Gesneriaceae, 1 Lamiaceae, 1 Lecythida-ceae, 3 Malvaceae, 3 Melastomataceae, 2 Myrtaceae, 1 Petiveriaceae, 1 Sapindaceae, 1 Scrophulariaceae, 1 Simaroubaceae, 1 Verbenaceae. We registered a great diversity and dominance at family level, highlighting Fabaceae and Acanthaceae.

el 4.5% de sus especies vegetales bajo alguna categoría de amenaza, han sido poco estudiados respecto a su flora palinológica. El objetivo de este proyecto es la caracterización palinotaxonomica de las especies vegetales presentes en el bosque seco tropical del norte del departamento de Bolívar. El material analizado en este estudio fue coleccionado en localidades de Tierra Bomba, Barú y San Jacinto. Como resultados preliminares de la colecta, procesamiento y montaje de las muestras, se obtuvo la descripción de 42 especies y 21 familias, que no están reportadas en la literatura palinológica actual disponible para bosque seco en el país; entre ellas están: 5 Acanthaceae, 2 Asteraceae, 2 Bignoniaceae, 1 Cactaceae, 2 Cappara-ceae, 2 Combretaceae, 2 Convolvulaceae, 1 Cor-

diaceae, 1 Ehretiaceae, 9 Fabaceae, 1 Gesneriaceae, 1 Lamiaceae, 1 Lecythidaceae, 3 Malvaceae, 3 Melastomataceae, 2 Myrtaceae, 1 Petiveriaceae, 1 Sapindaceae, 1

Scrophulariaceae, 1 Simaroubaceae, 1 Verbenaceae. Se registra una gran diversidad y dominancia a nivel de familia; destacándose Fabaceae y Acanthaceae.

Palabras clave: Bosque seco tropical, palinología, caribe colombiano, palinotaxonomía, abejas, miel



Pollen spectrum of honey and pollen pots of 5 species of bees from the municipality of San Jacinto, Bolívar-Colombia

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Melissopalynology studies the geographical location and botanical origin of honey, based on the pollen spectrum. Pollination services associated with bees are unknown from Colombian tropical dry forest as much as the flora visited by them. Knowledge of the botanical origin of honey (provision ecosystem service), obtained from identification of palynomorphs found in it, allows establishing not only the relative contribution of different plant species, but also help increasing honey production through the cultivation of honey plants in the surroundings of apiaries. In this study, pollen spectrum of honey from 4 bee species (*Tetragonisca angustula* Illiger, *Apis mellifera* Linnaeus, *Frieseomelitta nigra* Cresson and *Scaptotrigona* sp.) and 3 species of pot bees (*Tetragonisca angustula* Illiger, *Apis mellifera* Linnaeus and *Nannotrigona* sp.) was determined from the municipality of San Jacinto, Bolívar. The pollen spectrum identified in these samples corresponds to 22 palynomorphs distributed in 15 families. Families contributing to the greatest number of species were: Fabaceae, Moraceae, Asteraceae. Among

nectariferous species we found: *Coffea arabica* L., *Spondias* sp., *Caesalpinia pulcherrima* (L.) Sw., *Sapium* sp., *Pithecellobium* sp., *Hypochaeris* sp., *Hyptis* sp., *Cordia* sp., *Trophis* sp., *Gliricidia sepium* (Jacq.) Walp., *Trichilia* sp., *Gouania* sp., *Mikania* sp., *Inga* sp., *Citrus* sp. and *Austroeupeatorium* sp. Among species that are not nectar producers we found: *Acalypha* sp., *Poulsenia* sp., *Brosimum* sp., *Cecropia* sp., *Trema* sp. and *Piper* sp. The results of this research will contribute to the identification of honey plants that are visited by bees that produce honey in the region; this information will give added value to the honey extracted and marketed by beekeepers and meliponicultivists in the area.

Keywords: Tropical dry forest, palynology, colombian Caribbean, palinotaxonomy, bees; honey



Espectro polínico de miel y potes de polen de 5 especies de abejas del municipio de San Jacinto, Bolívar-Colombia

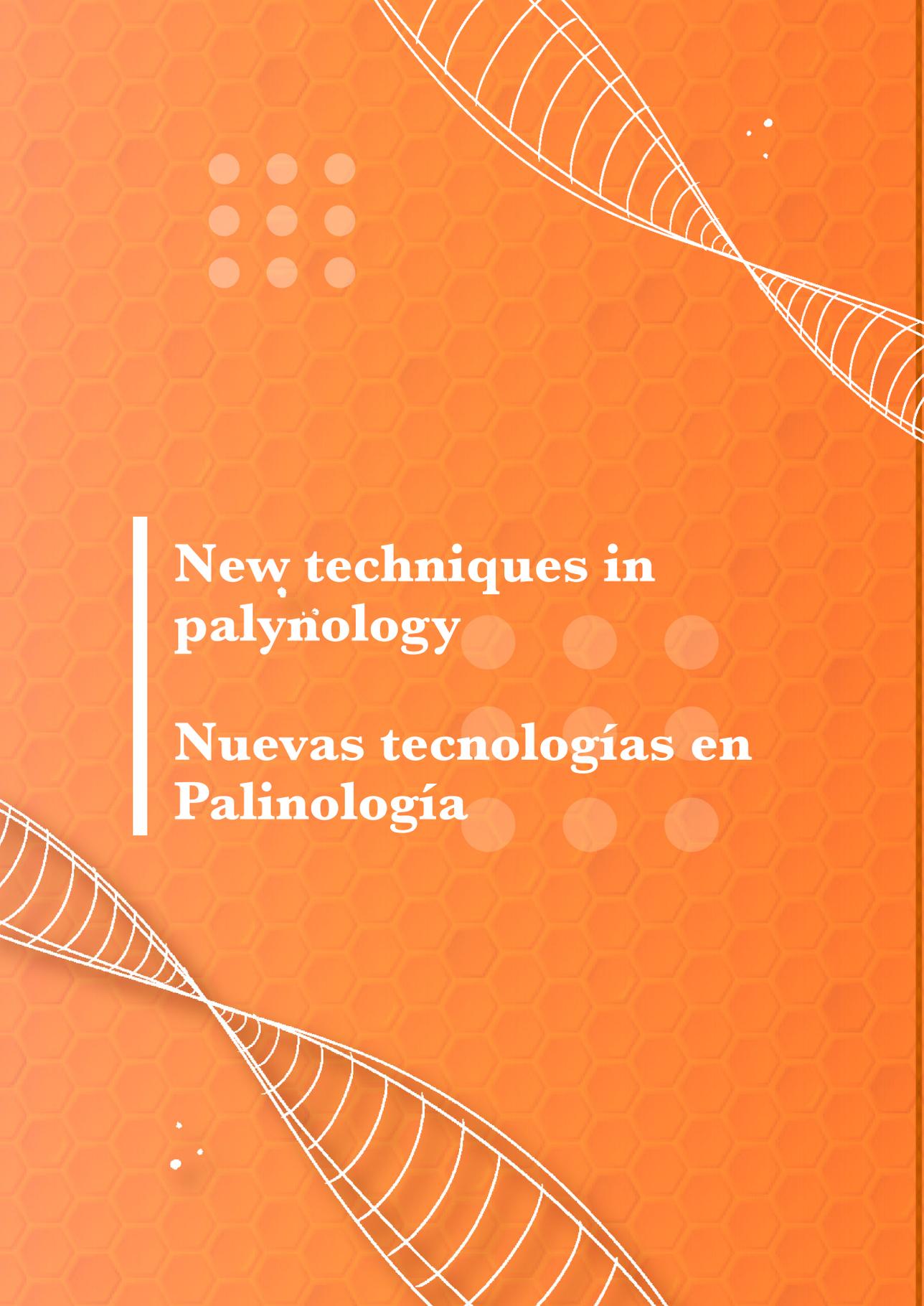
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La melisopalinología estudia la ubicación geográfica y origen botánico de las mieles, a partir del espectro polínico. De los bosques secos colombianos, se desconoce los servicios de polinización asociados a abejas, al igual que la flora que frecuentan. El conocimiento del origen botánico de la miel (servicio ecosistémico de provisión), logrado a partir de la identificación de los palinomorfos que se encuentran en ella, permite establecer no solo la contribución relativa de las diferentes especies vegetales, sino también a aumentar la producción de miel mediante el cultivo de plantas melíferas en los alrededores de los apiarios. En este estudio se determinó el espectro polínico de la miel de 4 especies de abejas (*Tetragonisca angustula* Illiger, *Apis mellifera* Linnaeus, *Frieseomelitta nigra* Cresson y *Scaptotrigona* sp.) y 3 especies de potes de abejas (*Tetragonisca angustula* Illiger, *Apis mellifera* Linnaeus y *Nannotrigona* sp.) procedentes del municipio de San Jacinto, Bolívar. El espectro polínico identificado en

estas muestras corresponde a 22 palinomorfos distribuidos en 15 familias. Las familias que aportaron el mayor número de especies fueron: Fabaceae, Moraceae, Asteraceae. Entre las especies nectaríferas encontramos: *Coffea arabica* L., *Spondias* sp., *Caesalpinia pulcherrima* (L.) Sw., *Sapium* sp., *Pithecellobium* sp., *Hypochaeris* sp., *Hyptis* sp., *Cordia* sp., *Trophis* sp., *Gliricidia sepium* (Jacq.) Walp., *Trichilia* sp., *Gouania* sp., *Mikania* sp., *Inga* sp., *Citrus* sp. y *Austroeupatorium* sp. Entre las especies que no son productoras de néctar encontramos a: *Acalypha* sp., *Poulsenia* sp., *Brosimum* sp., *Cecropia* sp., *Trema* sp. y *Piper* sp. Los resultados de esta investigación contribuirán a la identificación de las plantas melíferas que son visitadas por las abejas productoras de miel de la región; dicha información le dará un valor agregado a la miel extraída y comercializada por los apicultores y meliponicultores de la zona.

Palabras clave: Melisopalinología, bosque seco tropical, caribe colombiano, abejas, miel,



**New techniques in
palynology**

**Nuevas tecnologías en
Palinología**



The palynology of Mars analog acid saline lakes

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Permian red bed-hosted evaporites are regionally extensive in North America, occupying much of the surface and subsurface of the midcontinent region. In the southern USA these rocks are known as the Nippewalla Group (middle Permian, c. 270Ma), consisting of red bed siliciclastic siltstones and sandstones, bedded anhydrite, bedded halite, and minor grey siliciclastic laminated mudstones (Figure 1a, b). The evaporites were deposited in an unusual system of hypersaline ephemeral lakes and saline groundwater systems characterized by low pH, strong winds, and flooding-evapoconcentration-desiccation cycles.

Although high-fidelity data about the sedimentology, water chemistry, and paleotemperatures of these lake systems are known, little is known about the vegetation associated with these extreme equatorial Pangaeian environments. Palynological study of the Nippewalla Group sediments from Oklahoma in the 1960-70s described sporomorph assemblages dominated by semi-xerophytic conifers, peltasperms and tree ferns as well as a subsidiary hygrophytic community of mosses, ferns, algae, lichens and fungi. Because of the presence of halite the depositional environment was interpreted as coastal marine however these studies did not consider non-marine evaporite formation, incentivizing a revised environmental reconstruction.

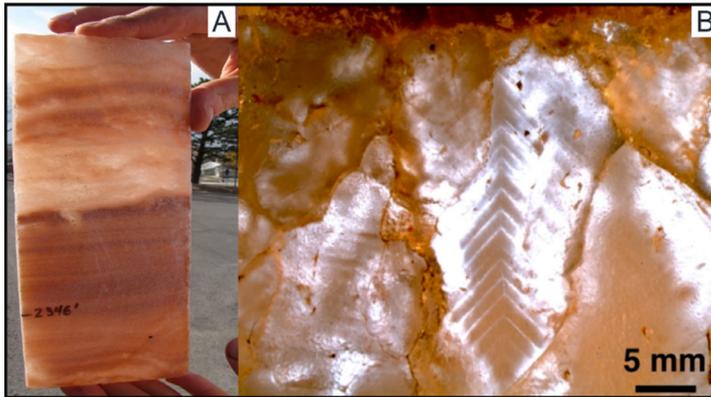
A paucity of well-preserved core through the Nippewalla Group and the dissolution of evaporites at outcrop has led to misinterpretations of the depositional environment, poor correlation with contemporary deposits in Kansas, Oklahoma, North Dakota and Northern Ireland, and a poor understanding of the vegetation. The Rebecca K Bounds (RKB) core (Figure 1a, b), at 99% complete, is an exceptionally stratigraphically complete and well-preserved core from Kansas. The targeted section of core is 700 ft of red siliclastics and bedded and displacive halite and gypsum belonging to the Nippewalla Group. Preliminary palynological study of the RKB bedded halite by examining thin sections has revealed excellent preservation of sporomorphs and plant cuticle as well as prokaryotes, algae, and organic compounds both within fluid inclusions and as solid inclusions. This suggests that the Nippewalla Group evaporites are a good trap for a variety of organic material and worthy of palynological study.

A 2-year study, funded by the Lindemann Trust, will assess the paleobotanical content of the Nippewalla Group evaporites to provide a new understanding of plant life in these warm, arid environments. The research will investigate: (1) How laterally extensive and long-lived were these extreme acid saline settings in Pangaea? (2) How might Pangaeian extreme environments and

climates have contributed to the end-Permian mass extinction? and (3) Can these rocks and their microfossil preservation inform us about how to best search for signs of life on Mars?

Sedimentological and mineralogical similarities between the Nippewalla Group and rocks on Mars (including Meridiani Pla-

num, Gusev Crater, and Gale Crater) make these Permian red beds and evaporites the best-known terrestrial analogue for Martian sedimentary rocks. A better understanding of how the Nippewalla Group evaporites preserve a variety of environmental information will help inform the search for signs of life in extra-terrestrial evaporites.



Keywords: Permian, palynology, evaporites, Mars, astrobiology



**Palynology is now digital.
Neotropical pollen
collection is the first stage
of a new era**

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STRI has the most complete collection of extant neotropical pollen in the world. Approximately 25.000 slides contain the pollen of 20.000 modern plant species collected by Professor Alan Graham. Information on each species is found on index cards including taxa name, family, the herbarium where it was collected from, how it was processed and additional information. Currently, this collection can only be used visiting the STRI Ancon facilities. However, we intend to revolutionize the traditional way that has been used for years in the study of pollen through the acquisition of high-resolution photographs, providing a digital tool that allows future students and researchers to access this information remotely even from their homes.

In the first stage of digitization, we transcribed the 25.000 index cards into a digital format. This process was done by the SI Transcription Center and its hundreds of volunteers. Each slide will have a QR code which generates a direct link to its metadata. The next stage is the digitization of the pollen grains. For this purpose we are using three light microscopes (Zeiss y Nikon) with a motorized stage computer controlled and a Zeiss microscope which employs a technique based on confocal laser scanning microscopy Airyscan. 20 grains per slide will

be digitized using an objective of 63 X (NA 1.4) and between 80 - 140 focal planes per grain will be taken in three different techniques including bright light, differential interference contrast and confocal Airyscan. Selected grains will be digitized using Confocal AIRYSCAN. This technology uses fluorescence spectral lines with different wavelengths allowing a resolution of 120 nm, reaching a higher resolution compared to traditional bright field microscopy.

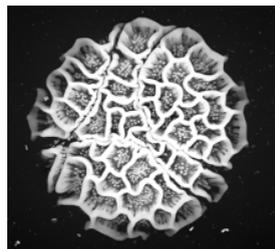
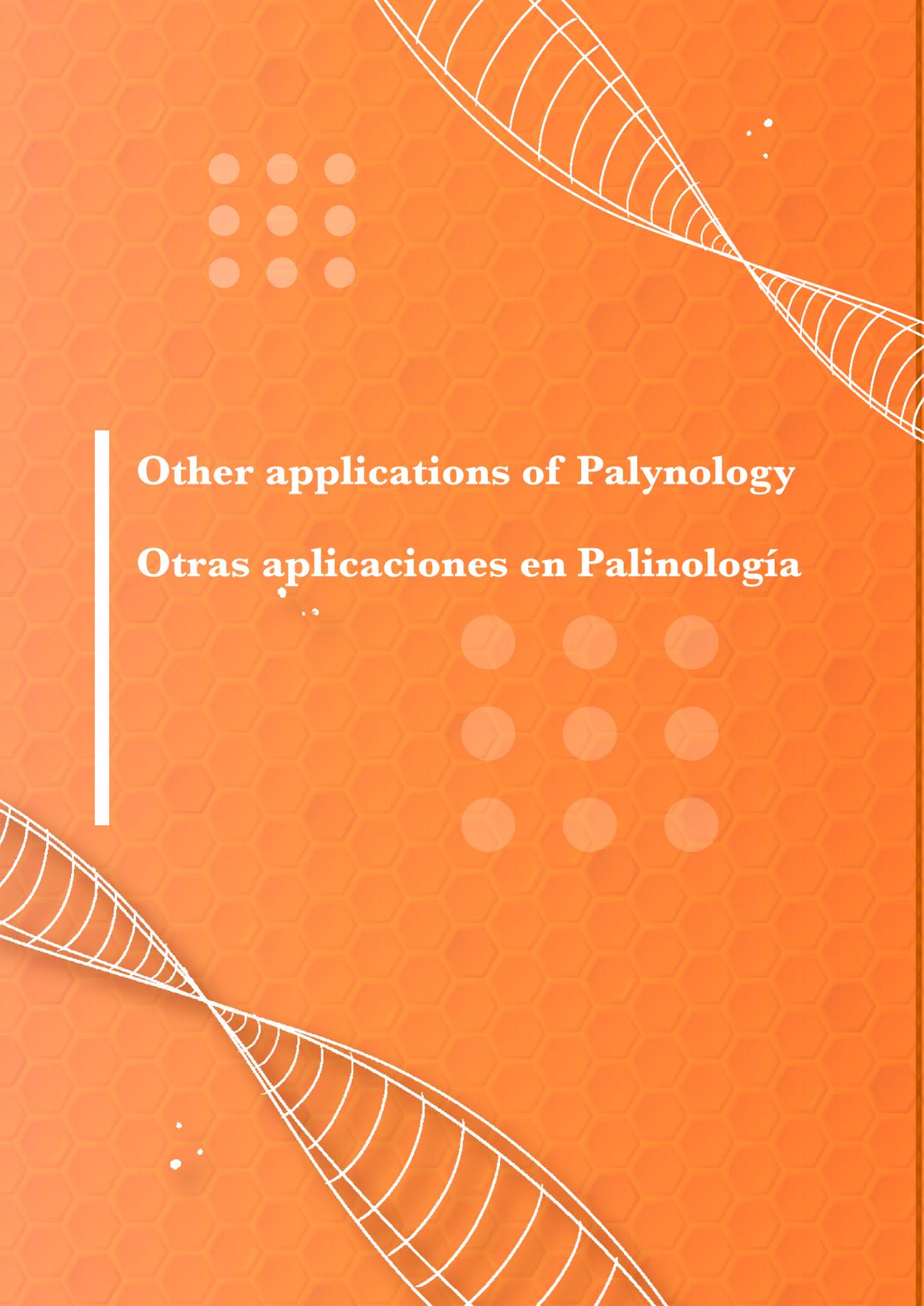


Fig. 1. *Passiflora cubalensis*. Zeiss LSM 980

The last stage for the management and visualization of the digitized material is the use of software called OMERO (open microscopy environment). This is an open source free software developed in Europe and used across many institutions in the world. We believe that this type of collections should be used right now, in a simple way and easily accessible from anywhere in the world. Additionally, the glycerin mounting method favors a high decay rate, therefore it is necessary to digitize it as soon as possible. These images will be used as a training center for a neural network to help in the process of identifying the morphological characteristics of each pollen grain using artificial intelligence. Although it represents an arduous task, the digital world is a reality and palynology must be a tool that is not excluded from this technological advance.

Keywords: collection, neotropical, pollen, digital, revolutionize



Other applications of Palynology

Otras aplicaciones en Palinología



Pollen morphology in
ornamental species of the
genera *Aeschynanthus*,
Columnnea,
Nematanthus, *Sinningia*
and *Streptocarpus*
(Gesneriaceae)

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Ornamental species are cultivated due to beauty of their flowers and leaves, this species are different from native species mainly in the flowering, shape and color of the flowers and leaves, which are normally structures with more vibrant colors than the native ones. The size and habitat of ornamental plants are much variable, from lawns, aquatic environment plants or even large trees. The number of families that contain ornamental purpose is enormous, and one of them is the Gesneriaceae. This family is widely distributed mainly in tropical regions and has 160 genera and 3,600 species, many of which have great potential for ornamental use or are already considered as such. Being the genera *Episcia* Mart., *Columnnea* L., *Sinningia* Ness., *Streptocarpus* Lindl., *Aeschynanthus* Jack., *Codonanthe* (Mart.) Hanst, *Gloxinia* L'Hérit, *Nematanthus* Schrad. and *Nautilocalyx* Linden well known by groups that sell ornamental plants. The present study had as objective the pollen morphology characterization of

11 ornamental species of Gesneriaceae: *Aeschynanthus* (one species, *A. pulcher* (Blume) G. Don. known as “columéia batom”), *Columnnea* (two species, *C. spp.* - “columéia” and *C. hirta* - “*columnnea* maravilhosa”), *Nematanthus* (one species, *N. wetsteini* (Fritsch) H.E. Moore - “peixinho, columéia-peixinho”), *Sinningia* (one species, *S. speciosa* (Lodd.) Hiern. - “*gloxinia*”) and *Streptocarpus* (six species, *St. ionantha* H. Wendl. - “african violets”). The pollen material was obtained from flowers shops, collected, herborized and deposited in an herbarium. Pollen grains were acetolyzed, measured ($n = 25$), and photographed under light microscopy. Qualitative data were described for the definition of pollen types and quantitative data were analyzed with statistical treatment appropriate to the size of the samples. The pollen grains presented in monads, isopolar, small, small to medium and medium with circular to subcircular amb, subprolate, prolate, and spheroidal prolate shape, 3-colporate, narrow and long to very long colpi, very small to small polar area, endoapertures circular to lolongate, exine very thin to thick, microreticulate (in *Aeschynanthus pulcher*, *Columnnea* spp., *Columnnea hirta* and *Sinningia speciosa*), reticulate (in *Streptocarpus ionantha*) and reticulate in the mesocolpus and microreticulate in the apocolpus in pollen grains *Nematanthus wetsteini*; sexine thicker than nexine. Despite the similarity of the morphopollinic characteristics observed in the analyzed species, it is noticed that the ornamentation pattern of the exine of the pollen grains allows the distinction of the species of the studied genera.

Keywords: acetolysis, cultivated plants, flowers, palynology, pollen grains



Preliminary qualitative
pollen grains data from
the clade “Paradrymonia
alliance” and *Nautilocalyx*
Linden ex Hanst.
(Gesneriaceae)

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Columnneinae is the largest and most diverse subtribe of Gesneriaceae. Historically, many genera of Columnneinae have been characterized by synapomorphies or by a combination of simpleiomorphic characters. Consequently, this generated the formation of unnatural groups like “*Paradrymonia* alliance” clade, requiring further studies on the morphological and molecular characteristics of the representatives of the subtribe. The aim of the present study is characterized and described the pollen morphology of the “*Paradrymonia* alliance” clade, to search for pollen data that characterize the subclades and including the paraphyletic genus *Nautilocalyx* Linden ex Hanst. Pollen grains were acetolyzed, measured and photographed under light microscopy. The preliminary results of the 12 species analyzed so far demonstrate the pollen grains are monads, is-polar, medium to large, with small variation of amb (circular, subcircular, circular-lobate

or subtriangular), small to very large polar area, with shape variation (suboblate, oblate-spheroidal, prolate-spheroidal, subprolate or prolate) even within the same sample. Tricolporate aperture, circularaperturate or fossoaperturate; wide to narrow, short to long ectoaperture, with margo, sometimes the ectoaperture are so long that they are found to form structures similar to syncolpores, rounded or tapered ends, ectoaperture membrane ornamented, circular or lolongate endoapertures, exine semitectate with microreticulate or microreticulate-reticulate ornamentation (with differentiation of apocolpus and mesocolpus), sexine is thicker than nexine. The previous results demonstrate a diversity of pollen grains of “*Paradrymonia* alliance” clade, which certainly helps and support the new taxonomic changes in the clade. The results also confirm Columnneinae (Gesneriaceae) as eurypalynous.

Keywords: Central American, *Chrysothemis*, Columnneinae, Palynotaxonomy, pollen types



Stones Field well WR
508 #1, Gulf of Mexico
palynology: a *Momipites*-
dominated environment
for this deepwater Wilcox
Group

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Palynological analyses of Late Paleocene to Middle Eocene drill cutting samples from the deepwater Wilcox Group in the northern Gulf of Mexico has yielded mainly low diversity terrestrial assemblages dominated by triporate pollen referable to the Betulaceae/Myricaceae and fossil pollen presumed to be of Juglandaceous affinity. The 69 drill cutting samples were recovered from Walker Ridge (WR) 508 #1 in the Stones field, with a measured depth ranging from 8,056 to 8,723 m. Age control has been provided by publicly available Bureau of Ocean Energy Management (BOEM) biostratigraphic reports. Plant and fungal spores, pollen, dinoflagellate cysts, acritarchs, and other palynomorphs have been identified and imaged using light microscopy, phase contrast microscopy, and differential interference contrast microscopy. Key pollen taxa recovered in addition to the Betulaceae/Myricaceae types, are from the Juglandaceae and Taxodiaceae families. Biostratigraphically useful species include *Momipites waltmenensis*, *Momipites wyomingensis*, *Momipites coryloides*, *Momipites ventifluminis*, *Mo-*

mipites leffingwellii, and *Momipites annellus*. Key *in situ* dinoflagellate cysts recovered include *Spiniferites* sp., *Operculodinium* spp., *Polysphaeridium* spp., *Heteraulacacysta* c.f. *campanula*, and *Lingulodinium machaerophorum*. Palynological concentrations in specimens/gram are calculated using *Lycopodium* markers. Concentrations are generally low throughout the section analyzed so far, with terrestrial palynomorphs more common than marine dinoflagellates, suggesting a high depositional rate diluting the marine organic fraction in turbidity currents. Reworked Mesozoic-age dinoflagellate cysts are frequent in some of the intervals sampled. This abundance of reworked specimens is complicating the palynological and biostratigraphic evaluation as care must be taken to use only *in situ* taxa to reconstruct paleo sea-surface conditions and environment. This deepwater record will be correlated to previously published palynological assemblages from coeval onshore outcrops.

Keywords: Paleocene, Eocene, Gulf of Mexico, pollen, dinoflagellate, Wilcox



Data analysis of pollen rain and atmospheric transport: Study of the pattern for the Fontes do Ipiranga State Park

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Studies of modern pollen rainfall constitute an important tool to determine the relationships between pollen grains, vegetation, geographic area and dispersion, associated with the atmospheric transport of pollen grains. They allow marking current environmental parameters as proxy data for paleoenvironmental reconstitution studies. Pollen rain data are still scarce in Brazil, a large part of the studies carried out in the domains of the Atlantic Forest, the Amazon Forest, Cerrado and Caatinga, contributes with data for the diversity of the neotropical palynoflora. Other studies aim to correlate the occurrence of different taxa with the landscape, and most of them indicate that there is a very close spatial correspondence between them. However, in some modern pollen rain from southern and southeastern Brazil, the presence of pollen grains from the Betulaceae family is evident, whose source area is the Andean region. The occurrence of pollen grains of the Betulaceae family is also verified in studies of paleoenvironmental reconstitution of the Quaternary, in core samples, demonstrating a pattern of dispersion by currents of long distances throughout the period until the present day. The present study aims to characterize the patterns of occurrence of pollen grains in relation to the vegetational context and atmospheric

currents, aiming to provide complementary data to the study of pollen dispersion at local and regional scales. This work presents partial data on pollen rain, collected in the Fontes do Ipiranga State Park (PEFI), a remnant of the Atlantic Forest in the southern metropolitan region of São Paulo. Four Old Field artificial pollen traps were installed in the PEFI during the spring-summer of 2008/2009 and the autumn-winter of 2009. The areas of insertion of collectors present a phyto physiognomy with different successional stages, in which P1 corresponds to the open area anthropized, with plantation of Pau-Brazil; P2 and P3 vegetated area with woodland and underwood and in P4 with the most preserved forest vegetation. Pollen analyzes are being carried out according to criteria established in the literature and neotropical pollen catalogs. The retro-trajectory analysis of the air masses that reached the atmospheric column of the study site, at different altimetric levels (4000, 2500, 1500, 500 m), were based on the HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model. As partial results, the following stand out: P1 (spring-summer and autumn-winter), the highest incidence of non-arboreal pollen grains (Poaceae and Arecaceae), corresponding to the dominant vegetation around the collector. P2

(spring-summer) had the highest incidence of arboreal pollen grains (Euphorbiaceae and Melastomataceae), native representatives of the Atlantic Forest, in addition to Pinaceae, a family introduced in the local vegetation, and Betulaceae (*Betula* L.), of Andean origin. The study reveals two contexts so far: 1) a close correspondence between the vegetation around the collectors and the local atmospheric currents, in which in P1 there is a predominance of non-arboreal pollen grains and in P2 there is a predo-

minance of arboreal pollen grains and; 2) a remote vegetation source area and long-distance atmospheric currents, departing from different regions of South America, transporting pollen grain from the Betulaceae family to the park. Thus, from the integrated analysis of pollen rain data and atmospheric data, it is intended to develop a conceptual model in order to describe the main patterns of palynomorph dispersion in relation to vegetation source areas and local and regional atmospheric circulation currents.

Keywords: Pollen rain, dispersion, neotropical region, atmospheric currents



Pollen morphology in *Dryades* Groppo, Kallunki & Pirani, a new genera of Rutaceae, and related species

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Rutaceae is positioned in Sapindales with approximately 2040 species in 150-170 genera, and two subfamilies, Cneroideae and Rutoideae, the latter being composed of two subtribes, Pilocarpinae and Galipeinae. Galipeinae species have particular morphological characteristics such as predominantly zygomorphic flowers with more or less tubular corolla and reduced number of fertile stamens. In this subtribe *Conchocarpus* J.C.Mikan is the one with the highest number of species and it is circumscribed by a combination of character states, that is, wi-

thout exclusive characteristics, which makes it a polymorphic genus and yours species were closer to species from other genera, such as *Andreodoxa* Kallunki, *Angostura* A.St.-Hil. and *Erythrochiton* Nees & Mart., than to each other. A recent study using different data proposed a new genus *Dryades* Groppo, Kallunki & Pirani, formed by some species of *Conchocarpus*. Thus, the aim of this study is to describe the pollen morphology of *Dryades* species and phylogenetically related species, in order to present data that can corroborate this new position of the

five species of *Conchocarpus* to a new genus. The pollen grains of 12 species were studied (*Andreodoxa flava*, *Angostura bracteata*, *Conchocarpus macrophyllus* [*Conchocarpus sensu stricto*], *Dryades concinna*, *D. cyrtantha*, *D. gaudichaudiana*, *D. insignis*, *Erythrochiton brasiliensis*, *Galipea jasminiflora*, *Galipea laxiflora*, *Rauia nodosa* and *Rauia resinosa*). The pollen grains were acetolyzed, measured, described qualitatively, and illustrated using light microscopy (LM) and scanning electron microscopy (SEM). The results showed that the pollen grains of phylogenetically close species differ mainly in terms of shape, number and type of apertures and ornamentation. *Dryades* spe-

cies are more similar to *Conchocarpus sensu stricto* species than to nearby genera. The pollen grains of *Dryades* species are monads, isopolar, medium (*Dryades concinna*) to large, subcircular or subtriangular amb (*D. gaudichaudiana*), small (*D. concinna*), large or very large (*D. gaudichaudiana*) polar area, prolate or subprolate (*D. insignis*), 3-colporate, long or very long (*D. gaudichaudiana*) and narrow colpi, lalongate endoapertures and microreticulate (*D. cyrtantha*) or reticulate exine.

Keywords: palynology, palynotaxonomy, pollen grains



Palynotaxonomy of *Columnea* L. (Gesneriaceae)

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Gesneriaceae is composed of 3500 species recently classified in the Euasterid group I, in Lamiales. Although the species of the family has a worldwide distribution, the center of diversity is from Colombia to Ecuador, the Central American region and southeastern Brazil. This study aimed to contribute to the pollen morphological characterization of the species, identifying pollen data

that can help in the taxonomy and expanding the knowledge about the pollen diversity of the genus studied. The analyzed species are: *Columnea crassa* C.V.Morton, *Columnea dictyophylla* Donn.Sm., *Columnea domingensis* (Urb.) BDMorley., *Columnea ericae* Mansf., *Columnea linearis* Oerst., *Columnea picta* H.Karst. and *Columnea schiedeana* Schltdl.. Pollen materials were collected at the Herbarium of São Paulo (SP), São Paulo, Brazil. The pollen grains were acetolyzed, measured and photo digitized later. Qualitative data were described. We observed pollen grains in monads, isopolar, medium to large, with subcircular, subtriangular, and hexagonal amb, planoperturate or angulaperturate, 3-colpate or 3-colporate, wide or long colpi with margo, lalongate endoaperture, microreticulate or reticulate ornamentation, ornate colpi membrane, nexine thicker than sexine. The results obtained allow us to differentiate the species analyzed by the pollen characteristics. The pollen diversity found in

the species analyzed so far allows classifying *Columnea* as eurypalynous, confirming the

morphological diversity of the Columneinae subtribe.

Keywords: Columneinae, eurypalynous, pollen grains



Modern Pollen rain at different altimetric levels in seasonal extremes of the southern portion of the Metropolitan Region of São Paulo, Brazil: evaluation and proposal of a dispersion model

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The present study aim to analyze the modern pollen rain from a vertical profile of 30 m above the ground, in order to verify the pollen contribution of a fragment of Atlantic forest (São Paulo, Brazil), in relation to local and remote vegetation sources, considering the seasonal climatic conditions (winter and summer) and the transport mechanisms that influence the dispersion and deposition of pollen grains in the vertical profile. Regarding the remote transport, there is a special interest in the deposition of pollen grains of the Betulaceae family in the region, being of Andean origin and characteristic of the neotropical mountain flora, adopted as a marker of altitude. Previous studies indicate the presence of pollen grains of the genera

Betula L. and *Alnus* Mill. in the region. The first one originates mainly in the southern portion of South America and the second along the Andes, which may be related to different long-distance transport patterns. In addition to the spatio-temporal dynamics of the emitting sources, altimetry profiling aims to understand how the deposition of pollen grains takes place at different altimetric levels in response to climatic seasonality, with summer being characterized by more unstable atmospheric conditions (convection) and abundant rainfall as opposed to winter when more stable conditions and less rainfall prevail. The samples were collected with “Oldfield” type artificial traps at three altimetric levels (surface, 15 m and 30 m) from the RADAR tower of Parque Cientec (IAG-USP), located in the Fontes do Ipiranga-PEFI State Park, in the southern portion of the Metropolitan Region of São Paulo, in the period of one year, between the winter of 2017 and the autumn of 2018. The processing of the samples was carried out at the Laboratory of Paleocology and Landscape Ecology of UNIFESP. Seasonal climate and local transport characterization will be carried out using data from the Meteorological Station of the IAG-USP, and the evaluation of long-distance air currents will be based on the analysis of retro-trajectory of the Hybrid Single Particle Lagrangian Integrated Trajectory Model-HYSPLIT. The integrated analyzes of the data will allow to propose a model of local and regional pollen grain dispersion, considering the source areas of the vegetational domains, near and

remote atmospheric currents, will provide important information for the study of the Quaternary.

Keywords: Pollen rain, altimetric profiling, model dispersion, neotropical region



Previous pollen data of Ornamental Brazilian Plants

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Ornamental plants are widely appreciated and cultivated as an ornament in landscape sectors because they are generally species that present intense, attractive and exotic flowers, thus making them widely used in landscaping in large urban centers as in gardens, public spaces and residential areas. These are plants that present a great diversity of floral visitors, which use the resources present in the flowers to obtain substances that will be used in food, with the bee being one of the main pollinating agents responsible for this process, making use of nectar for energy demand and pollen for protein, and it can also carry out fertilization and guarantee the reproduction of plant species, contributing to an increase in the genetic variability of plants. The aim of the present study is to characterize the pollen morphology of ornamental Brazilian plants: *Angelonia angustifolia* (white and purple), *Pentas lanceolata* (pink and red) and

Lysimachia congestiflora, belonging to the respective families of Plantaginaceae, Primulaceae and Rubiaceae. The pollen grains were acetolyzed, and later measured ($n = 25$) and photographed with the aid of light microscopy and scanning electron microscopy. Quantitative data will be used to describe pollen types and qualitative data will be statistically analyzed in an appropriate way for the sample size. The results of the five species analyzed showed that the pollen grains are considered monads, isopolar, small to medium in size, with a small variation of amb (subtriangular, circular or subcircular), a very small polar area, subprolate or spheroidal prolate shape, 3-colporate with narrow colpi. They present very long apertures and lalongate or lolongate endoapertures. The exine is semitectate, reticulate, with variations between extra thin, very thin and thin; sexine thicker than the nexine.

Keywords: floral resources, floral visitors, landscaping, ornamental plants, pollen types.



Palynotaxonomy
in species of
Trichosporeae
(Didymocarpoideae,
Gesneriaceae)

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Trichosporeae (Didymocarpoideae, Gesneriaceae) comprises 10 subtribes, 71 genera and 2400 species, distributed in Europe through Africa and S and SE Asia to the Pacific. This large tribe is considered the most complex in terms of its taxonomic classification among the Gesneriaceae. In this way, the present study aimed to analyze and describe the main characters of taxonomic value of pollen grains of 15 taxa representing four subtribes of Trichosporeae, namely: Ramondinae (*Ramonda myconi* (L.) Rchb. and *Ramonda nathaliae* Pinc & Petrov.), Streptocarpinae (*Streptocarpus caulescens* Vatte, *Streptocarpus gardenii* Hook., *Streptocarpus ionanthus* subsp. *grotei* (Engl.) Christenh., *Streptocarpus kirkii* Hook.f., *Streptocarpus saxorum* Engl. and *Streptocarpus variabilis* Humbert), Loxocarpinae (*Boea hygroskopica* F. Muell.) and Didymocarpinae (*Aeschynanthus speciosus* Hook., *Aeschynanthus tricolor* Hook., *Cyrtandra lagunae* Kraenzl., *Deinostigma tamiana* (B.L.Burt) D.J.Middleton & H.J.Atkins, *Didymocarpus cinereus* D. Don and *Primulina flavimaculata* (W.T.Wang) Mich.Möller &

A.Weber). The pollen material was obtained from specimens deposited in herbaria G and Z and from species cultivated in the Botanical Garden of Geneva, Switzerland and Greenhouse of Sítio Primavera, Brazil. Pollen grains were acetolyzed, measured and photographed under light microscopy. The sexine sculpture and exine structure of some species were electrographed and analyzed by scanning and transmission electron microscopy, respectively. Quantitative data were analyzed using descriptive and multivariate statistics. Structural and ultrastructural qualitative data of pollen grains were described. The species analyzed present pollen grains in monads; isopolar; small or small to medium (in *Streptocarpus saxorum*); amb circular, subcircular, subtriangular, triangular or quadrangular (or triangular, in *Streptocarpus variabilis*); polar area very small, small or large; shape suboblate, oblate spheroidal, prolate spheroidal and subprolate; 3-colporate, 3(4)-colporate (in *Primulina flavimaculata*) or 4(3)-colporate (in *Streptocarpus variabilis*), ectoaperture angulaperturate ou



fossaperturate (in *Ramonda nathaliae*), colpi short, long or very long, narrows, ends of colpi rounded or tapered, absence of membrane ornamented in species of *Ramonda* (*Ramondinae*), with margo, endoaperture circular (in *Streptocarpus caulensis* and *S. ionanthus* subsp. *Grotei*), lalongate (in *Ramonda myconi*) or lolongate (other species); exine tectate perforate (in *Boea hygroskopica*), nanoverrucate-nanoechinata (in *Deinostigma tamiana*), semitectate reticulate (in *Streptocarpus ionanthus* subsp. *grotei* and *Aeschynanthus tricolor*), semitectate microreticulate (in species of *Ramonda*, *Streptocarpus caulensis*, *S. kirkii*, *S. saxorum* and *S. variabilis*, *Aeschynanthus specio-*

sus, *Cyrtandra lagunae*, *Didymocarpus cinereus* and *Primulina flavimaculata*) and microreticulate-scabrate (in *Streptocarpus gardenii*); exine thin, tectum discontinuous and wavy as thick as nexine in *Deinostigma tamiana*, sexine thicker than nexine. Therefore, the pollen characters of *Trichosporeae* species show differences, mainly in relation to the amb, shape, number of apertures and exine ornamentation. Thus, our data indicate *Trichosporeae* as eurypalynous.

Keywords: floral resources, floral visitors, landscaping, ornamental plants, pollen types.







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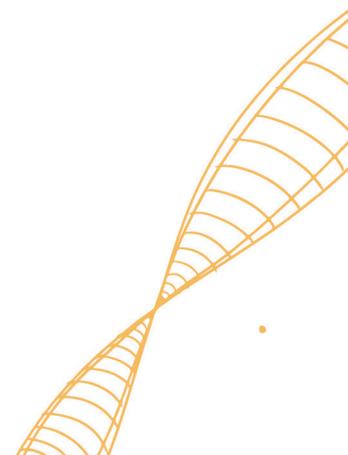


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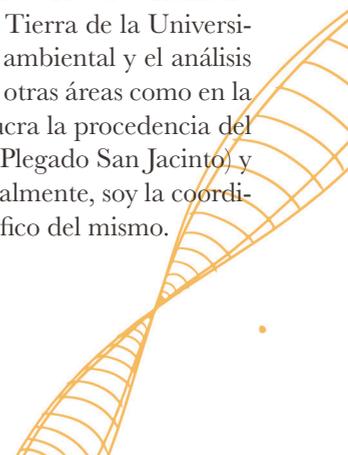
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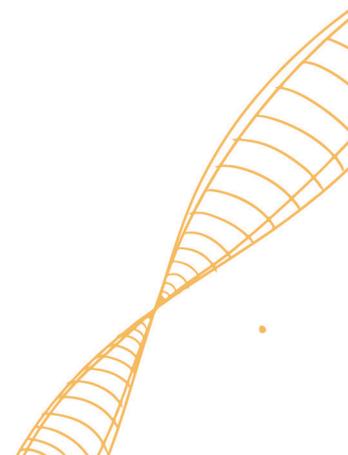


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