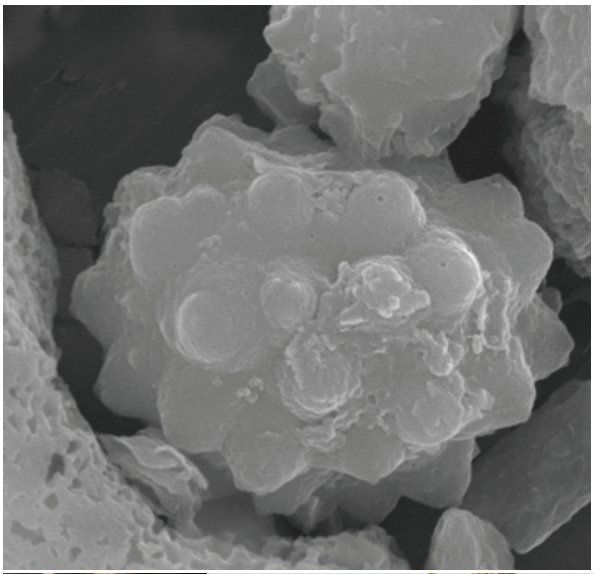
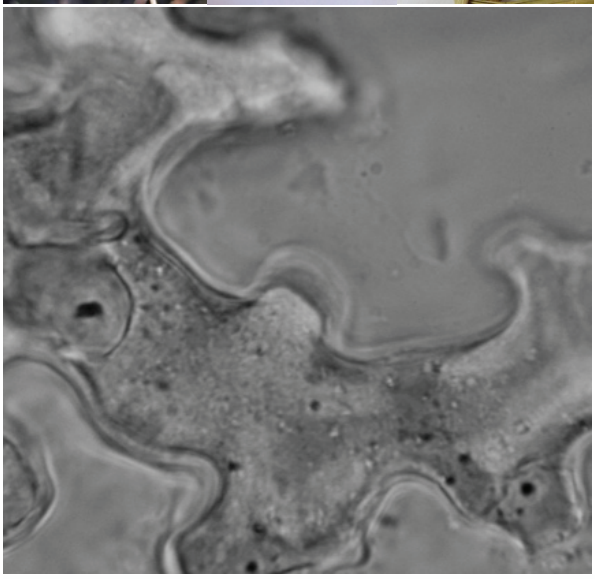


10th International Meeting on Phytolith Research

20 years of a multi-facetted research



Abstract Volume

September 12 - 14, 2016
Aix en Provence, France

Images on the cover, top to bottom:

SEM photograph of a globular echinate phytoliths, diagnostic of palms (Arecaceae).

Photographs of some African plant species analysed for their phytolith content.

Zoom on the tip of a silica plate that was >100 wide, extracted from the leaves of the fern species *Adiantum thalictroides*.

Rice field in Karnataka, South India

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Marco Madella,

Caroline Strömberg,

Carole Perry,

Zhaoliang Song,

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Dan Cabanes

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Phytoliths in archaeology: new approaches and discoveries

Phytoliths and threshing processes

Patricia C. Anderson * [1], Souhair Alkalesh [2]

[1] CEPAM – CNRS UMR7264, Université Nice Sophia Antipolis – Pôle Universitaire Saint Jean d'Angély - Nice, France
[2] CEPAM, GRENES – CNRS UMR7264, Université Nice Sophia Antipolis – Pole Universitaire Saint Jean d'Angély - Nice, France

Agricultural techniques can shed light on cultural identity, as well as economic use of plant products. Over nearly 20 years we've been finding phytolith spodograms with smooth, straight cuts in archaeological samples from the near Eastern Neolithic, Chalcolithic, and Bronze Age from mudbrick, in storage structures, and directly on threshing floors. Similar observations were made for a limited number of Western and Eastern European samples. To what extent do these special cuts really characterize the threshing sledge as opposed to other techniques? We have studied phytoliths produced by the use of different kinds of threshing sledges in Syria and Tunisia, as well as those produced by animal trampling there. In each case the threshing sledge produced a particular assemblage including smooth cut spodograms, as did our experiments with a reconstructed Bronze Age threshing sledge. We compare these assemblages with those from trampling, bearing in mind that trampling is a component of threshing sledge use. Finally we have looked at phytoliths produced by flailing, chopping straw on the ground, cutting it against a sickle and harvesting crops. All the latter can produce cut phytoliths but these are more jagged, and rare or absent. A statistical study (described in the poster session) focused on the morphology of these cuts, found that 2 types of cut morphology and orientation were only found in threshing sledge assemblage. Our criteria were used to study a Neolithic site in Syria, Chalcolithic sites in Syria, Israel, and Romania, and Bronze Age sites in Syria, showing the threshing sledge was producing chopped straw that was stored, or used in mudbrick, as well as undoubtedly to fuel ovens. The need for building mudbrick structures may have driven the use of the threshing sledge to quickly produce a fine grade of chopped straw. Phytoliths also showed evidence as to the harvesting and winnowing techniques, and in some cases whether harvesting, threshing, winnowing, and storage were taking place at the site, or elsewhere.

Keywords: threshing, threshing sledge, phytolith analysis, Neolithic, Chalcolithic, Bronze Age, Near East, ethno archaeology, experimental archaeology

*Speaker

Preliminary results of phytolith analyses from a geoarchaeological study of historic settlement of Kota Cina, North Sumatra (Indonesia)

Yohan Chabot *† [1], Aline Garnier‡ [2], Nicole Limondin-Lozouet [1], Yann Le Drezen [1]

[1] Laboratoire de géographie physique (LGP) – CNRS : UMR8591, Université Paris 1 - Panthéon-Sorbonne – bat. Y 1 Place Aristide Briand 92195 MEUDON CEDEX, France
[2] Laboratoire de géographie physique (LGP) – CNRS : UMR8591, Université Paris XII - Paris-Est Créteil Val-de-Marne (UPEC) – bat. Y 1 Place Aristide Briand 92195 MEUDON CEDEX, France

Since the 1980s the number of phytolith studies on palaeoenvironment research in archaeological contexts has risen. However, world wide, few historical and archaeological reports contain this data. In this project we report on data from North Sumatra (Indonesia). The geoarchaeological study undertaken at Kota Cina (North Sumatra) is a first effort that aims to reconstruct the environments of the last 1000 years with regard to human settlements. The ancient port of Kota Cina, located in an estuarine environmemt, was active between the XIth-XIVth centuries. Today the site is located 7 km from the coast, in marshy lowland near a *Nypa fruticans* (palm) mangrove. Kota Cina deposits provide a range of well-preserved and abundant phytoliths, particularly from the Arecaceae (palms). The analyses of these micro-fossils allows us to: (1) document vegetational changes in a coastal environment at Kota Cina and (2) to reconstruct human influences on the environment during site occupation (e.g., vegetation clearing and cultivation). Investigations typically combine modern and fossil phytolith sampling. Fifteen modern samples from different environments at Kota Cina and surroundings were analysed to establish a modern reference collection of the local current vegetation and to compare the modern phytoliths with fossil assemblages. For the palaeoenvironmental approach, twenty-five samples were taken in the stratigraphic sequence of Kota Cina. Two archaeological excavations and one sediment core were analyzed. The preliminary results show differences between the north and south paleovegetation of Kota Cina. During human settlement, Kota Cina habitation was a terrestrial environment in the South. The vegetation was more open than in north. Oryza, Zea mays, Musa morphotypes occurred and Arecaceae phytoliths are abundant. The occurrence of these edible plants in association with burned phytoliths and habitat remains indicates changes in the vegetation caused by human practices. To the north, the vegetation was denser and Arecaceae morphotypes are dominant. The area was at the edge of a peninsula in an estuarine environment probably covered by mangrove. Boat remains, paleochannels, Arecaceae phytoliths, mangrove species wood remains, anthropogenic mangrove, marine shell, and marine's vertebrate bones, indicate a marine environment and sailing activities.

Keywords: Geoarchaeology, Paleoenvironment, Phytoliths, Stratigraphy, Arecaceae

*Speaker
†Corresponding author: yohan.chabot@hotmail.fr
‡Corresponding author: aline.garnier@u-pec.fr

Early Neolithic flint miners' diet insights in the Iberian Peninsula through an integrated archaeobotanical study

Alexandre Chevalier *† [1], Susana Consuegra [2], Pedro Díaz-Del-Río [2]

[1] Royal Belgian Institute of Natural Sciences – 29, rue Vautier 1000 Bruxelles, Belgium
[2] Centro Superior de Investigaciones Científicas (CSIC) – Calle de Albasanz, 26-28 28037 Madrid, Spain

The Casa Montero site is located in the center of Spain, southeast of Madrid, at the edge of a plain that overlooks the confluence of two rivers, the río Henaras and Jarama. It consisted of a huge spread of by-products of flint industry and flint blades production, as well as 3794 shafts for flint nodules extraction of which 338 have been investigated, providing us with valuable information on the first Neolithic societies of the Iberian Peninsula. Indeed, based on 14C datating on bones and oak (*Quercus coccifera* L.) the use of the site has been dated precisely between 5300 to 5200 BCE, which would mean only four to five generations.
The majority of the archaeological material recovered corresponds to lithic remains from the extraction and transformation of flint. However, some pottery was also found, along with bone objects, animal remains, charcoal, lumps of pigment and certain mobiliary art, all typical of the Early Neolithic in the Iberian peninsula. Many of the shaft fillings at Casa Montero included a few fragments of charcoal. Analyses indicate that the Neolithic groups who used the mine mostly burnt Holm/Kermes oak (*Quercus coccifera* L.) and juniper (*Juniperus* sp.), although they also had *Alnus* spp., *Prunus* spp. and *Viburnum tinus* at their disposal. The sediments filling the shafts also include pollen remains, but these are largely of pine, a species not represented among the charcoal fragments. Finally, starch and silicophytolith analyses have been carried out on ceramic fragments, as well as on sediments directly associated to the walls of the ceramics. Our results show that at least four different plants, among them cereals, legumes, acorns and sedges have been used as food in the pots. We could also identify several phytolith morphologies associated with plants that may have been used for the manufacture of tools, such as ropes or scaffolding, necessary for the silex extraction.
These results are important for little is known about Early Neolithic miner's foods and diets in Europe. This situation is mostly due to the lack of relevant materials to carry out analyses on, namely cooking pots, but also because archaeologists working on flint mines usually focus more on flint extraction and shaping technologies than on miner's working conditions and everyday lives.

Keywords: phytolith, starch grain, residue analysis, Early Neolithic, diet, Southwestern Europe

*Speaker
†Corresponding author: alexandre.chevalier@naturalsciences.be

Phytoliths as a seasonality indicator? The example of the Neolithic site of Pendimoun, South-Eastern France

Claire Delhon *† [1], Didier Binder [1], Pascal Verdin [1], Arnaud Mazuy [1]

[1] Culture et Environnements, Préhistoire, Antiquité, Moyen-Age (CEPAM) – CNRS UMR7264, Université Nice Sophia Antipolis – Campus Saint-Jean-d'Angély, Nice, France

Pendimoun is a rock-shelter located in South-Eastern France, near the Italian border, at 690 m. a.s.l., just above the city of Menton. It is a key-site for the understanding of the Neolithization process in the Northern Mediterranean area (Binder, 2013) as it is among the oldest Neolithic sites known on the French littoral (*Impressa* culture, since ca 5700 BC). It was discontinuously occupied from the Mesolithic (8800-8400 BC) to the end of the Neolithic (2300-2000 BC) and was used mainly for pastoral purposes and domestic activities, including an abundant production of ceramic ware. Agriculture and cereal processing are also clearly attested during the *Impressa* occupation (grains, husk and straws macroremains, grindstones) and become more discreet in the overlying layers.
The phytolith analysis concerned one sample from a Mesolithic (Sauveterian culture) burial and 16 samples covering most of the 6th millennium BC (Impressa, Cardial, Early Square Mouth Pottery cultures).Important amounts of grass phytoliths were identified, suggesting that the livestock, whose dung constitutes an important part of the sediment, mainly fed on wild grasses. The scarcity of dicot phytoliths rules out the hypothesis of the use of tree branches as fodder while the animals were kept in the shelter. Although attested elsewhere (Delhon *et al.*, 2008), this feeding practice was considered unlikely at Pendimoun on the basis of charcoal analysis (Battentier *et al.*, 2015). The abundance of glume phytoliths is very low, except in the *Impressa* levels. As dehusking would have provided glume phytoliths, this result confirms that cereals were partly processed *in situ* only during the earlier stages of the Neolithic. Moreover, the scarcity of glume remains also suggests that the wild grasses browsed by the livestock were not bearing mature ears. Panicoid short cells proved to be higher than expected (most of the time between 1 and 5%) in an area where only few panicoid species can grow. We identified only three candidates for panicoid phytoliths suppliers: *Setaria* spp., *Digitaria sanguinalis* and *Echinocloa crus-galli*. All three have a short vegetation cycle entirely run between the end of spring and the beginning of fall, suggesting that the shelter was mainly used during that period. The low amount of glume phytoliths seems to restrict that range to the period before the ears maturity, namely the end of spring or early summer.

Battentier J. et al. 2015 : L'abri Pendimoun (Castellar, Alpes-Maritimes) : nouvelles données sur l'évolution du couvert forestier et l'exploitation du milieu au Néolithique (5800-2000 ans cal. BCE), *Quaternaire*, 26 (4) : 277-290.

Binder D. 2013 : Mésolithique et Néolithique ancien en Italie et dans le sud-est de la France entre 7000 et 5500 BCE cal : questions ouvertes sur les dynamiques culturelles et les procès d'interaction, in T.Perrin, C.Manen, G.Marchand, P.Allard, D.Binder, M.Ilett (eds.) *Transi-*

*Speaker
†Corresponding author: claire.delhon@cepam.cnrs.fr

tions, ruptures et continuité durant la Préhistoire, Paris, SPF : 341-355.
Delhon C. et al. 2008. Shepherds and plants in the Alps: multi-proxy archaeobotanical analysis of neolithic dung from "La Grande Rivoire" (Isère, France). *JAS* 35 (11): 2937-2952.

Keywords: Phytolith, Neolithic, SouthEastern France, seasonality, Panicoideae

Environmental and vegetation reconstruction during MIS 5-6 at Cova Negra (Xàtiva, Valencia, Spain): the evidence from phytoliths

Irene Esteban *† [1], Aleix Eixea [2], Valentín Villaverde [2]

[1] University of Barcelona (UB) – Dept. History and Archaeology, Spain
[2] University of Valencia – Dept. Prehistory and Archaeology, Spain

The Middle Paleolithic site of Cova Negra, in the Valencia region of Spain, is one of the richest Neandertal paleontological sites on the Iberian Peninsula. The archaeological evidence from Cova Negra indicates sporadic, short-term occupations of the site, suggesting a high degree of mobility among Neandertals (Villaverde et al., 1996). The Valencia region contains an abundant and valuable Middle Paleolithic archaeological record (Fernández Péris and Villaverde, 2001) and it is one of the fifty-two putative refugia regions within the Mediterranean region (Quézel and Médail, 2003), what might lead to the high and continuous Neandertal occupation of this region along the Middle and Late Pleistocene. This paper reports on the preliminary results of the phytolith analyses from Level VIII of Cova Negra site, dating probably to the MIS 5-6 (Villaverde et al., 2014). We use phytoliths as a tool for paleoenvironment, paleoclimate and paleovegetation reconstruction of the Cova Negra region. These deposits consist of in situ ash remains from suspected natural fires. These ashy layers were most probably formed after the burning of the vegetation covering the rockshelter during periods of non-occupation. Two additional deposits underneath and above Level VIII (Levels IX and VII) were also studied for comparison. The results of the fossil phytolith assemblage from Cova Negra was later compared with a preliminary modern reference collection of surface soils and plants from the study area. Phytoliths were identified in high frequencies in all the archaeological samples from the different levels studied. FT-IR (Fourier Transform Infrared Spectra) detected calcite as the main mineralogical component and this was from an organic origin (wood ash). Eudicotyledonous plants both from the leaves and fruits dominated the phytolith assemblage in Level VIII. Despite wood ash calcite was the main mineralogical component detected in samples, wood/bark phytoliths were barely identified. Grasses and sedges were also well represented. Among grasses, grass silica short cells (GSSCs) from the rondel type were abundant. Bilobates were also detected but in much lesser numbers, and saddles were absent. Finally, diatoms and sponge spicules were identified in high numbers in most of the samples. Plants growing in humid environments where water was highly available might produce most of the phytoliths identified in these layers. This phytolith assemblage was indicative to us of the presence of a deciduous forest and a temperate and humid environment in Cova Negra area during the time of deposition of Level VIII.

Villaverde, V., 2001. De neandertales a cromañones : el inicio del poblamiento en las tierras vale ncianas. València : Universitat de València, Fundació General.

Médail, F., Diadema, K., 2009. Glacial refugia influence plant diversity patterns in the Mediterranean Basin. Journal of Biogeography, 36(7), 1333-1345.

*Speaker
†Corresponding author: irene.esteban.alama@gmail.com

Villaverde, V., Guillemm P.M. Marrtínez-Valle, R., Eixea, A., 2014. Cova Negra. In R. Sala (ed) Pleistocene and Holocene Hunter-Gatherers in Iberia and Gibraltar Strait, pp. 361-369. Universidad de Burgos. Fundación Atapuerca.

Keywords: Middle Paleolithic, Neandertal, Riparian vegetation, Paleoenvironment, Paleoclimate, Paleovegetation, FTIR

Phytolith analyses in the Early Pleistocene sediments containing tools of early hominids in the Northern Armenia and paleoclimatic reconstruction

Alexandra Golyeva * [1], Olga Khokhlova [2], Elena Belyaeva [3], Vasily Lyubin [3]

[1] Institute of Geography Russian academy of science – 119017 Staromonetnij per., 27, Moscow, Russia
[2] Institute of Physical, Chemical and Biological Problems in Soil Science of RAS – Pushchino, Moscow region, 142290, Russia
[3] Institute of History of Material Culture, Russian Academy of sciences – Russia

One of the most promising challenges for the Pleistocene paleopedology is an analysis of environments of the initial hominid dispersal in Eurasia. The Caucasus Mountains are one of the main routes of the ancient hominid from the African homeland to Eurasia. The starting point for the early prehistory of the Caucasus is currently the Early Paleolithic site Dmanisi, located in South Georgia, which dates back to 1,81 ± 0,05 Ma. The recent results of archaeological research showed the Early-Middle Pleistocene stage of occupation of the Caucasus, which is clearly seen on the sites of northern Armenia.

We have studied 3 sections in the northern part of Armenian upland which included archaeological artifacts and possible Pleistocene pedosediments. The heterogeneous lithology of the sections studied is related to pulsating volcanic activity. The SIMS U–Pb dating of the zircons from volcanic ashes contained Early Acheulian lithic artifacts in the Karakhach site showed 1.942±0.046 Ma – 1.750±0.020 Ma and in the Kurtan site – 1.432 ±0.028 Ma (Presnyakov et al., 2012). The set of methods have been applied including the micro- and submicromorphological observations, phytolith analyses, measurement of magnetic susceptibility and isotopic composition of carbon and nitrogen, bulk chemical composition. We aimed to reconstruct the paleoenvironments in the period of the initial hominids dispersion.

The abundance of well-preserved phytoliths were detected as well as single spiculars and parts of diatoms. According to our results we believe that the earliest stages of the formation of the Armenian pedocomplex proceeded under paleoenvironmental conditions similar to those of a humid (sub)tropical climate.

Keywords: Initial hominids, paleoenvironmental reconstruction

*Speaker

Bulliform phytolith research in wild and domesticated rice paddy soil in South China

Xiujia Huan *† [1,2], Houyuan Lu [1], Can Wang [1], Xiangan Tang [3], Xinxin Zuo [1], Yong Ge [1,2], Keyang He [1]

[1] Institute of Geology and Geophysics, Chinese Academy of Sciences – No. 19, Beitucheng Western Road, Chaoyang District, 100029, Beijing, China
[2] University of Chinese Academy of Sciences (UCAS) – China
[3] Soil, Fertilizer, Environmental and Resources Research Institute, Jiangxi Academy of Agricultural Sciences – Jiangxi, China

Bulliform phytoliths play an important role in researching rice origins as they can be used to distinguish between wild and domesticated rice. Rice bulliform phytoliths are characterized by numerous small shallow fish-scale decorations on the lateral side. Previous studies have shown that domesticated rice has a larger number of these decorations than wild rice and that the number of decorations $\geq$9 is a useful feature for identifying domesticated rice. However, this standard was established based on limited samples of modern rice plants. In this study, we analyzed soil samples from both wild and domesticated rice paddies. Results showed that, in wild rice soil samples, the proportion of bulliform phytoliths with $\geq$9 decorations was 17.46% $\pm$ 8.29%, while in domesticated rice soil samples, the corresponding proportion was 63.70% $\pm$ 9.22%. This suggests that the proportion of phytoliths with $\geq$9 decorations can be adopted as a criterion for discriminating between wild and domesticated rice in prehistoric soil. This indicator will be of significance in improving the application of fish-scale decorations to research into rice origins and the rice domestication process.

Keywords: rice, bulliform phytolith, fishscale decoration, rice domestication

*Speaker
†Corresponding author: huanxiujia@mail.iggcas.ac.cn

Microfossils as narrators and protagonists in the stories of agricultural landscapes

Maria Alejandra Korstanje *† [1], Mariana Maloberti [1], Julieta Zapatiel [1], Laura Taddei Salinas [2], Patrica Cuenya [2]

[1] Universitad Nacional de Tucumán (UNT/CONICET) – San Martin 1545 - 4000, Tucumán, Argentina
[2] Universitad Nacional de Tucumán (UNT) – San Martin 1545 - 4000, Tucumán, Argentina

Through agro-archaeological studies in the El Bolsón valley (Catamarca, Argentina), we have identified different modalities of productive spaces as well as different agricultural practices that gave rise to a specific history for the place. We have carried out multiple microfossil extractions from sediments sampled in agricultural structures, as an avenue through which to interpret the special relationship through which farmers have involved themselves with plants under cultivation. While these studies allow us to interpret these relationships in local contexts or restricted to the site itself, the integration of information allows us to think about the different ways in which farming practices coexisted and also in its changes and continuities over time. In this paper we present a comparison of two nearby areas (El Alto El Bolsón and Yerba Buena) which, from the archaeological point of view, are considered two separate sites. They settle in different geomorphological scenarios, and present different architectural and artefactual features in surface. These supposedly indicated a technical and perhaps chronological differentiation, but the advancement of research has allowed us to review this idea, so both sites have participated in the same historical process. In order to compare the two sites regarding land use and agricultural practices, we studied microfossils. This approach allows us to understand farming practices in the long term. In this sense, the approach is contextual and not nominal. This implies that it is not the identification of a given taxa from phytoliths or starches (in the case of plants) or diatoms in particular, what allows us to interpret changes and continuities in farmers landscapes conformation, but rather the relationships, links and causalities that form the structure of land use itself. So, this study shows continuity in the variability of agricultural practices rather than a correspondence with different times of occupation. By the time the comprehensive and integrated evidence makes us think that the variability in agricultural practice was not exclusive to one or the other site, but rather appears in both, excluding then the chronological factor from the equation. This contextual approach, together with the methodology of multiple extraction of microfossils used by the team, allow us to visualize in a more complex, in the original sense of the word "landscape" to what otherwise would be only profiles, levels, samples and microfossils.

Keywords: Soils, Diatoms, Microfossils, Archaeology

*Speaker
†Corresponding author: ale_korstanje@hotmail.com

Building and Inhabiting Nan Madol: Integrating Phytolith, Plant Macroremain, and Sponge Spicule Data from Pahn Kadira Islet

Maureece Levin * [1], William Ayres [2]

[1] Stanford Archaeology Center – United States
[2] University of Oregon – United States

The Nan Madol site, located off the coast of Pohnpei, in the Western Pacific Ocean, is a complex of more than 100 artificial islets constructed between ca. 1500 and 500 BP. During this period, especially the latter half, it was the center of chiefly political power and home to the island's elites. Pahn Kadira islet, an elite residential center and the location of the temple Nan Kieil Mwahu (Ayres et al 1983; 2015), is positioned as critical for understanding elite residential and ritual activity, as well as the evolution of architectural forms. Ayres and colleagues have conducted survey, excavation, and faunal analysis, producing information on islet spatial layout, construction technology, and elite ritual and diet for the islet. In this paper, we ask what analysis of sampled sediments can add about human diet, local vegetation, and islet construction. To this end, we analyze phytoliths, sponge spicules, and plant macroremains from bulk soil samples collected during the initial excavations. These data corroborate previous conclusions about islet construction patterns and show a clear presence of palm trees on the artificial islet by ca 1000 BP. This supports the interpretation of a long-term occupation at Pahn Kadira, one showing multiple clear episodes of construction.

Keywords: Archaeology, Oceania, Nan Madol, Micronesia, Archaeobotany, Monumental Architecture

*Speaker

Keynote speech

Phytoliths in Archaeology: History and New Developments

Madella Marco * [1]

[1] Universitat Pompeu Fabra ICREA (UPF) – Barcelona, Spain

The development of methods for identifying the remains of wild and domesticated plant species has been a focus of archaeobotany since its inception. Phytolith analysis has increasingly taken its place as an important independent contributor of data in all areas of the globe and for many significant challenges for archaeology: agricultural origins and dispersals, resilience, human behaviour, identity and human-environment interactions. The volume of literature on the subject is now both very substantial and disseminated in a range of international journals. In this presentation, I will provide an historical perspective of the contribution phytolith analysis to these challenges and suggest future developments.

Keywords: history, methodology, phytoliths

*Speaker

Phytolith investigations at Sibudu Cave: towards understanding the Middle Stone Age of South Africa

May Murungi * [1], Marion Bamford [1]

[1] Evolutionary Studies Institute and School of Geosciences, University of the Witwatersrand – South Africa

This study presents a detailed Middle Stone Age (MSA) phytolith record from Sibudu cave located in KwaZulu Natal, South Africa. Sibudu cave is a well-studied archaeological site with deposits that have yielded an abundant assemblage of lithic, fauna and plant remains within a well-dated context. Phytolith analysis was applied to understand early human plant interactions at Sibudu and the environment in which they lived. Phytoliths at Sibudu are well preserved and are abundant, and although they many appear heat altered, they are identifiable and give insights into the vegetation type at Sibudu during the MSA. This has allowed for the identication of the types of plants utilised by early humans at Sibudu. An abundance of blocky and globular phytoliths may suggest an abundance of dicotyledonous plants at Sibudu that were the major source of fuel at Sibudu. Grass phytoliths occur in lower amounts and are possible evidence of kindling. Phytoliths that may not be related to fuel use are also present especially sedge phytoliths that corroborate the evidence of the use of sedges as bedding at Sibudu. This study shows that phytolith analyses can contribute to our understanding of early human-plant interactions and their environment and can provide a more complete understanding of the monocotyledonous plants mainly grasses, a currently missing component of the botanical studies at the site.

Keywords: Phytoliths, vegetation history, Middle Stone Age, Sibudu, South Africa

*Speaker

Phytoliths in modern plants and soils from Klasies River, Cape Region (South Africa): new findings for archaeological and paleoenvironmental purposes

Alice Novello *† [1,2], Marion Bamford‡ [2], Yvette Van Wijk [3], Sarah Wurz [2]

[1] University of Washington – University of Washington SEATTLE, United States
[2] University of the Witwatersrand, Johannesburg – South Africa
[3] Rhodes University – Grahamstown, South Africa

The archeological site of Klasies River (34S, 24E) is famous for the richness of its Middle Stone Age deposits, which offer the opportunity to document behaviors of early modern humans in Africa, as well as the paleoenvironmental context of their occupation of the area during the late Pleistocene. Klasies River is located at the meeting of three modern vegetation biomes: the Thicket, Fynbos, and Forest biomes, and under two different climate systems favoring high amounts of rainfall during the year (911mm/year, CRU records, 1961-1991). Some paleosols of the Main Cave (dated to 115 to 90 ka) include abundant plant remains such as seeds and charcoal, which suggests that micro-plant remains like phytoliths could also be present in the deposits. No phytolith reference collection based on both plant and soil material has been produced yet for Klasies, which complicated the interpretation of the phytoliths preserved in the cave deposits. One of our challenges was therefore to initiate a new and comprehensive phytolith reference collection of modern plants and soils occurring today in the vicinity of Klasies. For this purpose, we sampled $>$ 140 plants from 16 different vegetation patches located in a perimeter $<$ 5 km2 around the Cave sites. Phytolith extraction, description and counting have been limited so far to a set of 25 leaf specimens related to 13 different plant families, which were selected for their: i) ability to provide reliable paleoenvironmental information, and ii) potential to have been used by humans during their occupation of the area. Phytoliths from the soils were also analyzed to get a better perspective of the phytolith deposition in the area under natural conditions. Our analyses indicate that polygonal and/or ovate/orbicular phytoliths are the most recurrent and abundant morphotypes ($>$ 53% and up to 94%) produced in the leaf tissues of the Anacardiaceae, Asteraceae, Celastraceae, Ericaceae, Proteaceae, and Vitaceae species we studied, which are mainly woody species. Regarding the Cyperaceae, Poaceae, Restionaceae (all herbs), and one of the Proteaceae species (*Leucadendron spissifolium*, a fynbos shrub), they each produced a singular phytolith assemblage dominated by short cell phytoliths for Poaceae (92%), psilate and decorated globular phytoliths for Restionaceae (94%), and silicified papillae for both Cyperaceae (54%) and *L. spissifolium* (63%).
These findings suggest that precautions must be taken while interpreting the occurrence of globular and papillae types in recent and past deposits from the area since these phytoliths may be easily confused with the commonly used tree/shrub and sedge phytolith indicators, respectively. Besides, both globular and papillae phytoliths were identified in the fynbos soil, where they account for 34% and 8%, respectively. Our analyses also show that polygonal and/or ovate/orbicular phytoliths occur in varying amounts in modern soils of the area ($<$ 2%), although

*Speaker
†Corresponding author: novelloalice@gmail.com
‡Corresponding author: Marion.Bamford@wits.ac.za

they look abundant in the leaf plant tissues we analyzed. Conversely, grass short cell phytoliths are found abundantly in the soils collected in close proximity to the cave ($< 66\%$), where grasses do however occur sparsely in the current vegetation.

Keywords: Cape Floristic Province, fynbos, thicket, silica, cave

Plant-based pigment production on Rapa Nui

Welmoed Out * [1], Carolin Lubos [2], Svetlana Khamnueva [3], Marco Madella [4], Hans-Rudolf Bork [5], Andreas Mieth [3]

[1] Department of Archaeological Science and Conservation, Moesgaard Museum – Højbjerg, Denmark
[2] Institute for Physical Geography, Goethe University – Frankfurt am Main, Germany
[3] Institute for Ecosystem Research, Kiel University – Kiel, Germany
[4] ICREA, University Pompeu Fabra and IMC-CSIC – Barcelona, Spain
[5] Institute for Ecosystem Research and the Graduate School 'Human Development in Landscapes', Kiel University – Kiel, Germany

Since 2007, the German Archaeological Institute and Kiel University have undertaken archaeological excavations on the island of Rapa Nui (Easter Island, Chile). Excavations in 2011 and 2014 revealed pits that contain thin layers of charcoal and phytoliths and thick layers of reddish iron oxide at various locations on the island. These finds resulted in the hypothesis that people burned rhizomes of *Schoenoplectus californicus* spp. *tatora* (totora) to produce pigment, dyes or paint. The pits date to the 13th and 15th centuries, after the onset of the deforestation of the island and before the first arrival of Europeans. Phytolith analysis was carried out after micromorphological analysis had demonstrated that phytoliths were very common in one of the pits. The aims of the phytolith analysis were to understand what kind of material was burned in the pits, and to shed more light on the role of sedges. The research included samples from inside and outside pits from four soil profiles at three locations. The results provide new insights about plant use on Rapa Nui.

Keywords: Rapa Nui, pigment production, pits, fuel, ca. 1200, 1500 AD

*Speaker

Phytoliths in livestock dung: the use of modern reference materials and ethnoarchaeological approaches

Marta Portillo * [1,2], Matthews Wendy [1]

[1] Department of Archaeology, University of Reading – Whiteknights Box 227, Reading RG6 6AB, U.K.
[2] EU Horizon 2020 Marie Sklodowska-Curie Fellow – U.K.

Dung is a key interdisciplinary area of research as it provides valuable information on a wide range of environmental and ecological issues and socio-economic and cultural aspects of human life. Livestock dung is commonly found in many settlements, especially after the domestication of herds. Although receiving increasing attention in archaeology, dung materials are regularly overlooked, despite their worldwide economic importance as suppliers of manure, fuel source, temper and building material. This oversight is largely due to problems in identifying dung during excavation in the field and in routine sampling procedures in which dung and its contents are frequently disaggregated and lost or mixed with other components of different origin. In many worldwide contexts, only microscopic (e.g. dung spherulites, phytoliths, non-pollen palynomorphs), molecular, isotopic, elemental and charred indicators of dung may survive. Phytoliths by themselves cannot be easily related to dung as similar morphotypes may derive from dung and non-dung sources. Precision sub-sampling for phytoliths in the field or from blocks, however, when combined with high-resolution contextual micromorphology and compositional analysis, and biomolecular analyses by GC-MS and GC-C-IRMS, may enable more robust identification and interpretation of dung content and context, and thereby a wider study of animal ecology, environment, diet, management practices, and animal-human interactions.
One key area of research is the development of reference models and comparative analytical datasets on the characteristics, preservation and context of modern dung materials, dung-products and depositional contexts in current farming communities that maintain aspects of traditional ways of life in archeological site vicinities. These materials and activity areas include: dung pellets, sediments from pens, agricultural fields and pasture grounds, dung cakes, dung fuel residues from ovens and building materials (roofing, wall and floor plastering). Such materials from specific cultural and environmental contexts are examined using controlled ethnographic approaches, including questionnaires and ethical protocols. The specific objectives in research on this comparative data are, firstly, to obtain information on variation in the digestibility, durability and seasonality of phytoliths and other microfossils that are excreted with dung, which are still under-developed. Secondly, to evaluate the taphonomic history and preservation of these microfossils and dung remains in settlement, pen and off-site contexts and their wider ecological and social significance.
To illustrate the potential major contribution of integrated analysis of phytoliths and direct microfossil evidence from spherulites to our understanding of the major transformation from mobile hunting-gathering to more sedentary farming, a selection of case-studies are presented here from a transect through the Near East, one of the key heartlands in which plants and animals that were later domesticated occur naturally, and from the still little investigated North Africa, a potentially critical area with implications for surrounding regions including the Mediterranean

*Speaker

and the Sahara. The selected case-studies span the critical periods of transformation from ca. 10,000 cal BC to the last centuries BC. These integrated approaches demonstrate the potential contribution of the still needed systematic interdisciplinary studies of ethnographic dung to provide robust data for the development of models for the identification and interpretation of dung in archaeology.

Keywords: Near East, North Africa, ethnoarchaeology, animal, human interactions, livestock dung.

Radiocarbon Dating Modern Wild Rice (Zizania) Caryopses: An Exploration of Ancient Carbon Signatures

Linda Scott Cummings * [1]

[1] PaleoResearch Institute (PRI) – 2675 Youngfield St., United States

As part of a larger study of radiocarbon dating in Minnesota, modern wild rice (*Zizania*) was collected, processed, and radiocarbon dated. The freshwater reservoir effect (FRE) is well known in northern Europe and parts of North America. Suspected sources of ancient carbon in food residue are usually the water if the geological substrate erodes, introducing ancient carbon, hard water containing carbonates, and animals. Modern fish and land animals living in and around water and/or eating aquatic resources, date several to many hundreds of years old. Questioning the input of carbon from plants, however, challenges fundamental assumptions of radiocarbon dating. Recent research concerning carbon stored in grass phytoliths has shown that at least some grasses sequester ancient carbon in their phytoliths. Our questions for radiocarbon dating revolve around the plants and animals cooked in vessels, as well as those carbonized during daily life and recovered at archaeological sites. As part of the quest to understand ancient carbon input to cooking vessels, we dated modern wild rice caryopses. Our experiments include dating raw and boiled wild rice caryopses, then dating them using traditional pre-treatment methods (acid-base-acid), then with the addition of a non-polar solvent chemical pretreatment. In addition, we experiment with cooking wild rice, then dating the cooked caryopses using both the traditional ABA and non-polar solvent chemical pretreatments. Direct comparisons are made between these results, which indicate that, indeed, wild rice caryopses produced dates "too old" when compared with their harvest year.

Keywords: radiocarbon dating, dating grasses, cooking

*Speaker

Phytoliths in the stratigraphic layers of Tarioba Shell Mound (Rio Das Ostras, Rio de Janeiro, Brazil)

Rosa Souza * [1], Heloisa Coe [2], Michelle Duarte [1], David Machado [2], Bruno Oliveira [2], Isabella Ferreira [2], Ingrid Medeiros [2], Luiza Araújo [2], Abilio Soares-Gomes [1], Edson Silva [1]

[1] Departamento de Biologia Marinha, Instituto de Biologia, Universidade Federal Fluminense – Niterói, Rio de Janeiro, Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – São Gonçalo, Rio de Janeiro, Brazil

Since the beginning of the Holocene, people have occupied the central-south Brazilian coast, a very productive estuarine environment. Living as fishers and mollusk gatherers, they built sambaquis, prehistoric shell mounds up to 30 m high, which can still be found today, constituting an important testimony of paleodiversity and Brazilian prehistory. The role and function of sambaquis are not completely known, but it is well established that they are artificial buildings where can be found evidence of diverse activities (food processing, artifacts manufacturing, habitation structures, funerary ritual etc.). Most Brazilian shellmounds date from 6000 to 2000 cal, with a few dates up to 9000 cal BP. The aim of this research is to characterize phytoliths from "Sambaqui da Tarioba", a shell mound situated in Rio das Ostras, Rio de Janeiro, Brazil. The sambaqui was excavated in a sector of 1 m2 till reaching the natural strata at 110 cm deep. The soil was delayered by artificial 10 cm sections which revealed five archaeological stratigraphic layers (S1 to S5). A sample of mollusk shells (*Iphigenia brasiliana*) for each of these layers was used for radiocarbon dating. Phytoliths from all five layers were analyzed under optic microscope. They were classified and counted into different types. Data analysis was done using phytoliths D/P and Bi% indices and Principal Component Analysis. Our results indicate an occupation period of 550 yr for the 'Sambaqui da Tarioba', with dates ranging between 4,070 cal BP (beginning of occupation) and 3,520 cal BP (occupation ending). Regarding phytolith assemblages, globular granulate and bulliform phytolith types predominate. D/P index (from 0.39 to 4.73) suggests an open forest, and Bi% values indicate a strong water stress. PCA analysis of the phytolith assemblages, presence/absence of charcoal, sponge spicules and diatoms as well as dating and deepness of the archaeological stratigraphic layers revealed three different groups (S2-S3; S4-S5 and S1). These groups are explained by the first component responsible alone for more than 90% of all variation in the data. The first component is representative of the age estimates by C14 method. In conclusion, the analysis of phytoliths composition of the Sambaqui da Tarioba indicates that the vegetation surrounding this archeological site 4000 years ago A.P. consisted of dry forest. This condition seems to have extended over the 500 years that lasted the occupation of this site. Although most data indicate stable floristic and environmental conditions during this period, the PCA analysis indicates some changes over time. We conclude that, despite many biases associated with shell mounds, they still constitute good data repositories on biodiversity and Late Holocene environments.

Keywords: Sambaqui, Paleoecology, Brazilian Coastal Region

*Speaker

Revealing a 5000-year-old Beer Recipe in China

Jiajing Wang * [1]

[1] Jiajing Wang (Stanford University) – Stanford Archaeology Center, United States

The pottery vessels from the Mijiaya site reveal the first direct evidence of *in-situ* beer making in China, based on the analyses of phytolith, starch and chemical residues. Our data reveal a surprising beer recipe in which broomcorn millet (*Panicum miliaceum*), barley (*Hordeum vulgare*), Job's tears (*Coix lacryma-jobi*), and tubers were fermented together. The results indicate that people in China established advanced beer brewing technology by utilizing specialized tools and creating favorable fermentation conditions around 5000 years ago. For the first time we are able to identify the presence of barley in archaeological materials from China by applying a new method based on phytolith morphometrics, predating macrobotanical remains of barley by 1000 years. Our findings imply that the early beer making may have motivated the initial translocation of barley from the Western Eurasia into the Central Plain of China before the crop became a part of agricultural subsistence in the region 3000 years later.

Keywords: alcohol, China, phytolith analysis, starch analysis

*Speaker

Calibration of the phytolith marker and paleoenvironmental reconstructions

Quantitative reconstructions of vegetation cover from lake sediments: the power of multi-proxy analysis

Julie Aleman * [1], Karl Henga [2], Charly Favier [2], Laurent Bremond [2]

[1] Department of Ecology and Evolutionary Biology, Yale University – 165 Prospect Street, 06511 New Haven CT, United States
[2] Institut des Sciences de l'Evolution - Montpellier (ISEM) – CNRS UMR5554, IRD UMR226, Université Montpellier II - Sciences et techniques – Montpellier, France

Long-term ecological records from lake sediments represent a unique opportunity to understand vegetation responses to climate and disturbance changes at a temporal scale that is not accessible using field measurement or remote sensing data. These variables, however, are indirectly reconstructed using bio-proxies, such as phytolith, pollen or charcoal particles. Calibration studies are thus a critical requirement if quantitative reconstructions, in units comparable with field measurements or model output, need to be achieved. Particularly, long-term records can help disentangling the drivers of forest and savanna distribution, and of tree density within the savanna ecosystem, where both trees and grasses co-dominate. These questions represent a burning debate within the savanna community, and still no consensus has been reached even after decades of research. Phytoliths are increasingly used in tropical environments where many families produce diagnostic morphotypes. Especially, phytoliths analysis is particularly accurate in reconstructing woody cover, using the Dicotyledons to Poaceae index (D/P). In pollen analysis, the ratio of arboreal to non-arboreal pollen (AP/NAP) has been shown to precisely reconstruct woody cover in association with the D/P index. Moreover, pollen analysis enables differentiation between tree guilds, while phytolith analysis permits sub-family grasses distinction. Most calibration studies, however, have been performed on modern soil samples, but more data are needed from recent lake records, where most long-term reconstructions come from. Here we performed a multi-proxy analysis by analyzing the phytolith, pollen and charcoal content of precisely dated (210Pb) sediments from three lakes. Lacustrine sediments represent a unique way of continuous recording in tropical and sub-tropical environments. These three lakes are situated in Central African Republic and located in savanna, forest-savanna mosaics and forest. We show that the local environment surrounding the lake is critical for interpreting current and past phytolith assemblages, and the D/P index. The presence of a riparian forest in an open environment has no impact on phytolith assemblages or the D/P index, which instead reflect both the local and regional landscapes. Contributions from a marsh, if present in a forested environment, completely dominates the phytolith records, which consequently reflect only the local environment of the lake. Preliminary pollen results show however that the AP/NAP ratio records well signal from the landscape in both riparian and marsh-surrounded lakes. Finally, the pollen analysis enables determination of the composition of trees in both forest and savanna, and the contribution of pioneers, while phytoliths inform about grass composition.
We also found a high correlation between Poaceae phytoliths influxes and charcoal accumulation rates for the two lakes surrounded by a riparian forest. This correlation, associated with a high proportion of burned Poaceae phytoliths, suggests that Poaceae phytoliths are mainly

*Speaker

transported by wind in ash clouds produced by fires. We also identified that tree pollen are transported over long-distances by wind. We conclude that reconstructing vegetation from lacustrine records necessitate an analysis of taphonomic processes, especially production, transport and deposition, in order to interpret proxies source area. Therefore, multi-proxy analysis constitutes a powerful tool for reconstructing vegetation and unraveling potential taphonomic biases.

Keywords: Phytolith, pollen, calibration, vegetation cover, taphonomy

Modern phytolith assemblages from vereda wetlands in Minas Gerais cerrado, Brazil

Cristina Augustin *† [1], Lucena Ubiranan [2], Heloisa Coe [3], Guaciara Santos [4]

[1] Instituto de Geociências - Universidade Federal de Minas Gerais (IGC-UFMG) – Belo Horizonte-MG, Brazil
[2] Programa de Pós-Graduação em Geografia- Instituto de Geociências-Universidade Federal de Minas Gerais (IGC-UFMG) – Belo Horizonte-MG, Brazil
[3] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[4] Earth System Science Department -University of California- Irvine (UCI) – Irvine, CA, United States

The vegetation of the Brazilian cerrado has very diverse structures which range between grassland and dense forest. Within this matrix, distinctive wetlands termed veredas are present around slow-flowing water courses characterized by deposits and lines of palm trees marking confined water flow and fen peat but also with riparian scrub patches beside streams, plus lakes of varying size. The vereda grasslands are dominated by Poaceae, palm lines by Arecaceae (*Mauritia flexuosa*, *Mauritiella armata*), with Melastomataceae and Annonaceae as riparian scrub. Juncaceae are dominant around lake edges. Modern Phytolith Assemblages (MA) from vereda wetland are not well studied. The objective here is to acquire Pa/P (Palm trees/Poaceae) and other indices from the main vegetation structures within the two hydro-geomorphological domains of a cerrado drainage basin: veredas and lakes. The MA collected are: veredas with *Mauritia flexuosa, Mauritiella armata* and Annonaceae (MA1); Juncaceae at lake edges (MA2, MA3); vereda with forest cover and presence of Melastomataceae (MA4); vereda with predominance of Annonaceae (MA5); grassland in the vereda's hydromorphic field (MA6). Results will be used to interpret subsequent sedimentary analysis of vereda deposits. The study area is located within the River Peruaçu drainage basin (Minas Gerais, Southeastern Brazil) which has relatively undisturbed examples from vereda ecosystems. The extraction of the phytholiths from field surface samples followed standard methods. The morphotypes of each sample were identified and counted under the microscope. Pa/P index values are highest for MA4 (5.08) and MA1 (2.99) which represent hydrophilic ecosystems dominated by palm trees, with a smaller value for MA5 (0.57) which is dominated by Annonaceae. In addition to the Pa/P index, Bi index (water stress index) was calculated as well as the D/P ratio (Dicotyledons/Poaceae). Bi index values are higher in the environments near the lakes, MA2 (Lagoa Formosa) with 95.14% and MA3 (Lagoa Jatoba) 54.38%. Only one habitat has a low Bi index (MA1 (8.47%)), probably because its plants are developed in fluvial channels closer to groundwater, with tree roots systems capable of tapping water during dry periods. MA5 is the non-lake habitat with the highest Bi index (81.28%). The extensive MA6 grass-dominated zone has a value of 38.78%. High Bi index values are therefore found for all habitats except MA1, suggesting that water stress in the winter dry season is a major factor affecting most vereda habitats, including lakes. D/P results show that the cerrado domain surrounding the vereda is very weakly represented in modern assemblage records. Only MA6 seasonally-wet grassland contains phytoliths corresponding to

*Speaker
†Corresponding author: chaugustin@hotmail.com

woody species that could have come from the Cerrado (D/P = 0.19), probably carried by runoff from adjacent hillslopes. Overall, Pa/P, Bi and D/P values suggest that the current habitats are recognizable and separable using phytolith analysis. They additionally suggest that the vereda landscape could be discriminated from the surrounding cerrado on the basis of phytolith records.

Keywords: Phytoliths, Modern Assemblages, Cerrado Biome, Vereda Wetland

Long-term savanna functioning revealed by a multi-proxy approach

Laurent Bremond *† [1], Stéphanie Bodin [1], Ilham Bentaleb [1], Charly Favier [1], Karl Henga [1], Mike Makaya [2], Lauriane Navarro [1], Richard Oslily [3], David Sebag [4]

[1] Institut des Sciences de l'Evolution - Montpellier (ISEM) – CNRS UMR5554, IRD UMR226, Université Montpellier II - Sciences et techniques, École Pratique des Hautes Études [EPHE] – Montpellier, France
[2] Université des Sciences et Techniques de Masuku (URESTE) – Gabon
[3] Agence Nationale des Parcs Nationaux – Gabon
[4] Universite de Rouen, Laboratoire M2C – Université de Franche-Comté – France

Savannas are persistent tree-grass mixtures maintained by a combination of climatic, edaphic, fire and herbivory influences. The heterogeneity of ecological processes allowing tree-grass coexistence on the long term has led to different ecological models of savannas but no comprehensive theory. In addition, a major concern about the different models of savannas is the time scale of their validity because most of them are validated against a few years of data. The aim of this study is to develop paleoenvironmental proxies in savannas to draw a long-term perspective on how climate and land use changes have impacted savanna ecosystems. Six herbaceous swamps were cored in a mosaic of forest and savanna in the middle of the equatorial forest (Lopé National Park in Gabon). Multi-proxy analyses of the sediments are in progress: X-ray fluorescence core-scanning measurements, stable isotopes, phytolith, charcoal and pollen analysis. The first results show that the functioning of each swamp has a strong influence on the signal of each proxy recorded over the last 2000 years. At the local scale, the savanna tree-cover is well recorded by phytoliths and d13C and seems to be fire-dependent. Pollen assemblages are more related to a regional signal. The results permitted an investigation into the spatial scale resolution of each studied proxy by comparing inter-site signals within a restricted area of less than 50 km2 and the intra-site signals that correspond to the replicability and variability of the records. Finally, the reason for a simultaneous swamp starting up almost 2000 years ago within the six studied sites is discussed through a regional point of view.

Keywords: Paleoecology, savanna, multi, proxy, Congo Basin forest, Lopé, Gabon

*Speaker
†Corresponding author: laurent.bremond@univ-montp2.fr

Identification and discrimination of forest/savanna ecosystems of Brazil based on phytolith assemblages and indices to understand past vegetation and soil genesis

Marcia Calegari * [1]

[1] Departamento de Geografia, Universidade Estadoal do Oeste do Paraná – Brazil

The current research aims at developing a sound methodology for palaeoenvironmental reconstruction from terrestrial archives, such as soils, in the Neotropics. Truthful reconstruction of vegetation is essential for understanding historical trajectories of climate change, and to address the nature and extent of anthropic impact on ecosystems. Furthermore, soils are ubiquitous terrestrial sediments and represent a major reservoir for climatic proxies, both physico-chemical and biological. Within soils are preserved one of the most durable plant microfossils: phytoliths. Phytoliths from soils and palaeosols have been successfully used to reconstruct past climate and vegetation in tropical regions but only a few examples relate to the Neotropics and even less to Brazil. Here, we focus on a set of interrelated but complementary datasets to clarify the Quaternary evolutionary trajectories of ecoregions and soils of great importance for the climatic history and the agrarian management of Brazil: 1) analysis of phytoliths, 2) soil genesis and evolution, 3) carbon stable isotopes in a temporal framework of radiocarbon dates. Phytolith analysis is approached through the development of modern reference collections from main forest ecosystems of Brazil (both as phytoliths from plants and as assemblages from the A1 soil horizon). Plant samples, litter and soil samples were collected along transects at eight locations in Brazil: Amazon Forest: i) Primary Forest, ii) secondary forest in ADE (Amazonian Dark Earths) area; Atlantic Forest: iii) Ombrophilous Dense Forest (ODF) of *Terras Baixas,* and grassland '*campos nativos'*; iv) *Restinga* and mangrove vegetation; v) Montane Ombrophilous Dense Forest; vi) Semideciduous forest; vii) Cerrado (savannah); viii) Mixed Ombrophilous Forest with *Araucaria.* In total 467 plant samples were collected, which are currently being analyzed. To date we have analyzed about 200 species of the collections of the Amazon Forest, the Forest de Tabuleiro and native (grassland) RNV area and *Cerrado* stricto sensus. Representative species from these biomes are, in general, good phytolith producers. Furthermore, we observed morphotypes with environmental and taxonomic significance. The project results will benefit from models of paleoenvironmental reconstruction and studies of soil genesis. It is also expected that our results will support policy makers in the management of Brazilian biomes, endangered vegetation protection policies, agricultural policies for the preservation of soil and assessment of human impact on natural and anthropic communities.

Keywords: palaeovegetation, climate, Neotropic, Forest, Savannah, Biogenic opal

*Speaker

Phytoliths as indicators of Quaternary geomorphological dynamics in alluvial-colluvial ramps, Espinhaço mountain range, Minas Gerais, Brazil

Karina Chueng * [1], Heloisa Coe [2], Cristina Augustin [3], Alessandra Mendes Carvalho Vasconcelos [4], Kita Macário [5]

[1] Universidade Federal Fluminense (UFF) – Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[3] Universidade Federal de Minas Gerais (UFMG) – Brazil
[4] Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) – Diamantina - Minas Gerais, Brazil
[5] Laboratorio de Radiocarbono da Universidade Federal Fluminense (LAC-UFF) – Brazil

The Espinhaço Mountain Range is a mesoproterozoic tectonic deformation zone located in the eastern area of the state of Minas Gerais (Brazil). One of the most common features in this massif is the occurrence of outcrops of quartzite, which are interspersed with alluvial-colluvial ramps. The main objective of this work is to contribute to the understanding of the geomorphological processes that led to the formation of depositional ramps close to the quartzite outcrops, by inferring climate variations from phytolith and carbon isotope studies. Twelve soil profiles were sampled in three areas (Area 1: between Guinda and Diamantina; Area 2: Chapadinha – Gouveia; and Area 3: Morrinhos), totalling 45 soil and sediment samples. Topographical, grain size, phytolith, isotopic and organic carbon analyses and 14C- AMS dating were performed. It was observed from the analysis of three alluvial-colluvial ramps that the geomorphological processes acted differently. In the three studied areas, the phytolith and isotopic results did not indicate any major changes in the type of vegetation over time, although variations have been found along the slopes. In Guinda and Morrinhos, phytolith stocks, varying in accordance with the particle size, do not follow the pattern of decreasing with depth. In Chapadinha, stocks decrease with depth. The D/P indexes were always low (06-29) and Bi indexes were very high (75 to 94% in Areas 1 and 2, 48 to 84 % in Area 3). In Areas 1 and 2, the phytoliths are highly weathered, indicating that the erosive processes are intense. In Area 3, the phytoliths are well preserved, suggesting greater geomorphological stability. In the three areas, the predominant types of phytoliths are those produced by grasses, especially parallelepipedal bulliform and cuneiform. In Area 3, despite the predominance of the bulliform type, phytoliths characteristic of Poaceae, such as bilobate, polylobate, cross and trapeziform types were also found, as well as the globular granulate type. The δ13C analysis indicates open vegetation with a predominance of grasses, especially the C4 type. Differences in regard to the greater or lesser presence of woody plants were most observed among the surface samples of the profiles of a same transect, or from one area to another, rather than along each profile. Another trend observed in all areas was the reduction of the presence of woody plants with depth (about 5700 cal years BP). The analyses indicate the predominance of savanna vegetation since 6038 years BP. The phytolith analysis associated with the geomorphology was found to be highly effective in understanding the evolution of the landscape and environmental changes. These analyses

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are of great relevance for the temporal reconstruction of the region and the interpretation of geomorphological processes operating efficiently in the transport and deposition of sediments in this region.

Keywords: Geomorphological dynamics

Characterization of modern phytolith assemblages from the 'Caatinga' biome, Northeast Brazil

Heloisa Coe *† [1,2], Sarah Ricardo [1], Raphaella Dias [1,3], Leandro Sousa [4], Alessandra Vasconcelos [5]

[1] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[2] Universidade Federal Fluminense (UFF) – Brazil
[3] Universidade Federal do Rio de Janeiro (UFRJ) – Brazil
[4] Universidade Federal Rural do Semi-árido (UFERSA) – Brazil
[5] Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJR) – Brazil

The 'Caatinga' in Northeastern Brazil is the fourth largest biome in the country, occupying about 11% of the territory. It is a semi-arid region, with high solar radiation, low cloudiness, high average annual temperature (about 26-27°C in the dry season) and low rates of relative humidity and potential evapotranspiration. Climate is strongly seasonal with an extremely irregular rainfall regime. Rainfall occurs from February to May only. From Tupi-Guarani origin, the name "caatinga" means "white forest", which characterizes the vegetation during the dry season, when the leaves fall and only the shiny white trunks of the trees and shrubs remain on the dry landscape. The vegetation in the Caatinga consists of small dry deciduous trees and shrubs often with thorns or spines. Cactaceae, Bromeliaceae and herbs are quite common. Some annual plants such as Poaceae and other herbs, vegetate during the rainy season. Despite being known as a uniform biome, the Caatinga is divided in several phytogeographical domains or eco-regions. In this study, surface soil samples (0-10 cm deep) from five different vegetation types were analyzed for their phytolith content to establish modern reference collections (Modern Assemblages - MA) that will enable paleoenvironmental reconstruction. Samples were collected in the Northern Sertaneja Depression, in the states of Ceará and Rio Grande do Norte, in the Caatinga Open Shrubland (MA1), Medium Caatinga Forest (MA2), High Caatinga Forest (MA3), Riparian Forest (MA4) and Caatinga Dense Shrubland (MA5). The analyses of the five modern assemblages indicated a high degree of conservation of phytoliths in the soil, the morphotypes and their amounts varying according to the overlying vegetation and the soil granulometry. The sample that presented the highest quantity of classified phytoliths was MA3 and the lowest percentage was observed in MA1. Regarding phytolith stocks, the largest were found in MA3, MA2 and MA5, and the lowest in MA1 and MA4, respectively. The phytolith morphotypes varied with the vegetal formation, but globular granulate predominated in all the samples, followed by globular echinate and elongate, which is expected in predominantly tree and shrub vegetation. Phytolith indexes D/P (0.6 to 15), Bi (50 to 78%), Iph (53 to 87%) and Pa /P (0.1 to 8.9) are compatible with the type of vegetal formation analyzed. Despite some limitations, phytoliths are a promising tools for improving knowledge of the vegetation of this region, as well as for use in paleoenvironmental reconstructions of the biome.

Keywords: Semi-arid, modern phytolith assemblages

*Speaker
†Corresponding author: heloisacoe@yahoo.com

Assessing aridity and other climatic variables using grass opal phytoliths in subtropical southern Africa

Carlos Cordova * [1]

[1] Department of Geography, Oklahoma State University – Stillwater, OK, United States

Studies of opal phytoliths in Africa have focused on the variations of morphotypes across latitudinal and altitudinal climatic gradients. This relation has often been expressed through indices (e.g., aridity and climatic indices) and ratios (e.g., dicot-graminoid ratio), and in some cases through multivariate statistics. The aridity and climatic indices use proportions of diagnostic GSSC in C3 (Pooideae) and C4 (Panicoideae and Chorlidoideae) grasses in a phytolith assemblage. The dicot-graminoid ratio uses morphotypes recognized mainly as tree phytoliths, which in the case of tropical Africa includes mainly spherical (globular) morphotypes. In principle, the use of GSSC protocols and indices across the African continent should be easier because the distribution of vegetation and climatic zones north and south of the equator mirror one another. In practice, however, the application of such protocols and indices in the subtropical and temperate regions of southern Africa faces several problems. One of such problems lies on the fact that the relation between panicoid and chloridoid short cells not always conform to moisture-aridity gradients in parts of Southern Africa. There are several reasons why this unconformable relation exists: (1) in southern Africa the Chloridoideae grasses are abundant even in humid/mesic areas, which make it difficult to always single them out as the drought resistant grass subfamily; (2) some prominent Chloridoideae grasses do not produce the trademark saddles that characterize this subfamily; (3) most arid regions are dominated by *Stipagrostis* (Aristidoideae subfamily), which belittles the Chloridoideae-Panicoideae climatic relationship; and (4) *Stipagrostis* produces a variety of round cells, which are often mistaken as pooid rondels. Additionally, the climatic indices, which are based on the proportions of pooid rondels to other morphotypes do not apply to this region because, as stated above, rondels are produced by a number of C4 grass genera, and because C3 grasses in Southern Africa are not always represented by the Pooideae sufamily, but also by the still poorly studied Danthonioideae and Ehrhartoideae subfamilies, both of which produce a high diversity of short cell morphotypes.
In this paper several indices and ratios are tested on GSSC assemblages from samples collected along a transect extending from the Atlantic to the Indian Ocean coast at approximately latitude 28◦ S, encompassing elevations from near sea level near 2000 m. The transect goes across several moisture gradients in the summer rainfall region (from sub-humid to arid) and part of the winter rainfall region, passing through areas with annual precipitation around 200 mm to areas with more than 1000 mm a year. In other words, from east to west, the transect starts on the Indian Ocean Coastal Belt, across lowland savannas, patches of savannas, grasslands and forest, to the subalpine grasslands of the Drakensberg, then crossing the High Veld grasslands of the Free State, mosaics of upper Nama Karoo, Kalahari savanna, Kalahari sandveld, the Bushmanland Karoo, and the winter-rainfall areas of the succulent karoo in Namaqualand.

Keywords: Africa, Southern Africa, Biomes, Transect, Grasses, short cells

*Speaker

Phytoliths as useful tools for multi-proxy assessments of local herbivore impacts on wetlands

Abraham Dabengwa *† [1], Lindsey Gillson [1], William Bond [1]

[1] University of Cape Town (UCT) – Private Bag X3 Rondebosch 7700 Cape Town, South Africa

Surface moisture availability is an important resource affecting the structure and functioning of wetland communities. The herbaceous layer dominated by grasses is a key resource areas (KRA) providing water and forage to wild and domestic herbivores, particularly in times of moisture stress. However, utilization of wetlands by herbivores can affect the composition and/or structure of the grass assemblage. This potentially affects the ecological resilience of the local grass community, especially under prolonged water stress. Palaeoecological records can be used to investigate plant-animal associations because they focus on KRAs. Phytoliths and dung spore proxy records were obtained from a wetland borehole in a mesic grassland-savanna matrix in Vryheid, South Africa. We hypothesized that herbivore utilization of grasses during periods of stress modified the grass assemblage from tall palatable to short grazing stress tolerant tribes and that this was accelerated by climate stress. Phytolith indices for water stress (Fs), Chloridoid:Panicoid ratio (Iph) and *Sporormiella* dung spores (Sp) from phytolith samples. The Sp ratio was compared with *Sporormiella* dung spores from the pollen method. It was not possible to clearly distinguish between herbivore-driven (*Sporormiella*) and climate-related (water stress) effects on Iph in some instances. However, the patterns from the herbivore indicators were correlated. Our results suggest that climate and disturbance interact to change the local grass layer in KRAs landscapes but that these areas are also resilient. The high correlation between herbivore abundance records indicates that we can use this knowledge to reassess phytolith and pollen records from regions that experienced megafaunal collapse using grasses.

Keywords: grasses, water stress, key resource areas, local vegetation structure, resilience

*Speaker

†Corresponding author: abrahamdabengwa@gmail.com

Paleoenvironmental reconstruction of land use and vegetation cover in the Macacu and Caceribu river basins, Rio de Janeiro, Brazil

Jenifer Gomes * [1], Heloisa Coe [1,2], Alberto Figueiredo Jr [1], Kita Macário [1]

[1] Universidade Federal Fluminense (UFF) – Campus da Praia Vermelha, Niterói, Brazil
[2] Universidade do Estado do Rio de Janeiro – Faculdade de Formação de Professores, Patronato, São Gonçalo, Brazil

The Macacu and Caceribu river basins (Rio de Janeiro, Brazil) are located in the eastern portion of the Guanabara Bay, under great anthropic influence. They constitute an under-studied area regarding the evolution of vegetation and landscapes. This study aims at contributing to the reconstruction of vegetation and land use changes in these basins over the Quaternary. Phytoliths were chosen as proxies because they brought positive results in several paleoenvironmental studies conducted in coastal areas devoid of unoxidized sediments. In addition, as paleoenvironmental reconstructions are more complete and accurate when multiproxy approaches are followed, we used stable isotope analysis (δ13C), grain size analysis, and 14C-AMS dating. Twenty-seven predominant plants were collected, representing the current vegetation of the study area, in order to compare the phytoliths found in these plants with those observed in surface and deep sediments. The sediment samples were collected in the mangrove forest at the mouth of the Caceribu river, named Testimony 1 (T1). Additional drilling was conducted in a swamp near the Caceribu riverside, and called T2 (Testimony 2). A soil profile (Gleysol) was collected in Magé. Seven reference samples were also collected. They are modern surface assemblages MA1 (herbaceous marsh), MA2 (hillside forest), MA3 (banana plantation), MA4 (sugar cane plantation), MA5 (low mountain forest), MA6 (low mountain forest with bamboo) and MA7 (pasture). We also collected 3 samples from points along the banks of the river Caceribu. In T1 we have a mangrove swamp that serves as a sedimentary deposit and which presented a mixture of grass (MA 7) and wood (MA 2 and MA 5) phytoliths. In T2, the presence of the sandy grain-size fractions is characteristic of the proximity of the river (MA 1). At points 1, 2 and 3, the D/P index indicated a more humid environment, like at MA 2 and MA 5. The isotopic values from the soil profile are -27.15 and -28.67 . The D/P index is relatively low but C3 plants dominate. From the studied points, no major changes in the type of vegetation have been identified that would suggest a change in bioclimatic conditions throughout the Quaternary. However, it is possible to infer, from the isotopic values (-28.67 and 21.64) and phytolith indexes, that throughout the analyzed area, the environment was predominantly humid with a vegetation cover made of C3 plants. Changes in tree cover appear to be linked to local factors such as the type of sediment, the topographic position and the proximity to rivers or to sea.

Keywords: vegetation reconstruction, river basins, Brazil

*Speaker

Fire episodes response to the droughts and El Niño events in the past 1700 years: phytolith and multiproxy records from the tropical sediments in southwest China

Yansheng Gu *† [1], Hongye Liu [1], Djakanibe Desire Traore [1], Shuqi Yu [1]

[1] China University of Geosciences – China

Tropical monsoon rainforest in southwest China (21-22 N, 101-102 E) is sensitive to the evolution of Indian Summer Monsoon from the past to present. Drought and fire episodes related to the monsoon evolution played a great role on the vegetation structure and rainforest ecosystem function. The aims of this research are to reconstruct the local palaeovegetation, palaeoclimate, and fire history of Xishuangbanna, and to understand the extent to which the rainforest was sensitive to climate change using phytolith, TOC, magnetic parameters, grain size and charcoal records from a fluvial sediment profile in the tropical Xishuangban rainforest area. Grass phytolith indices have been successfully used to reconstruct humidity and aridity in marine sediments, wetlands, grasslands and rainforest area. 33 phytolith morphotypes are described in detail. The major plant groups documented are the Poaceae, Cyperaceae, Compositae, ferns, gymnosperms, and broad-leaved trees. Poaceae phytoliths include short cells, long cells, bulliform cells, and hair cells (grass-type). Short cells can be classified as Pooideae (rondel and trapeziform), Panicoideae (bilobate, cross, and polylobate), Chloridoideae (square saddle), Bambusoideae (oblong concave saddle), and Arundinoideae (trapeziform saddle or plateaued saddle) based on their micro-morphological characteristics and typical descriptions. Depth distribution pattern of climate (temperature and aridity) indices indicate that the study area has witnessed 4 phases of climate changes as follows: (1) 1700-1100 cal BP, alternation of warm-dry and/or cool-wet and cool-dry, temperature declining in response to the Bond 1 Event and weakening Indian Summer Monsoon; (2) 1100-700 cal BP (Medieval Warm Period), alternation of hot-humid and hot-arid, temperature rising in response to enhanced solar variability and strong Indian Summer Monsoon; (3) 700-250 cal BP (Little Ice Age), mostly cold-wet inter-bedded with warm-dry, declining temperature in response to the low solar variability and weak Indian Summer Monsoon; (4) 250 cal BP-present, mostly warm-dry inter-bedded with cold-wet, rising temperature in response to the increasing solar variability and strong Indian Summer Monsoon. Fire indicators such as micro/macro-charcoals, burnt phytoliths, and highly-weathered phytoliths are exploited to reconstruct the fire episodes that occurred in the past 1700 years. The study area has experienced 2 phases of fire history as following: (1) 1700-700 cal BP, small scope of fires in response to the rising droughts marked by high frequency and low amplitude oscillation linked to the rising El Niño events; (2) 700 cal BP-present, large scope of fires in response to the droughts marked by low frequency and high amplitude oscillation related to the declining El Niño events. The fire occurrence in the tropical rain forest of Xishuangbanna is predominantly under the control of natural climate variability and El Niño events. Nearly every fire episode is coupled with a climatic event and triggered vegetation composition changes marked by pronounced expansion of grasses. These results are significant to understand the in-

*Speaker

†Corresponding author: ysgu@cug.edu.cn

teractions between climate change and tropical rainforest. Our study provides some innovative evidence for the history and impact of Indian Summer Monsoon on southwest China.

Keywords: Tropical rainforest, Indian Summer Monsoon

Peatland primary productivity response to the monsoon evolution in the past 20,000 years, Central China

Hongye Liu * [1], Yansheng Gu [1,2], Yangmin Qin [1,2], Xianyu Huang [1,2]

[1] State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan – China
[2] Hubei Key Laboratory of Wetland Evolution Eco-Restoration, China University of Geosciences, Wuhan (WEER) – China

A better understanding of a peatland primary productivity and carbon storage might provide an insight into future ecosystem response to global change. Dajiuhu wetland is a key area for understanding how wetland responded to the monsoon climate system in central China. In order to explore the relation between peatland primary productivity and paleoclimate change, a continuous and undisturbed peat core (ZK5) with a depth of 300 cm was collected using a 50-cm-long Russian-type peat corer at the center of the Dajiuhu Peatland. TOC and LOI, phytolith assemblages and indices (*Iw*, Bc), and geochemical elementary data are comprehensively analyzed to rebuild the paleo-monsoon history and peatland primary productivity in the past 20 cal ka BP. The dominant phytoliths in core samples are from grasses including bulliform cells (parallelepipedal bulliform cells and cuneiform bulliform cells), short cells (rondels, bilobates, crosses, saddles and trapeziform polylobates), long cells (elongates smooth, elongates dendriform, and elongates echinate) and hair cells (point-shaped), and trees including vascular tissues, multifaceted blocky, acicular hair cells, and unknown origin. Phytolith indices including bulliform cells index (Bc), warmth index (*Iw*) were calculated and analyzed. Chronology is determined by ten radiocarbon dates. The phytolith assemblages exhibited 4 paleoecology zones and reflected the history of paleovegetation evolution, indicating a large dominance of Pooideae during the Holocene; The geochemical elements combined with the deposition rate revealed 5 stages of peatland evolution. Correlation of primary productivity with the monsoon intensity and solar radiation during the past 20000 years revealed the followings: low primary productivity and plant biomass input were induced during the weak monsoon and declined insolation during Last Glacial Maximum (20-18 cal ka BP); last Deglaciation (18-11.5 cal ka BP) was characterized by the wildly fluctuating monsoon and increasing primary productivity; during the early-mid Holocene (11.5-3.0 cal ka BP), high primary productivity and rising temperature corresponded to the enhanced monsoons; decreasing primary productivity were observed due to the reduced solar radiation and weak monsoons since 3.0 cal ka BP. Two significant long-scale cold events are recorded by warmth index including Heinrich (H1) and Younger Dryas (YD). The complex climatic combination (warm-wet, warm-dry, cold-wet, cold-dry) in the study area is different from the typical pattern (cold-dry and warm-wet) in the Chinese Loess Plateau. Our results are significant in understanding how peatland primary productivity responds to the monsoon changes since the Last Glacial Maximum in Shennongjia National Nature Reserve.

Keywords: Dajiuhu Peatland, geochemical elementary

*Speaker

Determining new C4 grass plant functional types to reflect the grass cover diversity in Africa

Marine Pasturel * [1,2], Anne Alexandre [1], Carlos Cordova [3], Abdoulaye Wélé [4], Assize Touré [4], Jean-Charles Mazur [1], Christelle Hély-Alleaume [5]

[1] Centre européen de recherche et d'enseignement de géosciences de l'environnement (CEREGE) – Aix-Marseille Université - AMU, CNRS UMR7330, IRD UR161 – Aix-en-Provence, France
[2] Ecologie, Systématique et Evolution (ESE) – AgroParisTech, Université Paris XI - Paris Sud, CNRS : UMR8079 – Orsay, France
[3] Department of Geography, Oklahoma State University (OSU-Geography) – Department of Geography, Stillwater, OK , U.S.A.
[4] Centre de Suivi Ecologique (CSE) – Fann Residence, BP 15532, Senegal
[5] Institut des Sciences de l'Evolution - Montpellier (ISEM) – CNRS UMR5554, IRD UMR226, Université Montpellier II - Sciences et techniques, École Pratique des Hautes Études [EPHE] – France

African inter-tropical herbaceous biomes will likely face drastic changes in a near future. Their grass cover, which can represent up to 90% of the biomass, shows a high diversity in floristic composition, height and structure, due to different grass acclimation to water deficits, minimal temperature and disturbances. This diversity, however, is not taken into account in Dynamic Global Vegetation Models (DGVM), which weakens the simulations of inter-tropical herbaceous biomes spatial boundaries. In the present study we defined two C4 grass PFTs relevant for characterizing with more accuracy grass cover composition, structure and response to precipitation. First, we set up a vegetation classification, from a regression tree based on C4 grass physiognomic group combinations and leaf area index (LAI) data, practical for both West and Southern Africa and useful for DGVM output interpretation. Secondly, direct relationships (Spearman correlations) between the abundance of each physiognomic group and LAI were characterized at 0.5○ for both Senegal and South Africa. Thirdly, we statistically checked whether the grass physiognomic group composition and the herbaceous LAI were recorded in phytolith indices that constitute unique proxies for African inter-tropical grass covers. Two grass groups named according to the lowermost ("low") limit of the culm height (cm) of their median species were selected. A short-grass group (low10) was dominant in steppes with herbaceous LAI lower than 1.5, whereas a medium-sized grass group (low30) was dominant in savannas with herbaceous LAI higher than 1.5. In Senegal the shift of dominance from low10 to low30 as well as a shift of structure (LAI) characteristic of the steppe/savanna transition was correctly traced by a 20-40 threshold in Iph phytolith index. In South Africa the limited set of phytolith data did not allow observation of the full savanna/steppe transition.These findings should help to implement the parameterization of two C4 grass PFTs (xerophytic and mesophytic) in vegetation models.

Keywords: PFT, herbaceous biomes, LAI

*Speaker

Differential characteristics of mesophilous and xerophilous grasses trichomes in the south of Western Siberia

Marina Solomonova * [1]

[1] Altai State University (ASU) – 656049, Barnaul, pr. Lenina 61, Russia

Paleoreconstruction using phytolith analysis in the south of Western Siberia encounters difficulties due to lack of species reference collections. This study investigates the characteristics of grass trichomes which may be used as reference for this area. Golyeva A.A. (2001) uses various types of silicified trichomes, such as 'forest' and 'meadow' grasses silicified thrichomes, to interpret phytolith spectra from the temperate zone of Eurasia, especially from the European area of Russia. However, silicified trichome shape characteristics and differences are not detailed. Trichomes are formed not only in forest and meadow grasses but also in steppe grasses. Here we investigate whether any qualitative and quantitative characteristics can be used to differentiate trichomes from mesophilous and xerophilous grasses. Eleven species of grasses that form trichome phytoliths were studied: *Agrostis vinealis, A. gigantea, Calamagrostis epigeios, C. pseudophragmites, Setaria viridis, S. pumila, Stipa zalesskii, S. lessingiana, S. capillata, S. korshinskyi and S. pennata*. Eco-coenotic conditions of grasses were discussed.The following trichome characteristics were identified: trichomes proportion among other phytoliths, form (oval or trigonal), presence of prickle. Additionally, length, breadth and ratio of length and breadth were measured. These characteristics allow to partition the grasses into two groups: xerophytes and mesophytes. Mesophilous grasses are characterized by the occurence of trichomes and prickles, a large representation of trichome triangle forms and a large proportion of trichomes. Length and breadth of trichomes also reflect the partition of grasses into two groups : xerophytes (*Stipa*) and mesophytes (*Agrostis, Calamagrostis*). The length of trichome is the criterion the more statistically significant. Mesophilous grasses produce longer trichomes. The identified silicified trichome characteritics can be used for paleoecological reconstructions. Golyeva A.A., 2001. Fitolity i ikh informatsionnaya rol v izuchenii prirodnykh i arkheologicheskikh obyektov. Elista, Syktyvkar (in Russian, with English Abstract).

Keywords: phytoliths, trichomes, grasses, morphometry

*Speaker

Keynote speech

The curious case of Cenozoic South America: Assembling the grassland biome with almost no grasses

Caroline Strömberg *† [1], Regan Dunn [2], Richard Madden [3], Matthew Kohn [4], Alfredo Carlini [5]

[1] University of Washington (UW) – Seattle, United States
[2] Field Museum of Natural History (FMNH) – Integrative Research Center, Field Museum of Natural History, Chicago, United States
[3] University of Chicago – Chicago, Illinois, United States
[4] Boise State University, Department of Geosciences (BSU) – Boise, Idaho, United States
[5] Universidad Nacional de La Plata (LIFIA) – Buenos Aires, Argentina

Grassland ecosystems constitute one of the most prominent biomes today, covering about 40% of Earth's land surface. The assembly of the grassland biome has been of vital concern among paleontologists and evolutionary biologists for 140 years. Grassland evolution has primarily been studied using indirect lines of evidence, in particular the evolution of tall (hypsodont) cheek teeth of large mammalian herbivores, whereas direct paleobotanical data have historically been scarce. However, in recent years, phytoliths analysis has emerged as a useful tool for tracking the expansion of open habitats dominated by grassland vegetation, not least because of the potential for phytoliths to preserve in a wide range of Cenozoic deposits that do not contain other types of plant fossils. Phytolith records from North America and Eurasia have shown that grass-dominated vegetation spread in the late Oligocene or early Miocene, many million years before hypsodont ungulate herbivores evolved, supporting a link between floral and faunal change in these regions. In southern South America, hypsodont herbivores appeared and diversified in the middle Eocene (38 Ma), a pattern that was long thought to mark the spread of savanna vegetation 20 million years earlier than on any other continent. We have tested this hypothesis by analyzing early Eocene-middle Miocene (ca 49-12 Ma) phytolith assemblages from Patagonia (Argentina and Chile). In addition to 'traditional' compositional analysis of phytolith assemblages, we used a new proxy for habitat openness (reconstructed Leaf Area Index; $rLAI$) to evaluate whether habitats were open or closed, regardless of the relative abundance of grasses. The $rLAI$ method relies on the fact that anticlinal epidermal cells (reflected as phytoliths) of non-grass plants change shape and size depending on light environment (with larger, more undulated cells in shaded environments) to infer light environment/habitat openness in fossil assemblages. Our phytolith assemblage compositional analysis showed that grasses were rare in Patagonia for most of the Cenozoic, and did not form grasslands until sometime after the middle Miocene. Instead woody plants, including palms, remained prominent in vegetation through the middle Miocene. However, these relatively grass-free habitats became increasingly open during the middle Eocene (as inferred using $rLAI$), culminating in non-analog palm shrublands roughly concurrently with the earliest hypsodont herbivores. Isotopic data from the same strata record

*Speaker
†Corresponding author: caestrom@uw.edu

arid climates consistent with this vegetation inference. These patterns suggest that, unlike for North America and Eurasia, hypsodonty in South America did not signal the arrival of grass-dominated habitats, but rather open systems with high availability of (likely inorganic) dietary abrasives. Our work shows that a combination of phytolith assemblage composition analysis and the *rLAI* method has great potential for reconstructing the Cenozoic emergence of not just grasslands but open habitats more generally-including vegetation types that have no modern counterpart.

Keywords: Patagonia, grassland evolution, Leaf Area Index

Quantification, localisation, and role of phytoliths in modern plants

Variations in morphology and type of phytoliths according to the age of leaves and position in the vegetal body in Brachiaria decumbens

Raphaella Dias * [1,2], Heloisa Coe† [2,3], Igo Lepsch [4], Sarah Ricardo [2], Emily Gomes [2]

[1] Universidade Federal do Rio de Janeiro (UFRJ) – Maracana, Rio de Janeiro, Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[3] Universidade Federal Fluminense (UFF) – Brazil
[4] Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ) – Piracicaba, San Paolo, Brazil

Brachiaria decumbens is a Poaceae that accumulates large amounts of phytoliths. Previous studies have shown that the quantity of silica and phytoliths increases with the age of the leaves. Based on these observations, this study aimed to verify changes in the morphological development of phytoliths according to the age of the leaf and according to the part of the plant where they are found (leaf, root, stem and seed). For this, samples of root, stem, seed and leaves of different ages were collected from different individuals of *Brachiaria decumbens* species, which grew spontaneously in the campus soil of the Institute of Agricultural Sciences - UFMG / Montes Claros. The leaves were rated on a scale from zero (F-0) for the youngest to nine (F-9) for the oldest, these being already senescent. Clarification of the plant tissue with sodium hypochlorite, wet oxidation and calcination in muffle were used for the extraction and visualization of phytoliths. The analysis of the phytoliths involved weighing, counting under optical microscope, and description and classification according to ICPN. We found that phytolith formation starts as soon as the tissues of the leaves begin to differentiate in the very young stage (F-0), when the leaves were still curled. The mass of phytoliths increases with the age of the leaves, which may explain the greater roughness of old leaves. In all leaves the same phytolith types were found: short cell bilobate, polylobate, cross and long cell elongate echinate both sides, elongate echinate one side and elongate psilate, as well as silicified stomata. At the edges of the leaves a differentiated structure with continuous sheaves can be found, whereby the bilobate type phytoliths have become larger and more flattened. Despite the increase in phytolith mass with increasing leaf age, there was no significant difference in the proportion of morphotypes produced or in their size. In seeds, elongate echinate type phytoliths have a sinuous flattened shape and bilobate type phytoliths are still in formation, being very rounded and small in size. In the roots short-cell bilobate and cross types were not found, but there was the rondel type, which seems to be situated in the Casparian strip (which may have significant endoderm protection functions). In the stem a significant amount of phytoliths (2.7% of the initial weight) were found, these being of the same morphotypes as the leaves, as well as having the same tissue structure, organization and size of phytolith.

Keywords: Poaceae, Panicoideae, plant morphology, senescence

*Speaker
†Corresponding author: heloisacoe@yahoo.com

Amorphous silica biomineralizations in species from Argentina: content, morphologies and tissue location, systematic and ecological relations

Mariana Fernández Honaine *† [1,2,3], Maria Laura Benvenuto [1,2,3], Stella Maris Altamirano [1,2,3], Mara De Rito [3,4], Margarita Osterrieth [1,2]

[1] Instituto de Geología de Costas y del Cuaternario, Universidad Nacional de Mar del Plata-CIC – Mar del Plata, Argentina
[2] Instituto de Investigaciones Marinas y Costeras, Universidad Nacional de Mar del Plata-CONICET – Mar del Plata, Argentina
[3] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Argentina
[4] Facultad de Ciencias Agrarias, Universidad Nacional de Mar del Plata – Balcarce, Argentina

Silicification of plants is a widespread process and involves a high amount of plant families. The study of the content and distribution of amorphous silica biomineralizations in plant tissues has been approached by diverse disciplines, due to the relevance and applications that silicophytoliths have on different research areas. The knowledge of the plant production in a specific area, has multiple applications from anatomical/functional, through ecological up to palaeobotanical and palaeoenvironmental. The present study aimed to compare the content, morphologies and tissue distribution of silicophytoliths in leaves of species from different communities of Argentina. We evaluated how silica content varied according to systematic, life cycles (perennials vs annuals), habit (herbs vs arboreals) and status (native vs exotic), and compared with results obtained by other researches. We analyzed at which level the phytolith morphologies can discriminate between plant groups, and which morphologies may be more relevant for taxonomy. Leaves from at least 3 individuals of 92 species, grouped in 26 families, representing some of the main communities of Buenos Aires, Misiones, and Tierra del Fuego provinces, were collected. Silicophytoliths were extracted through a calcination technique, and silica content was measured as % dry weight. Silicophytoliths were counted and described under optical microscope following specific literature. Data of silica content was subjected to Kruskal Wallis and Mann-Whitney tests, depending on the hypothesis evaluated. Morphology data was subjected to Principal Component Analysis. Fifteen species do not produce silicophytoliths. The silica content ranged between 0.38% (*Ranunculus apiifolius*) and 19% (*Chusquea ramossisima*) and varied according to systematic. However, it was possible to observe that two species of a same genera had different behavior (producer and not producer). At family level, the highest media content was observed in Urticaceae and the lowest in Ranunculaceae. Differences were detected between Poaceae vs Asteraceae, Juncaceae, Rosaceae and Solanaceae ($p< 0.01$). Within Poaceae, Asteraceae and Cyperaceae families, no silica content differences were detected among species. There were no statistical differences between annuals and perennials, and natives and exotics (except within Poaceae family), contrary to what it was reported previously by other researchers. Leaf silica content content in herbs was higher than in trees and shrubs ($p< 0.01$); however, families with higher silica accumulation are mostly herbaceous (grasses, sedges). The main silicified tissue is epidermis, but also xylem and parenchyma became silicified. PCA showed that it is possible to

*Speaker
†Corresponding author: fhonaine@mdp.edu.ar

differentiate some families based on their phytolith assemblages. Poaceae (short cell phytoliths), Cyperaceae (cone shaped phytoliths), Urticaceae, Moraceae and Cannabaceae (cystoliths) are clearly differentiated from other groups. The redundancy of some morphologies such as tabular polygonal (derived from epidermis) and cylindrical sulcate xylem, makes difficult the discrimination of some groups. Finally, a detailed morphometric study will probably allow some additional differentiation, also within the groups already differentiated. However, besides the diagnostic character of the phytolith morphologies of specific taxa, it is relevant to increase our knowledge about the distribution of the silicification process among plants, not only for palaeobotanical but also for anatomical, physiological and ecological purposes. Acknowledgments: PICT 2036, PICT 1583, EXA 741/15

Keywords: leaf silicophytoliths, silicophytolith content, Argentina

Influence of silicon in plant – insect interactions: Evidence from Lepidoptera stem borers

Gerald Juma *† [1,2,3], E. Njuguna [1,2,4], G. Ong'amo [1,2,3], B. Le Ru [1,2,3]
Paul-André Calatayud‡ [1,2,3]

[1] International Centre of Insect Physiology and Ecology (ICIPE) – Nairobi, Kenya
[2] Laboratoire Evolution, Génomes, Comportement et Ecologie (EGCE) – IRD UMR247, CNRS UPR9034, Universitée Paris Sud – Gif-sur-Yvette, France
[3] University of Nairobi – Nairobi, Kenya
[4] Jomo Kenyatta University of Agriculture and Technology (JKUAT) – Nairobi, Kenya

Silicon (Si) is among the most abundant elements on earth's crust with many roles in plants. Although in higher plants, most of the chemical defense systems are conferred by plant secondary metabolites, the monocotyledons, particularly grasses, which usually contain much lower levels of secondary metabolites than the dicotyledons, may in addition depend on other mechanisms such as silicon (Si)-based defenses. Silicon accumulated in grasses mediate plant resistance to insect herbivores, particularly to chewing insects, through the enhancement of plant phytoliths, which provide a mechanical barrier to feeding. This presentation gives a summary of the research studies done during the last five years at icipe (International Centre of Insect Physiology and Ecology, Nairobi, Kenya) to determine the influence of Si in plant-Lepidoptera stem borers' interactions. Our results indicated that Si mediates maize plant resistance to Lepidoptera stem borers through formation of a Si barrier that physically interferes with caterpillar feeding and/or plant penetration, thus significantly interfering with the larval performance. However, such Si-based influence varies according to several factors including the stem borer species, the soil type and the environmental conditions. This partly, explains the current geographic distribution of the main Lepidoptera stem borer's pests of maize in the East African Mountains.

Keywords: Defense, herbivory, climate change, Africa

*Speaker
†Corresponding author: gjuma@uonbi.ac.ke
‡Corresponding author: pcalatayud@icipe.org

Phytoliths in grass and non-grass species: Pattern, function and evolution

Ofir Katz * [1]

[1] Ben-Gurion University of the Negev and Dead-Sea and Arava Science Center – Israel

A large portion of what we know about phytolith formation and function is derived from studies on grasses, which are one of the most phytolith-rich plant families. Non-grass species are seldom studied because of their low phytolith contents, and it is uncertain to what extent phytolith formation patterns and functions in grasses also apply for non-grass species.
Studying phytolith contents in Asteraceae species along a large rainfall gradient in Israel, in both grazed and ungrazed plots, has revealed that phytolith formation patterns in grass and non-grass species differ in several aspects. While grass phytolith contents along rainfall gradients tend to be higher in rainier sites (due to greater water availability) and extremely arid sites (due to small body size and the protective roles of phytoliths against aridity and herbivory), Asteraceae species did not show any single clear pattern. Moreover, while grass species tend to form more phytoliths when exposed to herbivory, and have higher phytolith contents in inflorescences compared to vegetative shoot parts, the opposite is often observed in Asteraceae species. These results suggest differences in phytolith functions between grass and non-grass species, especially in relation to aridity and herbivory. Nonetheless, further analysis of phytolith abundance in angiosperms reveals that orders in which phytolith-rich taxa occur have emerged mostly during the Early/Late Cretaceous boundary and have diversified mostly during the Late Cretaceous. This suggests that phytolith-rich angiosperms share an early evolutionary history. The Late Cretaceous is also characterized by the evolution of more derived dentition among certain herbivorous dinosaur groups such as the hadrosaurs and ceratopsians, which are thought to be better adapted to abrasive (potentially phytolith-rich) food. Thus, it is possible that the emergence of multiple phytolith-rich angiosperm clades during this time is connected to changes in dinosaur diets. Such a connection can be through a direct plant-herbivore escalation, but also because dinosaurs with silicon-rich diets excreted more readily-available silicon that could be exploited by phytolith-rich plant clades. Hence, the functional history of this unique plant trait is starting to be revealed, and may provide new insights as to the role silicon plays and has played in plant and global ecology.

Keywords: Ecology, water, herbivory, evolution, role

*Speaker

Phytoliths, agriculture and environmental stress

Jean-Dominique Meunier *† [1], Doris Barboni [1], Muhammad Anwar-Ul-Haq [2], Perrine Chaurand [1], Clément Levard [1], Catherine Keller [1]

[1] Centre Européen d'Enseignement et de Recherche en Geosciences de l'Environnement (CEREGE) – Aix-Marseille Université - AMU, CNRS : UMR7330, Institut de recherche pour le développement [IRD] : UR161 – Technopole Arbois Méditerranée, Aix en Provence, France
[2] University of Agriculture – Faisalabad, Pakistan

Recent studies have suggested that land use and particularly agriculture can modify the Si cycle through depletion of soil available Si. The extent of the perturbation, yet, is not known although it may be a critical factor for maintaining high yields of crops that are Si accumulators i.e. most of the cereals. Albeit generally not considered as an essential element, Si is used as a fertilizer in a few countries including Japan, China, South America and USA (Florida), essentially to overcome the depletion of the bioavailable Si in rice cultivation. The beneficial effects of Si have been demonstrated by many studies using pots, hydroponic and field experiments and are particularly remarkable in plants exposed to biotic or abiotic stresses such as drought. Si in the plants is mostly composed by dissolved Si in the xylem and by phytoliths in the cells and cell walls. How phytoliths may help the plants to mitigate environmental stress is still poorly documented. In order to determine if plant develop specific phytolith distribution under drought stress, we conducted hydroponic experiments using PEG-6000 for simulating water stress at the root level. Durum wheat (Triticum durum) was used because of its common occurrence under dry climate. In addition to morphological plant measurements and analysis of Si concentration in plant parts, we analysed phytolith morphotypes under the microscope after a wet extraction/acid digestion, and using in situ analysis of phytoliths in leaves by X-ray imaging, i.e. combining 2D chemical mapping by micro X-ray fluorescence spectroscopy (micro-XRF) and 3D imaging by X-ray micro-computed tomography (micro CT). Si application in the nutrient solution provides some evidence that Si mitigates the effect of water stress by improving shoot and root development and water uptake and retention in the leaves of *Triticum durum*, in agreement with previous studies. PEG affects the concentration of Si in the shoots and its distribution in the epidermal cells, notably by limiting the formation of silicified trichomes. The mitigating effect of Si is attributed to the reinforcement of the structure of leaves through preferential phytolith accumulation above the veins. The development of silicified trichomes in durum wheat depends primarily on the availability of Si in soil and is not an adaptation to water stress.

Keywords: phytolith, agriculture, water stress

*Speaker
†Corresponding author: meunier@cerege.fr

Keynote speech

Biosilicification in plants: chemistry, function and analysis

Carole Perry *† [1]

[1] Interdisciplinary Biomedical Research Centre, Nottingham Trent University – Clifton Lane, Nottingham NG11 8NS, United Kingdom

Biosilicification in plants and other organisms is a complex process under biological control that generates materials that act to protect and in some cases boost plant function. As well as transport of the 'element' in some form, control over nucleation, growth, aggregation and cessation of growth is required in order to generate the wonderful silicified structures that are found in a wide range of plants. All processes occur in a largely aqueous environment and the silica structures that form vary from plant to plant and sometimes many different structures can be found within a single plant cell! Using examples from the work of my research group and others, I will present the current level of understanding about the solution chemistry of 'silicon' pertinent to both the soil environment and to the environment in which silicified deposits form. I will provide information on how silica structures form and how these structures can be modified by contact with an environment that includes ions and/or biomolecules. I will discuss a range of methods that can be used to analyze for the presence of 'silicon' in solution and the solid state and present a new approach for the analysis of silicified structures including phytoliths.

Keywords: Biosilicification

*Speaker
†Corresponding author: carole.perry@ntu.ac.uk

Phytoliths of characteristic plants from the 'Caatinga' biome, Northeastern Brazil

Sarah Ricardo *† [1], Heloisa Coe [2,3], Raphaella Dias [2], Leandro Sousa [4]

[1] Universidade do Estado do Rio de Janeiro (UERJ) – UERJ, Av. Sao Francisco Xavier, 524, Maracana, 20550-900, Rio de Janeiro, Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – Brazil
[3] Universidade Federal Fluminense (UFF) – Brazil
[4] Universidade Federal Rural do Semi-árido (UFERSA) – Brazil

Located in northeastern Brazil, the 'Caatinga' biome covers about 11% of the country and is characterized by a semi-arid climate with vegetation adapted to high temperatures, low precipitation and uneven rainfall distribution throughout the year. Among the ways in which the plants adapt to the extreme climate, we can mention the loss of foliage during the dry season, reduced leaf blades or leaves transformed into spines and also water accumulation in underground storage organs. The unjustified belief that 'Caatinga' is an ecosystem poor in biodiversity and endemism, make it the most undervalued and botanically unknown Brazilian biome, without any phytolith studies in the region until now. Although some areas have been quite anthropized, the 'Caatinga' has several phytogeographical areas, and a significant number of rare and endemic taxa. 33 characteristic species of the region, belonging to 16 different families (Arecaceae, Anacardiaceae, Apocynaceae, Bignoniaceae, Boraginaceae, Bromeliaceae, Chrysobalanaceae, Erythroxylaceae, Euphorbiaceae, Fabaceae, Malphigiaceae, Malvaceae, Myrtaceae, Rhamnaceae, Rubiaceae and Verbenaceae) were analyzed. For the phytolith extraction, the organic matter of collected leaves was burned using a solution of nitric acid 65% and sulfuric acid 95%. The results showed that the analyzed plants are, in general, good phytolith producers, the most prevalent being tracheids, followed by polyhedral, globular granulate, elongate and trichomes, among others. We also observed some phytoliths in this study that we consider as being characteristic of a particular genus / species, as in the case of an elongate found in two species of the genus Croton (Euphorbiaceae) and trichomes of *Licania rigida* (Chrysobalanaceae). Another interesting result was the bromeliad *Encholirium spectabile*, where we found a huge production of globular echinate. A variation in the production of phytoliths was also verified for families such as Euphorbiaceae and Fabaceae, where the species production varied from high to non-production of phytoliths. The types of silicification found may be related to the environmental characteristics of the "Caatinga", where plants develop mechanisms against desiccation. The deposition of Si in their cells may be a survival strategy in this environment. Further studies in the region will provide more information on the production of phytoliths by plants of this important biome.

Keywords: Biomineralization

*Speaker
†Corresponding author: sarah.fricks@gmail.com

Phytoliths and the biogeochemical cycles of silicon and carbon

Origin, location and molecular characterization of phytolith carbon: insights for the phytolith carbon cycle

Anne Alexandre *† [1], Jérôme Balesdent [2], Isabelle Basile-Doelsch [1], Daniel Borschneck [1], Patrick Cazevieille [3], Claire Chevassus-Rosset [3], Emmanuel Doelsch [3], Araks Harutyunyan [4], Laurent Lemée [5], Armand Masion [1], Jean-Charles Mazur [1], Hélène Miche [1], Patrick Signoret [1], Stephane Viel [6], Fabio Ziarelli [6], Guaciara Santos [7]

[1] CEREGE, Aix en Provence – Centre National de la Recherche Scientifique - CNRS – France
[2] CEREGE, AIx en provence – Institut National de la Recherche Agronomique - INRA – France
[3] UPR Recyclage et risque, Montpellier – Centre de coopération internationale en recherche agronomique pour le développement [CIRAD] – France
[4] Department of Earth System Science, University of California, Irvine – United States
[5] IC2MP, Poitiers – Centre National de la Recherche Scientifique - CNRS – France
[6] Institut de Chimie Radicalaire – Aix-Marseille Université - AMU – France
[7] University of California - Irvine – United States

Phytoliths contain occluded organic compounds called phytC. Recently, phytC content, nature, origin, paleoenvironmental meaning and impact in the global C cycle have been the subject of increasing debate. Inconsistencies were fed by the scarcity of in situ characterizations of phytC in phytoliths. Here, using cutting-edge technics, we present new data allowing to further characterize phytC. The internal structure of harvested grass short cell phytoliths is reconstructed at high spatial resolution using 3D X-ray microscopy. Two pools of phytC, possibly differently protected from mineralization, are suggested from nanoscale secondary ion mass spectrometry (NanoSIMS) measurements. Plant absorption, translocation and occlusion of soil C in phytoliths is traced using 13C labeling. Simultaneously, the molecular composition of phytC is unraveled using pyrolyse-gas chromatography-mass spectrometry (Py-CG-MS) and dynamic nuclear polarization-solid-state nuclear magnetic resonance (DNP-SSNMR). The findings allow to precise the fluxes that need to be taken into account to quantify the phytC cycle at the soil/plant/atmosphere interface. This approach points out the lack of data required to estimate the phytC sequestration flux. The current available data suggest that there is no significant biosequestration of C by soil phytoliths in grassland ecosytems.

Keywords: phytolith, carbon, biosequestration

*Speaker
†Corresponding author: alexandre@cerege.fr

Phytolith Dating in Archaeology and Paleoecology: Basic Issues and Possible Answers

Dolores Piperno * [1]

[1] Smithsonian Institution – Washington DC and Panama, United States

Carbon-14 determinations of the organic material deposited inside of phytoliths have been carried out since the 1970s when investigators first discovered and utilized the potential of phytolith 14C analysis in archaeological and paleoecological dating. Since then, a number of studies have utilized phytolith dating, and a number of controversies have arisen concerning the original sources of the phytolith carbon, its viability for accurate dating, and the proper pretreatment methods before submission to radiocarbon facilities as well as the protocols at the facilities themselves. This paper reviews these issues and offers some possible answers as to the utility of phytolith 14C analysis in archaeology and paleoecology.

Keywords: phytolith carbon 14, pretreatments, interpretation of results

*Speaker

New estimates of global phytolith and phytolith-occluded carbon pools and fluxes

Paul Reyerson *† [1], Guaciara Santos [2]

[1] University of Wisconsin (UWL) – La Crosse, WI, United States
[2] University of California, Irvine (UCI) – United States

Phytoliths are microscopic grains of silica (SiO2nH2O) formed within plants. Phytoliths also contain small quantities of other elements and compounds, most notably organic carbon. Upon plant decomposition, phytoliths are released into soils where a small percentage can persist for thousands of years. Biogenic silica production by land plants is thought to be on par with that produced in oceans by marine organisms. Some researchers contend that the that the amount of C in phytoliths can be up to several percent. Thus, the rate of phytolith C (phytC) production may be quite large. This also implies that phytolith storage in biomass and soil pools may be a sizable and stable sequestration mechanism of atmospheric CO2. If this is true, then phytoliths may account for a large fraction of the total amount of C stored in biomass and soil pools. However, global phytC pools and fluxes have never been calculated. Here we assemble estimates of global phytolith and phytC cycling, using the global organic carbon cycle as a starting point. Phytolith silicon concentrations in organic C pools and fluxes were assumed to be between 1.2% and 4.0%. The concentration of C in phytoliths was found to be between 0.04 and 0.21%, based on several laboratory analyses and values found in the literature. Our findings indicate that phytC is a very minor component of all organic carbon pools and fluxes, in the range of $< 0.01\%$ to 0.04%. Our results indicate that 0.14 – 2.32 teramoles (Tmol) of phytC is produced annually, with a net land accumulation rate of < 0.01 – 0.05 Tmol yr-1. By comparison, global biomass C production is 4,787.28 – 5,453.33 Tmol yr-1, and the net accumulation rate is 49.95 – 116.56 Tmol yr-1. Soils contain the largest quantities of phytC, at 8.69 – 128.25 Tmol, while biomass contains 1.11 – 23.05 Tmol. In conclusion, we have found that phytolith C concentrations border on the trace level. Because of this, global phytC storage is not a major atmospheric C sequestration mechanism.

Keywords: Biogeochemical cycles, phytoliths, occluded carbon, sequestration

*Speaker
†Corresponding author: preyerson@uwlax.edu

Keynote speech

Recent advances in phytolith carbon research

Guaciara Santos * [1]

[1] Earth System Science, University of California Irvine (ESS/UCI) – Irvine, United States

Phytolith carbon (phytC) analyses have opened several lines of investigation in paleoenvironmental and crop domestication studies through radiocarbon (14C) dating, and CO2 sequestration capabilities through encapsulation in plant biosilica particles. These investigations require that phytC is from a photosynthetic origin as well as its host-plant tissues. As intuitively appealing as the atmospheric carbon (atmC) to phytolith assumption may be, a number of investigations showed that phytC 14C signatures for contemporary plants display anomalous 14C values of hundreds to thousands of years [1]. It appeared that soil carbon (soil-C) pollution in plant tissue and phytoliths was to blame [2]. Therefore, stronger evidence based on isotopic phytolith analyses using quality sounded experiments (aboveground and belowground carbon manipulations) and multiple laboratories was required to address this issue. The non-photosynthetic source hypothesis was addressed using comparative isotopic measurements (14C and 13C) of phytC, plant tissues, atmospheric CO2, and soil organic matter [3]. Simultaneously, multiple lines of investigations were carried out on phytolith extraction and purity evaluations [4], which in turn better constrain phytC concentrations. Here, we provide evidence that 14C phytC offsets occurred in association with a soil-C contribution to phytC, regardless of the phytolith extraction protocol adopted, and that phytC is from a mixed carbon pool (between soil-C and atmC). A continuous ramped temperature procedure under an oxygen stream was also used to evaluate the decomposed products of phytC (low-temperature reactive versus thermochemically resilient [3]). Meanwhile, NanoSIMS analyses of phytolith polished sections were used to locate phytC in the phytolith siliceous structure and to give insight into the nature of the organic matter (OM) [5]. Through Raman spectroscopy we found that the phytC chemical structure changed depending on growth conditions [6], while labeled amino acids (15N and 13C) provided conclusive evidence of the phytoliths' direct occlusion of carbon acquired by plant-root [7]. This presentation will briefly review these findings, which have rebutted traditional concepts, as well as address technical questions raised by opposing researchers during its development: Can isotopic fractionation and/or over-oxidation during phytolith chemical extractions be invoked as an explanation for the anomalous 14C phytC ages [8]? What does "old" uptake of soil-C to phytC really means when the 14C results show both positive and negative offsets [3,8]? How can heterogeneous carbon pools (such as phytC) be partitioned by distinctive chemical extractions and heating treatments [3], while homogeneous pools cannot [9]? What are the confounding factors that dissuade the use of phytC as a dating material [8] and CO2 sink [3]?

1 Santos et al. 2010. Radiocarbon 52, 113-128.

2 Santos et al. 2012. Biogeosciences 9, 1873-1884. doi:10.5194/bg-9-1873-2012

*Speaker

3 Reyerson et al. 2016. Biogeosciences, 13(4), 1269-1286, doi:10.5194/bg-13-1269-2016.

4 Corbineau et al. 2013. Rev. Palaeobot. Palyno. 197, 179–185.

5 Alexandre et al. 2015. Biogeosciences 12, 863–873, doi:10.5194/bg-12-863- 2015.

6 Gallagher et al. 2015. Front. Plant Sci. 6, 753, doi: 10.3389/fpls.2015.00753

7 Alexandre et al. 2016. Biogeosciences 13(5), 1693-1703, doi:10.5194/bg-13-1693-2016

8 Santos et al. 2016. JAS 71, 51-58. doi:10.1016/j.jas.2016.04.015
9 Fernandez et al. 2014. Anal. Chem., 86, 12085–12092.

Keywords: phytolith carbon, radiocarbon dating, isotopes, NanoSIMS, Raman, Thermo analysis

Keynote speech

Phytolith as medium of coupled biogeochemical cycles of silicon and carbon: a case study of China

Zhaoliang Song * [1]

[1] Institute of the Surface-Earth System Science Research, Tianjin University – Tianjin, China

The coupled biogeochemical cycles of silicon (Si) and carbon (C) in terrestrial biomes that are regulated by plant activities play a significant role in controlling atmospheric CO2. Phytoliths, the biogenic silica deposited within plant tissues during plant growth, generally take the shape of plant cells where biogenic silica precipitates and occlude 0.2–5.8% of organic carbon for most high plants. Carbon sequestered wthin phytoliths may be enriched in soils and sediments for hundreds to thousands of years depending primarily on the chemical composition and morphology of phytoliths, and soil and climatic conditions. Phytolith C sequestration is considered to be one of the most important biogeochemical C sequestration mechanisms. Here we review recent advances in phytolith C sequestration study and estimate the potential of phytolith C sequestration in China. The results show that the phytolith-occluded carbon (PhytOC) production rates among terrestrial biomes in China decline as croplands> forests> grasslands. Furthermore, active management measures such as rock powder amendment, organic mulching, partial plant harvesting, and growing Si-accumulating plants to enhance aboveground net primary productivity (ANPP) and silicon fertilization have great potential to promote the phytolith C sink. However, further studies are required to demonstrate the magnitude, exact mechanisms involved, and the cost of these management measures on phytolith C sequestration in various terrestrial biomes, and to make phytolith C sequestration a globally significant biogeochemical C sequestration mechanism.

Keywords: carbon sink, terrestrial ecosystems, grassland, forest, cropland

*Speaker

Morphology, morphometry, taxonomy and taphonomy of phytoliths

Keynote speech

Phytolith taphonomy in archaeological sites

Dan Cabanes * [1,2]

[1] Rutgers University – New Brunswick, NJ, United States
[2] Max Planck Institute for Evolutionary Anthropology – Leipzig, Germany

Opaline phytoliths are commonly used in paleoecological and archaeological research. The quality of these investigations depends on the accuracy and precision of the data obtained. Phytoliths inorganic nature makes them relatively resistant to most post-depositional processes, although individual phytolith preservation can change depending on the burial conditions. Therefore, understanding why and how phytoliths have been preserved is essential to produce high-quality phytolith analyses. This presentation aims to introduce the latest advances in the field of phytolith taphonomy and to explore different approaches to evaluate the preservation state of fossil phytoliths.

Keywords: Taphonomy, Diagenesis, Preservation, Archaeology, High resolution analyses

*Speaker

Quantitative trumps qualitative: developing automated approaches to phytolith analysis

Rand Evett * [1]

[1] Department of ESPM, University of California, Berkeley – United States

Based on the trajectory of other disciplines that analyze biological shape data, it is clear that phytolith analysis will become increasingly quantitative in the future, with greater emphasis on computer-assisted automation. Although phytolith researchers have successfully addressed many research questions through qualitative approaches to phytolith analysis, quantitative approaches, if practicable, offer several significant advantages. Computer-assisted analysis will enable the use of more efficient morphometric descriptors of phytolith shape and ornamentation, the development of semi-automated quantitative classification systems and the construction of widely accessible, cloud-based morphometric databases. Because numerous disciplines have progressed further along this path, phytolith researchers can draw on the considerable body of research available in the literature. Transitioning phytolith analysis into a fully quantitative, automated scientific discipline is a worthy long-term goal that will undoubtedly require decades of work to achieve. Phytolith researchers can contribute to progress toward this goal by talking with each other about what is needed, developing standardized protocols when appropriate, and testing, developing, reporting on, and sharing successful new quantitative approaches they have tried.

Keywords: Morphometrics, Multivariate analysis, Automated classification, Elliptic Fourier analysis

*Speaker

Effects of fire in phytolith assemblages: experimental approach and archaeological applications

Shira Gur-Arieh *† [1], Dan Cabanes‡ [1], Amanda Henry [1]

[1] Max Planck Research Group on Plant Foods in Hominin Dietary Ecology, Max Planck Institute for Evolutionary Anthropology – Deutscher Platz 6, 04103 Leipzig, Germany

The identification of burnt phytoliths in the fossil record has important implications in paleoecological and archaeological research. To date, different methods have been proposed to identify burnt fossil phytoliths but none of them considered the effects of post-depositional processes. Here we present a new method to identify burnt phytoliths using Fourier transform infrared spectroscopy (FTIR). We experimentally burned intact and isolated wheat leaf and inflorescence phytoliths at different temperatures. The preliminary results suggest that burnt phytoliths can be identified using FTIR grinding curves. However, post-depositional processes, in particular rehydration, can affect our ability to detect burnt phytoliths due to changes to their crystal structure. Therefore we can potentially identify burnt phytoliths in the fossil record, but cannot conclusively identify unburnt material.

Keywords: Burning, FTIR spectroscopy, postdepositional processes

*Speaker
†Corresponding author: shira_gur@eva.mpg.de
‡Corresponding author: dan_cabanes@eva.mpg.de

Silicophytoliths and taphonomy in Cenozoic pedostratigraphic sequences of the Pampean Plain, Argentina

Margarita Osterrieth *† [1], Natalia Borrelli [1], Maria Laura Benvenuto [1], Mariana Fernández Honaine [1], Lucrecia Frayssinet [2], Stella Maris Altamirano [1], Mara De Rito [1], Roberto Donna [1], Micaela Paolicchi [1], Maria Alvarez [1]

[1] Instituto de Geología de Costas y del Cuaternario (IGCyC), FCEyN-UNMdP. Instituto de Investigaciones Marinas y Costeras (IIMyC), CONICET-UNMdP. Buenos Aires, Argentina. – Argentina
[2] Facultad de Ciencias Naturales y Museo UNLP – Argentina

ABSTRACT

Grasslands and savannas occupy one forth of the total surface of South America continent, and within it, the Pampean plain region, located in the central area of eastern Argentina, covers an area of 1,200,000 km2. The dominant soils are Mollisolls generally deep, developed from well-drained loessic parental material and characterized by a silty-loam texture. Pampean Plains is one of the most fertile regions of the world. Intense agricultural activities are carried out there and this, in turn, has strongly modified the native plant communities, especially grasslands. Depending on the environmental and pedological conditions, silicophytoliths are affected by diverse taphonomical processes, both in natural and anthropic environments. They can be preserved, dissolved or fragmented, and also be transported by different agents (wind, water, animals and people). Other taphonomical aspects also important to evaluate are the methodologies used in silicophytolith studies, from soil sampling to studies at a submicroscopic level. There are several current methodologies and the work is essentially done at a very detailed resolution level, which could lead to interpretation errors if the environmental or paleoenvironmental context of the study material is unknown or not clearly stated. The study area is located in regional geomorphological units from Pampean Plain, Argentina, and integrated profiles representative of typical pedoestratigraphic sequences were analyzed. Silicophytoliths were analyzed as part of the whole mineralogy of the soil samples and morphologies were described under optical and scanning electron microscopes. The results show high amounts of silicophytoliths which have been affected by various physical and chemical alteration and/or by taphonomic processes of different types and degrees of intensity. The percentage and number of silicophytoliths per gram of soil vary. In superficial horizons (O, A), the percentage ranged between 10-65%, with 11.000.000-30.000.000 phytoliths per gram of soil (n/g.s). In subsuperficial horizons (AC, B, BC) between 2-6% and 1.000.000-5.000.000 silicophytoliths n/g.s were observed. The percentage of silicophytoliths in loessic parent material (C) ranges between 0.4-2%, with 500.000-2.000.000 n/g.s. In paleosols, percentages range between 1-8%, and the number of silicophytoliths per gram of soils were 1.500.000-8.000.000. Silica and silicophytolith biomass content per ha of soil varied according C biomass, in the pedostratigraphic Cenozoic sequences from Pampean plains. Our data show that the content of silicophytoliths decreases between 50 and 95% from superficial to subsuperficial soil horizons due to pedological processes. The comprehension of the physico-chemical

*Speaker
†Corresponding author: mosterrii@hotmail.com

degradation and transference processes within silicophytolith-plant-soil-environment system is essential in order to evaluate the role of taphonomical processes in the biogeochemical cycle of silicon. Finally, it is proposed that the displacement of native grasslands may be bio-physico-chemically balanced by the introduction of crops, in relation to the silicon cycle, since they are also important silicophytolith producers in the SE Pampean agroecosystems.
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Keywords: Pedological processes, methodology, loess, paleosols

Phytolith Morphometrics: An Update on Zea mays Signatures and Comparisons from the American Southwest

Linda Scott Cummings * [1]

[1] PaleoResearch Institute (PRI) – 2675 Youngfield St., United States

ImageJ and plugins developed for phytolith morphometrics provide the backbone of our technology for morphometric studies. Image capture, one challenging and time consuming aspect of this analysis, is easier using drawing tablets or surfaces. Our methods, including improvements in the mechanics of drawing phytoliths, are discussed, followed by potentials for interpretations. Morphometric analysis of phytoliths obtained directly from archaeological cobs and reference cobs of ancient varieties including Chapalote, Reventador, and Teosinte, are compared to reference cobs from the Southwest (Tohono O'odham 60-day flour and Hopi Blue flour) and the Plains. Our expanding database of more than 50 cobs allows examination of relatedness of the reference cobs and the archaeological cobs to one another. Close relationships between some of the archaeological cobs, explored since 1999, and either or both Chapalote and Reventador indicates retention of primitive popcorn traits in many of the archaeological varieties. It also points to derivation of maize farmed in antiquity from Chapalote, Reventador, and Teosinte. Principal components analysis and cluster analysis provide two mechanisms for examining relatedness of archaeological cobs. Plotting closeness of fit of archaeological cob populations on the landscape allows for examination of potential trade and movement of people since ownership of seed is known to be closely controlled. This movement, whether it represents people moving on the landscape or trade, involves people who live in villages (Puebloan people from the Southwest, Fremont people from the Great Basin, and various Plains tribes) and people who appear to be more mobile, living in smaller habitations. The future direction of comparison with aDNA from archaeological cobs, as well as DNA from modern cobs is anticipated to hold the key to unraveling the past. Ultimately, morphometric analysis of phytoliths derived from archaeological cobs is designed to address questions of social relatedness and movement of peoples, and it might ultimately be able to assist in defining social lineages.

Keywords: morphometrics, ImageJ, maize, Zea mays

*Speaker

Morphometric study of variance in articulated dendritic phytolith wave lobes between selected species of Triticeae and Aveneae

Luc Vrydaghs * [1], Terry Ball [2], Tess Mercer [2], Zsuzsa Lisztes-Szabó [3], Akos Pető [3]

[1] CReA - Patrimoine Université Libre de Bruxelles – av F.D. Roosevelt, 50 B, Bruxelles, Belgium
[2] Brigham Young University – Provo, UT, United States
[3] Hungarian National Museum, National Heritage Protection Centre – Budapest, Bulgaria

A previous study explored the intraspecific morphometric variance among wave lobes of articulated dendritic phytoliths within selected species of cereals (Ball et al. 2016). This study was a first step towards understanding the variance between species. It demonstrated that there is significant variance between different accessions of the species and between the different bract types and inflorescences spike locations of the bracts within the accessions of the species. We concluded that when preparing reference data researchers should assure that they sample all bract types from all inflorescence spike locations from several accessions for each species in order to obtain reliable data. We further found that shape morphometries are more reliable and require a smaller sample size for statistical confidence than size morphometries when analyzing wave patterns in these taxa. Once we understood morphometric variance among wave lobes of articulated dendritic phytoliths *within* species our next step in developing this research tool was to study the variance *between* species. We will report our findings in this contribution. We began by expanding our reference collection. It now includes about 52 taxa distributed over 136 specimens. Many of the major cultivated cereal crops, their wild ancestors as well as some weeds are represented within the reference collection. Analysis of the ranges of means of the wave lobe morphometric variance for the studied taxa revealed a broad overlapping at the intra- and intergeneric levels. Still, some intervals in the minimal and maximal range of means tend to discriminate some taxa. These minimal and maximal intervals of range of means appear to be more diagnostic for the size morphometries than for the shapes measurements. In this contribution we will discuss some of the issues raised by these results as well as avenues to apply these findings to archaeological samples. Ball, T.B.,Vrydaghs,L., Mercer, T., Pearce, M., Snyder, S., Lisztes-Szabó, Z. and Pet'o, A. 2016. A morphometric study of variance in articulated dendritic phytolith wave lobes within selected species of Triticeae and Aveneae. Vegetation History and Archaeobotany.

Keywords: articulated dendritics, morphometry

*Speaker

Poster session

Identifying the specific action of the threshing sledge on phytoliths in cereal straw: a quantitative study of experimental, ethnographical, and archaeological material

Souhair Alkalesh * [1], Patricia C. Anderson [1]

[1] Culture et Environnements, Préhistoire, Antiquité, Moyen-Age (CEPAM) – Université Nice Sophia Antipolis, CNRS UMR7264 – Campus Saint-Jean-d'Angély, Nice, France

The threshing sledge or tribulum is a wooden plank pulled by animals and armed with flint inserts or more recently, with metal inserts, for threshing, cutting and chopping cereals on a prepared threshing floor. It was widely used in the Near-East and Mediterranean areas probably since the Neolithic, according to indirect evidence (phytoliths and flint blades), and undeniably since the 4th/3rd millennium according to its mention in cuneiform texts. Qualitative phytolith research on ethnographical threshing residues and experiments using a reconstructed tribulum of the Bronze Age have shown a link between particular cut profiles of phytoliths and the use of a tribulum (Anderson et al. 2006), distinct from fracture patterns caused by cutting with a sickle or animal trampling (Anderson et al, 2004; 2006; 2011; 2014). Here we revisit these and other new samples and the classification of the phytolith cuts produced by various treatments of the cereals, using correspondence analysis. This research confirms that phytoliths resulting from tribulum-treated samples show specific cut profiles and orientations, particularly the "straight oblique" profile. These smooth cuts with preferential orientation in relation to phytolith direction in spodograms which seem to be characteristic of the use of a tribulum, are a result of the interaction of motion of the flint or metal inserts and the layer of cereals on the threshing floor. Based on these observations, we compared the control correspondence analysis results with phytolith samples from two archaeological sites dating from the 8th to the 5th millennium BP: Tell Halula in the north of the Euphrates valley, and Tell Ziyadeh in the Khabur valley in north-eastern Syria to detect signs of the use of the tribulum as a threshing tool.

Keywords: Tribulum, threshing sledge, phytolith analysis, phytolith cut, quantitative analysis, Cereals, experiments in archaeology, ethnography

*Speaker

Reconstruction of the FLK Zinj paleolandscape (1.83 Ma, Olduvai) using phytoliths

Héctor Arráiz * [1], Doris Barboni [2], Enrique Baquedano [3], Audax Mabulla [4], Manuel Domínguez-Rodrigo [1]

[1] Universidad Complutense de Madrid – Spain
[2] Centre Européen d'Enseignement et de Recherche en Geosciences de l'Environnement (CEREGE) – Aix-Marseille Université - AMU, CNRS UMR7330, IRD UR161 – Aix en Provence, France
[3] Museo Arqueológico Regional de Madrid – Spain
[4] Université de Dar es Salaam – P.O. Box 35091 Dar es Salaam, Tanzania

In order to frame hominin evolution into a landscape and characterize the local habitat of Olduvai hominins, the phytolith content of 27 samples from different trenches sampling the FLK Zinj paleolandscape (FLK Zinj, AMK, PTK and DS sites, _˜25 ha), provides botanical evidence for a mixed paleovegetation dominated by forest with open-spaces dominated by grasses at Tuff IC deposition time (about 1.832 miilion years ago). The analysis reveals the abundance of woody plant phytoliths (from 12% to 75% relative to the total assemblages), and of grass short cell phytoliths (up to 68% of the assemblages). The presence of palm phytoliths (up to 56% of the assemblages) attests for meso-haline soils in the area in agreement with the presence of the saline/alkaline Olduvai paleolake and one (or more) groundwater discharge areas (freshwater springs). The presence of a dense-wooded vegetation is not consistent with the supposed presence of a river channel 50 to 200 m southeast of the FLK Zinj site. This study contributes to better document the spatial distribution of plants in the Zinj area. It shows that the wooded area extended to the south and the west of the sites previously analyzed by Ashley et al. (2010). The presence of ferns phytoliths in the assemblages suggests shaded and humid habitats, which further suggests for the presence of freshwater (rivers or springs) that might have attracted hominids and other animals. The availability of freshwater and the faunal and lithic remains recovered in the sites argues for a behavioral model for these sites in which hominins used the site not only as a refuge, but also to process animal carcasses and to carry out other activities related to central place foraging.

Keywords: Phytoliths, Olduvai, hominins, paleovegetation, Africa

*Speaker

Phytolith evidence of wetland geomorphological changes in the Cerrado biome, Minas Gerais, Brazil

Cristina Augustin *† [1], Ubiranan Lucena [2], Guaciara Santos [3], Heloisa Coe [3,4]

[1] Instituto de Geociências - Universidade Federal de Minas Gerais (IGC-UFMG) – Belo Horizonte-MG, Brazil
[2] Programa de Pós-Graduação em Geografia- Instituto de Geociências-Universidade Federal de Minas Gerais (IGC-UFMG) – Belo Horizonte-MG, Brazil
[3] Earth System Science Department -University of California- Irvine (UCI) – Irvine, CA, United States
[4] Instituto de Formação de Professores - Universidade Estadual do Rio de Janeiro (UERJ) – Patronato, São Gonçalo - RJ, Brazil

Reconstructions of paleo-environment and soil evolution usually requires multiproxy approaches. Recent studies in Brazil have shown the potential of combining phytolith and 14C analysis of soil profiles for reconstructing past climatic and geomorphic conditions. Phytolith analysis is used here to reconstruct paleoenvironmental conditions in the Peruaçu drainage basin, located in the semiarid portion of Minas Gerais (Brazil) while 14C analysis provided the timeframe of environment changes. Basin hillslopes are covered by Cerrado vegetation, a varied mosaic of woodland, scattered trees, shrub thickets and grassland. The flat valley bottoms are very different, with fen peat and slow water flow. They are termed veredas and are part of the cerrado wetlands characterized by lines of palm trees within extensive seasonally-wet grassland, with small scattered lakes approximately following the main channel. Climate is semi-arid with mean annual precipitation of 1100 mm concentrated within 4 to 5 months (November to March) and mean annual temperatureis of 25∘C. The origin of vereda lakes in this basin is uncertain and could be due to past hydrogeomorphological events which altered small affluent configurations of the Peruaçu River. Reconstruction of vereda evolution requires to understand the changes in local water balance and associated hydro-geomorphology. Phytolith analysis is used here with other proxies to investigate lake origin and drainage change. Environmental reconstruction is based on four samplings. Two samplings were done in the slope soils, at the upper head and upper-middle course of the Peruaçu River. Two more samplings were done in the lake sediments. Slope angle and vegetation cover were used to plan the samplings. Laboratory analysis included soil/sediment organic content, pH, phytolith analysis, C istopes and 14C-AMS dating of soil organic matter. Phytolith results reveal four palaeoenvironments: a) very humid; b) humid; c) water deficient; and d) dry. Dry periods are suggested at 4632 yr cal BP (reconstruction from the bottom lake sediments), at 4042 yr cal BP (reconstruction from River Peruaçu head) and at 4211 yr cal BP (reconstruction from the Peruaçu middle course). Results also indicate the occurrence of the first main humid period at 3707 yr cal BP at Jatoba lake and 3060 yr cal BP at the River Peruaçu head. This lasted until 2905 yr cal BP. The present second humid period began from 984yr cal BP onwards. The humid periods are accompanied by an increase in soil organic matter and clay content. There is a large difference in dates for the older wetter phase of the two sampled lake cores (3707yr cal BP vs 1781yr cal BP). The older date at Jatoba lake

*Speaker
†Corresponding author: chaugustin@hotmail.com

suggests that this was part of a separate affluent river system. Overall results show that past variation in vegetation cover is driven by 1) local variation of the water table controlled by basin bottom – upper slope hydro-geomorphological adjustment over time, and, 2) climatic change involving much drier conditions than today.

Keywords: Phytoliths, Cerrado, Vereda wetlands, Hydrogeomorphological Changes, Climatic change.

Dimensions of bilobate phytoliths in 15 Poaceae species of Central Africa: is morphometry relevant for paleoenvironmental studies?

Benjamin Bourel *† [1], Alice Novello [2]

[1] Centre européen de recherche et d'enseignement de géosciences de l'environnement (CEREGE) – Aix Marseille Université, CNRS UMR7330, IRD UR161 – Aix-en-Provence, France
[2] Department of Biology and the Burke Museum of Natural History and Culture – University of Washington, Seattle, United States

The Poaceae family produces diagnostic phytoliths, the so-called grass silica short cells, which include rondels, bilobates, crosses, polylobates and saddles for the most generic morphotypes. These morphotypes display shapes and sizes that are very distinguishable and different from phytoliths produced by other plant families. Among them, the bilobates have in common a general "dumbbell" shape consisting of two lobes inter-connected by a shank. Bilobates are produced in abundance by species of the Panicoideae grass subfamily, but also in high abundances by a few grass species among the Arundinoideae, Chloridoideae and Ehrhartoideae grass subfamilies, which all occur today in low-altitude environments of Central Africa. In order to determine whether the dimensions of bilobate phytoliths vary among grass species of Central Africa and if some morphometric parameters can be used to infer grass taxonomy, we analyzed bilobate phytoliths from 15 different species including eight Panicoideae, three Arundinoideae, two Chloridoideae and two Ehrhartoideae. Bilobates produced by each species were photographed at x500 magnification with a camera connected to an optical microscope. More than 718 bilobate bodies (between 49 and 55 per species) were then measured by imagery software. Five distinct parameters were measured on each bilobate individual: length of the base, length of the shank, average length of the two opposite lobes, width of the shank and average width of the two opposite lobes. Measurements data were processed using R statistics 3.3.1 and discussed in regard to the taxonomical and ecological features of each grass species.Statistical analyses indicate a significant relationship between the length of the bilobate base, the width of the bilobate shank and the water-requirement of each grass species. Bilobates with longer bases (22.8 $\pm$0.8 μm in average) and thinner shanks (3.7 $\pm$0.1 μm in average) are indeed mainly produced by xerophytic species of the Aristidoideae and Chloridoideae subfamilies, while bilobates with shorter bases (18.0 $\pm$0.5 μm in average) and thicker shanks (4.2 $\pm$ 0.1 μm in average) are mainly produced by non-xerophytic species of the Panicoideae and Ehrhartoideae subfamilies. These results highlight again the potential for bilobate dimensions, instead of non-measured features (e.g. shape of the base/top, section, lobes), to improve paleoenvironmental studies.

Keywords: Poaceae, Paleoenvironment, Proxy, Biometric analysis, Africa

*Speaker
†Corresponding author: bourel.benjamin1@gmail.com

Pen management and livestock activities based on phytoliths, dung spherulites and minerals from Cova Gran (Southeastern Pre-Pyrenees)

Aitor Burguet-Coca *† [1,2], Jorge Martínez-Moreno [3], Rafael Mora [3], Alfonso Benito-Calvo [4], Ethel Allué [1,2], Dan Cabanes [5,6]

mm [1] Institut Català de Paleoecologia Humana i Evolució Social (IPHES) – Tarragona, Spain
[2] Àrea de Prehistòria, Universitat Rovira i Virgil (URV) – Tarragona, Spain
[3] Centre d'Estudis del Patrimoni Arqueològic de la Prehistòria (CEPAP) – Facultat de Lletres, Universitat Autònoma de Barcelona, Bellaterra, Spain
[4] Centro Nacional de Investigación sobre Evolución Humana (CENIEH) – Burgos, Spain
[5] Max Planck Institute for Evolutionary Anthropology – Leipzig, Germany
[6] Department of Anthropology, Rutgers University – New Brunswick, NJ, United States

Rockshelters and caves have been used as livestock enclosures during prehistoric and historical times in the Mediterranean region. These archaeological contexts, known by the French term *foumier*, are characterized by the overlapping of dung burnt episodes related to livestock activities. In these contexts, the macro-archaeological record is sparse and therefore archaeological interpretation has to rely on the micro-archaeological remains. The combination of phytolith, dung spherulites, and mineralogical analyses through Fourier Transformed Infrared Spectroscopy (FTIR) allows to understand the processes involved in the formation of *foumier* layers and provides light on the human activities carried out in these sites. Here we present the preliminary results for the study of phytoliths, dung spherulites, and mineralogy in the Holocene sequence of Cova Gran de Santa Linya (Southeastern Pre-pyrenees). The archaeological evidence suggests that the site was used as a pen area in two archaeological levels (2N and 3Nb) corresponding to the Bronze Age (3320-2720 calBP) and Late Neolithic (5270-4620 calBP) respectively. For this study we analyzed a total of 21 samples collected from the profile E during 2015 field season. FTIR spectra show the presence of anthropogenic calcite (ashes), thermally altered clay, and quartz, in most of the samples. Dung spherulites concentrations are high in all samples. Phytoliths concentrations and morphologies are homogeneous along the sequence. The presence of weathered morphotypes is low (below 10%). Most of the phytoliths correspond to monocotyledonous plants, and among them grass inflorescence is overrepresented in relation to the leaves and stems. C3 pooid-type are the most abundant grass short cells, and only low percentages of C4 panicoid-type short cells have been recovered. Dicotyledonous and wood/bark phytolith morphotypes show low values. These preliminary results indicate a continuity of the activities carried out in the site from the Late Neolithic to the Bronze Age. However, a higher presence of thermally altered clays and high-temperature ashes in the Neolithic layers might indicate different intensities of occupation and dung management for these two periods. The later has implications for the study of livestock management and transhumance practices during the recent prehistory of the Southeastern Pre-Pyrenees area.

*Speaker
†Corresponding author: aitorburguetcoca@gmail.com

Phytoliths as indicators of Quaternary geomorphological dynamics in alluvial - colluvial ramps, Espinhaço mountain range, Minas Gerais, Brazil

Karina Chueng *† [1], Heloisa Coe [2], Cristina Augustin‡ [3], Alessandra Vasconcelos§ [4], Kita Macário¶ [5]

[1] Universidade Federal Fluminense (UFF) – Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – São Gonçalo, RJ, Brazil
[3] Universidade Federal de Minas Gerais (UFMG) – Brazil
[4] Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) – Diamantina - Minas Gerais, Brazil
[5] Laboratorio de Radiocarbono da Universidade Federal Fluminense (LAC-UFF) – Brazil

The Espinhaço Mountain Range is a mesoproterozoic tectonic deformation zone located in the eastern area of the state of Minas Gerais, Brazil. One of the most common features in this massif is the occurrence of outcrops of quartzite, which are interspersed with alluvial-colluvial ramps. The main objective of this work is to contribute to the understanding of the geomorphological processes that led to the formation of depositional ramps close to the quartzite outcrops, by inferring climate variations from phytolith and carbon isotope studies. Twelve soil profiles were sampled in three areas (Area 1: between Guinda and Diamantina; Area 2: Chapadinha – Gouveia; and Area 3: Morrinhos), totalling 45 soil and sediment samples. Topographical, grain size, phytolith, isotopic and organic carbon analyses and 14C- AMS dating were performed. It was observed from the analysis of three alluvial-colluvial ramps that the geomorphological processes acted differently. In the three studied areas, the phytolith and isotopic results did not indicate any major changes in the type of vegetation over time, although variations have been found along the slopes. In Guinda and Morrinhos, phytolith stocks, varying in accordance with the particle size, do not follow the pattern of decreasing with depth. In Chapadinha, stocks decrease with depth. The D/P indexes were always low (06-29) and Bi indexes were very high (75 to 94% in Areas 1 and 2, 48 to 84 % in Area 3). In Areas 1 and 2, the phytoliths are highly weathered, indicating that the erosive processes are intense. In Area 3, the phytoliths are well preserved, suggesting greater geomorphological stability. In the three areas, the predominant types of phytoliths are those produced by grasses, especially parallelepipedal bulliform and cuneiform. In Area 3, despite the predominance of the bulliform type, phytoliths characteristic of Poaceae, such as bilobate, polylobate, cross and trapeziform types were also found, as well as the globular granulate type. The δ13C analysis indicates open vegetation with a predominance of grasses, especially the C4 type. Differences in regard to the greater or lesser presence of woody plants were most observed among the surface samples of the profiles of a same transect, or from one area to another, rather than along each profile. Another trend observed in all areas was the reduction of the presence of woody plants with depth (about 5700

*Speaker
†Corresponding author: karinachueng@yahoo.com.br
‡Corresponding author: chaugustin@hotmail.com
§Corresponding author: alessandravascon@gmail.com
¶Corresponding author: kitamacario@gmail.com

cal years BP). The analyses indicate the predominance of savanna vegetation since 6038 years BP. The phytolith analysis associated with Geomorphology was found to be highly effective in understanding the evolution of the landscape and environmental changes. These analyses are of great relevance for the temporal reconstruction of the region and the interpretation of geomorphological processes operating efficiently in the transport and deposition of sediments in this region.

Keywords: Southern Espinhaço, Brazil, Geomorphological dynamics

Paleobiogeoclimatic reconstruction in the Quadrilátero Ferrífero (Southeastern Brazil) inferred from fluvial successions

Heloisa Coe * [1,2], Amanda Pacheco Seixas [2], Jenifer Garcia Gomes * [2], Luiz Barros† [3], Kita Macário‡ [2]

[1] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[2] Universidade Federal Fluminense – Brazil
[3] Universidade Federal de Minas Gerais (UFMG) – Pampulha, Belo Horizonte, Minas Gerais, Brazil

The Quadrilátero Ferrífero is an important mineral province in the south-central region of Minas Gerais State, Southeastern Brazil, and has one of the largest iron ore reserves in the world. Previous work in this region has indicated that the formation of fluvial successions with duricrusts coincided with drier/cooler climatic phases alternating with moister/warmer periods during which the formation of fluvial successions without duricrusts occurred. However, there are still many gaps in regard to these climate variations. Thus, the paleobiogeoclimatic reconstruction from fluvial deposits in the Quadrilátero Ferrífero is extremely important for the inference of the environmental conditions during the deposition of these sedimentary records. This study aims to investigate evidence of bioclimatic oscillations obtained directly from three depositional successions (DS) and discuss their influence on the geomorphogenisis of local river valleys. For this purpose, phytolith, carbon isotope and granulometric analyses were carried out, as well as dating of soil organic matter through radiocarbon and of sediments using OSL. The results show that in the oldest depositional succession (DS1 - about 34ka) the predominant phytoliths are those of bulliform parallelepipedal, elongate, acicular and globular granulate types and δ13C values are typical of C3 plants. On the other hand, despite having a similar phytolith assemblage (abundance of bulliform parallelepipedal, elongate, bulliform cuneiform, acicular, globular psilate and bilobate flat/concave types), the fluvial successions associated with significant conglomeratic duricrusts (DS2 and DS3) present a dominance of δ13C values characteristic of C4 plants. The Bi index indicates water stress in all the successions, and the Ic index suggests decreasing temperatures with depth in DS3. Thus, the three fluvial successions indicate a savanna-like environment, but depositional successions DS2 (_˜27ka) and DS3 show drier/cooler climatic conditions when compared to DS1 and to the present-day regime. These drier/cooler conditions in steep valleys with unprotected hillslopes may have been decisive for the formation of relatively thicker layers of gravel and sand, which later became duricrusts. The results indicate that climate has played an important role in the regional hydrosedimentological dynamics, given the variations in vegetation influencing the formation and abandonment of fluvial floodplains. Despite the limitations encountered due to the high degree of alteration of the phytoliths, which reflects the intensity of weathering and erosive processes, and the abundance of iron oxides, which clearly reduced the phytolith stock, this proxy, combined with other indicators, was able to identify changes and infer the paleoclimatic conditions that influenced the geomorphological processes occurring in the region during the Quaternary.

*Speaker
†Corresponding author: luizfpbarros@yahoo.com.br
‡Corresponding author: kitamacario@gmail.com

Phytolith analysis at the Chalcolithic site of Maidanetske (Ukraine) between mega-sites and steppe developments

Marta Dal Corso *† [1], Welmoed Out [2], Wiebke Kirleis [1]

[1] Christian-Albrechts-Universität – Kiel, Germany
[2] Department of Archaeological Science and Conservation, Moesgaard Museum – Højbjerg, Denmark

Phytolith analysis showed to be a powerful tool for the detection of grassland communities worldwide. In addition, its application in archaeological sites can provide insights on plant use for food and non-food purposes, including the reconstruction of cereal processing. With such direction of research, the study of phytoliths is integrated in the multi-disciplinary research project at the archaeological site of Maidanestke (Cherkasy Oblast, Ukraine). In this paper preliminary results and future directions of phytolith research are presented. The two main lines of phytolith investigation concern the understanding of routine activities and functional areas at the site and the study of the local vegetation history. This village of ca. 3000 houses corresponds to a so-called "mega-site" of the Trypillia-Cucuteni Culture, which covered ca. 200 ha and was occupied between ca. 4100-3600 BCE (Late Trypillia period, Early Chalcolithic). The poor preservation of plant macro-remains and charcoal lead to the need for an on-site integration of different proxies, including phytoliths. Concerning the landscape development, the site is located at the border of the North Pontic forest-steppe region on loess soils with paucity of waterlogged archives for pollen studies. The seek for off-site geo-archives for soil, sediment and phytolith analyses, aims at detecting landscape changes and the weight of prehistoric human impact.

Keywords: Ukraine, steppe vegetation, Trypillian Culture, mega, sites

*Speaker
†Corresponding author: mdalcorso@gshdl.uni-kiel.de

Salt spring from Halabutoaia (Neamt, Romania): contribution of phytoliths analysis to reconstruction of paleoenvironment and human activities

Mihaela Danu *† [1], Claire Delhon‡ [2], Olivier Weller§ [3]

[1] Alexandru Ioan Cuza University of Iasi ; Faculty of Biology – Blvd Carol I 20A, Iasi 700506, Romania
[2] Culture et Environnements, Préhistoire, Antiquité, Moyen-Age (CEPAM) – CNRS : UMR7264, Université de Nice Sophia-Antipolis – Campus Saint-Jean-d'Angély, Nice, France
[3] Archéologies et Sciences de l'Antiquité (ArScAn) – CNRS : UMR7041, Université Paris I - Panthéon-Sorbonne, Université Paris X - Paris Ouest Nanterre La Défense – Nanterre, France

The salt spring exploitation from *Halabutoaia* (Tolici, Neamt County, Romania) dates back to the Early Neolithic and lasted throughout the Chalcolithic. The deposit stratigraphy is estimated at 8 m and covers 2,500 years of history (c. 6000-3500 BC). In order to reconstruct the paleoenvironment and to document the impact of human activities on the territory of Halabutoaia site, we carried out a detailed study of phytoliths preserved in several archaeological levels assigned to Cris, Precucuteni and Cucuteni Cultures. We carried out the analysis of 26 samples. Besides morphotypic classification, we calculated phytolith ratios in order to emphasize changes in the relative abundances of morphotypes ("Bulliform Index", Panicoideae short cells vs Pooideae short cells, spike phytoliths vs. phytoliths from vegetative parts of grasses). The most identified morphotypes come from grass family. Analysis revealed an important representation of inflorescence phytoliths (especially dendritic forms) showing the anthropogenic origin of the assemblages. Panicoid forms are also well represented. These forms may derivate either from wild millet (*Setaria* sp.), which spontaneously grows in the area, or from cultivated millet. In some very punctual assemblages, dicotyledonous forms are very well represented. Taking into account the low phytoliths production by dicotyledonous plants, it involves a special accumulation of these types of plants that could be related to woody plants used as fuel for salt production. Microscopic investigations on phytoliths did not allow us to identify the purpose for which those plants were brought to site. Specifically, it is not possible to find out if their presence is connected to the combustion structures, because combustion is a process that leaves no visible tracks on phytoliths. Also, it is very possible that grasses had a very important role in pyrotechnology used to produce salt, either as the main fuel or as a mean for controlling the temperature or even as a firelighter.

Keywords: salt spring, Neolithic, Cucuteni, phytoliths, human impact, Halabutoaia (Romania).

*Speaker
†Corresponding author: danum2007@yahoo.com
‡Corresponding author: claire.delhon@cepam.cnrs.fr
§Corresponding author: olivier.weller@mae.cnrs.fr

Root silicification of grasses and crops from Pampean region and its relevance on silica and silicophytolith content of soils

Mariana Fernández Honaine *† [1,2,3], Micaela Paolicchi [1,2,3], Margarita Osterrieth [1,2], Maria Laura Benvenuto [1,2,3]

[1] Instituto de Geología de Costas y del Cuaternario, Universidad Nacional de Mar del Plata-CIC – Mar del Plata, Argentina
[2] Instituto de Investigaciones Marinas y Costeras, Universidad Nacional de Mar del Plata-CONICET – Mar del Plata, Argentina
[3] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Argentina

Root tissues of grasses and dicots can accumulate amorphous silica. Particularly in Poaceae family, silica can be restricted to the endodermis, spread throughout all tissues or deposited into intercellular spaces. The aim of the present study were 1) to analyze the silica content in typical grasses and crops (soybean, maize, wheat) from Pampean region, Argentina; 2) to evaluate the potential input of silica and silicophytoliths from roots to soils in natural and cultivated areas. Roots from eight typical pampean grasses and three crops were collected from field. Also, soil samples, including the roots developed within them, were collected every 10 cm along the profiles from natural and cultivated areas. They were dried and weighted, and the relative contribution of roots to total weight was calculated. Root silicophytoliths were extracted following a calcination technique and the content was calculated as percentage of dry weight. Silicophytolith morphologies were described under light microscope, according to previous literature. Silicophytolith content ranged between 4-11% in pampean grasses and between 0.8-4.20% in crops. *Bothriochloa laguroides* and *Sorghastrum pellitum* produce silica aggregates in endodermal walls; while the rest of the grasses produce silicifications of endodermal walls and xylem. In crops, silica is deposited in xylem, endodermal cells and epidermal cells. In soils, the abundance of roots was higher in the first 10 cm. In this section the roots represented the 0.39% of the weight of natural soils and 0.03% of cultivated soils. Towards the base to the profiles the values ranged between 0.0013-0.023% and 0.002-0.001%, in natural and cultivated soils, respectively. Considering a 15% (mean value) of silica content of roots obtained from soils, the total silicophytolith input from roots to soils was 0.0585 gr per 100 gr of soil (at first 10 cm) and between 0.000195-0.00345 gr per 100 gr of soil (10-60 cm) in the natural area. Instead, in crop area, where silica in roots was 11%, the mean value of silica input was 0.0033 gr per 100 gr of soil (first 10cm) and 0.00011-0.00022 gr per 100 gr of soil (10-60cm). The main morphologies found in soil roots were silicified xylem and elongate phytoliths, similar to those found in roots from Pooideae grasses and crops. The results obtained in this study revealed that 1) silicophytolith production in roots from pampean grasses and crops is abundant; 2) the morphologies found are consistent with previous studies in relation to Poaceae; 3) the input of silica and silicophytoliths from roots to soils may be more relevant in natural than in cultivated areas, due to the higher development of roots but also due to the higher production of silicophytoliths in native grasses. Since root silicophytolith morphologies seem to be more labile than the morphologies produced by other grass organs, it may be possible that they have a strongest influence on silica cycle

*Speaker
†Corresponding author: fhonaine@mdp.edu.ar

in soils, due to a higher/faster dissolution rate; they also may contribute to the preservation of soil aggregates, due to the role that silica has on soil structure. Acknowledgments: PICT 2036, PICT 1583, EXA 741/15

Keywords: root silicophytolith content, endodermis silicification, amorphous silica, input, Pampean region, Argentina, soil

Calcium oxalate crystal production in different plant communities of the Pampean Plain: a comparative analysis

Mariana Fernández Honaine *† [1,2,3], Stella Maris Altamirano [1,2,3], Natalia Borrelli [1,2,3], Maria Laura Benvenuto [1,2,3], Margarita Osterrieth [1,2]

[1] Instituto de Investigaciones Marinas y Costeras, Universidad Nacional de Mar del Plata-CONICET – Mar del Plata, Argentina
[2] Instituto de Geología de Costas y del Cuaternario, Universidad Nacional de Mar del Plata-CIC – Mar del Plata, Argentina
[3] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Argentina

Calcium oxalate crystals (COC) are the most prevalent and widely distributed mineral deposits throughout the families of higher plants. COC were analyzed in vegetative organs and fruits of 13 species from different plant communities of the Pampean Plain: forests (*Acacia melanoxylon*, *Celtis ehrenbergiana*, *Eucalyptus globulus*), agroecosystems (*Glycine max*), and wetlands (*Alternanthera philoxeroides*, *Bidens laevis*, *Hydrocotyle bonariensis*, *Ludwigia peploides*, *Mikania parodii*, *Polygonum hydropiperoides*, *Ranunculus apiifolius*, *Rumex crispus* and *Typha latifolia*). Organs were placed in an ultrasound bath and washed with distilled water to remove possible mineral contaminants. Afterwards, diaphanization, clearing of tissues with 50% sodium hypochlorite and cross sectioning were realized. The material was mounted with gelatin-glycerin and COC were identified and described with optical, polarization and scanning electron microscopes. Crystal density was calculated and the composition of the crystals was analyzed by X-ray dispersive spectroscopy (EDS). Statistical analyses (Kruskal-Wallis test and Principal Component Analysis) were made in order to compare COC size and production between communities, species and organs. Druses were observed in *C. ehrenbergiana*, *E. globulus*, *A. philoxeroides*, *H. bonariensis*, *L. peploides*, *P. hydropiperoides*, and *R. crispus*. Raphide bundles were present in *L. peploides* and *T. latifolia*; and prismatic crystals in *A. melanoxylon*, *E. globulus*, *H. bonariensis*, *L. peploides* and *R. crispus*. Calcification mainly occurred in parenchymatous tissue. No COC were observed in *B. laevis*, *M. parodii* and *R. apiifolius*. A single crystal morphology was observed per organ, except in leaves of *L. peploides* and *E. globulus*, which present both druses and raphides, or druses and prismatic crystals, respectively. In fruits, only prismatic crystals were observed independently of the morphology produced in the vegetative organs. The species analyzed had significant differences in the size of the COC (H: 443.5, $p< 0.001$). Particularly, some aquatic species (*A. philoxeroides*, *L. peploides*, *P. hydropiperoides* and *R. crispus*), given the great size of their druses (36-58μm), could not be differentiated among them ($p> 0.05$). Considering each species, the fruits had smaller COC (5-11μm) than the vegetative organs (14-210μm, $p< 0.001$). The COC density was significantly different between communities, species and organs, and allowed to distinguish the community and the organs with greater production of COC. Thus, the tree species were grouped together with the fruits of the species analyzed given their greater COC density: 9167-28308 and 1112-18531 crystals/mm2, respectively. Inside this group, *C. ehrenbergiana* and *E. globulus* have more affinity because they produce druses, unlike *A. melanoxylon* and the fruits analyzed that

*Speaker
†Corresponding author: fhonaine@mdp.edu.ar

produce prismatic crystals. It was not possible to discriminate between the aquatic community (7-250 crystals/mm2) and the crop (340 crystals/mm2). The description and quantification of COC allowed to distinguish among different plant communities, species and organs. The fruits showed the smallest size and the highest density of crystals. This particular pattern ensures the normal growth and development of the embryos, since crystals act as a calcium source, prevent damage from insects and allow reproductive success of the species. Acknowledgments: PICT 2036, PICT 1583, EXA 741/15

Keywords: Crystal size, Crystal density, Plant communities, Pampean Plains

Palaeoenvironmental reconstruction of landscape dynamics over the last 30,000 years in the Sudanian environment (Falémé valley, Senegal): preliminary results of a phytolithic approach

Aline Garnier * [1], Laurent Lespez [1], Michel Rasse [2], Benoît Chevrier [3,4], Brice Lebrun [5], Chantal Tribolo [5], Eric Huysecom [6]

[1] Laboratoire de géographie physique (LGP) – CNRS UMR8591, Université Paris I - Panthéon-Sorbonne, Université Paris-Est Créteil Val-de-Marne (UPEC) – Meudon, France
[2] Environnements et sociétés de l'Orient ancien (ARCHEORIENT) – CNRS UMR5133, Université Lumière - Lyon II – Maison de l'Orient et de la Méditerranée, Lyon, France
[3] Archéologies et Sciences de l'Antiquité (ArScAn) – Université Paris 1 - Panthéon-Sorbonne, CNRS UMR7041, Université Paris X - Paris Ouest Nanterre La Défense – Maison René Ginouvès, Nanterre, France
[4] Université de Genève – Genève, Switzerland
[5] Institut de Recherches sur les Archéomatériaux (IRAMAT) – CNRS UMR5060, Université de Technologie de Belfort-Montbeliard, Université Michel de Montaigne - Bordeaux III, Université d'Orléans – France
[6] Laboratoire Archéologie et Peuplement de l'Afrique (LAPA) – Genève, Switzerland

In West Africa, palaeoenvironmental data covering the Upper Pleistocene are rare. The lack of well-dated sedimentary records prevents a sufficient spatial reconstruction to understand the climatic and environmental dynamics that operated during this period. The recent discovery of particularly well-preserved deposits covering the last 70,000 years in the Falémé Valley (Senegal, Sudanian zone) offers new research perspectives. In particular, the sedimentary records attributed to stage 2 (MIS 2, 24-12 ka. BP), in part contemporaneous with the last arid period at the end of the Pleistocene (20-12 ka. BP) and the transition to the Holocene, are well-developed and bring new information on this poorly known period in West Africa. This poster presents the initial results for the sedimentary and landscape dynamics of the Falémé from 30 000 to 5000 years BP. The study is based on investigations conducted in the field (geomorphology, chronostratigraphy) and in the laboratory using an approach combining micromorphological and phytolith analysis of the deposits. The study of the microfacies of the deposits by micromorphology is a key step in the interpretation of hydrosedimentary processes and thus in the understanding of phytoliths taphonomy. Fieldwork and micromorphological study revealed a highly complex depositional sequence with eolian and alluvial sources as well as reworking due to run-off and pedogenesis. Phytoliths assemblages analysis of 22 fossil samples covering the last 30 000 years, show strong vegetation dynamics during this period. Phytoliths from the stage 2 deposits are dominated by GSCP and more particularly by saddle morphotypes suggesting the development of a xerophytic savanna. Samples from the beginning of the Holocene (12 ka. BP) indicate denser and humid vegetation with the appearance of Bambusoideae saddles and higher percentages of woody dicotyledons phytoliths. At the end of the Middle Holocene (around 5000.cal BP) phytoliths analysis testify of an openness of the vegetation with an increase of GSCP.

*Speaker

Do grass phytolith assemblages in soils reflect the abundance and repartition of grass ecological types of South Niger?

Issiaka Issaharou Matchi * [1,2], Doris Barboni [3], Saley Karim [4], Saadou Mahamane [4]

[1] WASCAL GRP Climate Change and Biodiversity, University Felix Houphouët Boigny; – Abidjan, Côte d'Ivoire
[2] Université de Diffa – Diffa, Niger
[3] Centre Européen d'Enseignement et de Recherche en Geosciences de l'Environnement (CEREGE) – Aix-Marseille Université - AMU, CNRS UMR7330, IRD UR161 – Aix en Provence, France
[4] Université Dan Diko Dankoulodo – Maradi, Niger

Grass phytolith assemblages preserved in soils and having good taxonomical significance are valuable tools for documenting and interpreting the response of African grass-dominated biomes to past climate changes. Climate controls the present-day distribution and abundance of grass ecological types in west African grasslands such as pronounced latitudinal differences exist between the drier north, characterized by small, mainly therophytic grasses using C4 NAD-ME photosynthesis, and the more humid south, characterized by tall, often hemicryptophytic grasses with mainly C4 NADP-ME photosynthesis. We collected 51 surface soil samples in different bioclimatic regions in South Niger and carried out botanical relevés at the sampling plots. Phytolith assemblages were extracted from the soils to evaluate the relative abundance of grass and non-grass morphotypes. Our results show that maximum relative abundance of Saddle types occurs at arid Sahelian sites (up to 79% in Bakabe) dominated by short grass Chloridoideae. Maximum relative abundance of Bilobate types is observed in Sudan sites where higher abundance of Panicoideae grasses occurs. Saddle phytoliths of the Tabular equidimensional type and the Tabular long convex edges saddles characterize sites with a high share of C4 PS-NAD (NAD-ME) photosynthesis grasses. Sites with higher abundance of C4 MS (NADP-ME) are characterized by phytolith assemblages with Tabular equidimensional saddles, and various bilobate types (Trapeziform, "saddle-bilobates", bilobates with short, tabular, round lobes, long and tabular bilobates, Tabular, 3-lobed crosses and rondel phytoliths with oblong base and keeled or truncated tops). Through statistical analysis, we will evaluate how well phytolith assemblages match with botanical data especially regarding the abundance and distributions of grass ecological and photosynthetic types.

Keywords: Grass ecology, Taxonomy, Semi, arid environment, Palaeoecology

*Speaker

Phytolith analyses from the Pleistocene and Holocene sediments In Koobi Fora basin, Kenya

Rahab Kinyanjui *† [1,2], E.k. Ndiema [1], P.w.k. Kiura [1], J.w.k. Harris [1], Marion Bamford [2]

[1] Earth sciences Department, National Museums of Kenya – P.O Box 40658-00100, Nairobi, Kenya
[2] Evolutionary Studies Institute, University of the Witwatersrand – Private Bag Wits 2050, South Africa

Phytolith analyses have increasingly gained popularity as a proxy to reconstruct past vegetation cover in prehistoric sites. In particular because they preserve well in a variety of East African depositional regimes and they are useful in reconstructing grasslands dynamics which have been a key component of the vegetation structure in the East African region since the Pliocene. Here we present phytolith data analysed from both Pleistocene and Holocene sediments that are separated by unconformity that lasted for over 500 ka. The analysis of phytolith assemblages suggests that vegetation cover during the Pleistocene period was more stable consisting of both herbaceous taxa dominated with C4 grasslands while during the Holocene period vegetation structure switched between wetland grasslands and marshlands as reflected by Cyperaceae and palms phytoliths and open to wooded grasslands.The data reflects Pleistocene environments were more stable than the Holocene environments due to climatic variability. During the Early Holocene the climates were more humid and the lake level was higher than the present day which dropped by ca 30m during Mid-Holocene when the climate became increasingly drier.

Keywords: C4 grasses, lake level, variability

*Speaker
†Corresponding author: rkinyanji@gmail.com

Giant reed (Arundo donax L.) ecotypes phytolith assemblage

Szilvia Kovács * [1], Petra Kiss [1], Zsuzsa Lisztes-Szabó [1]

[1] University of Debrecen, Department of Agricultural Botany, Crop Physiology and Biotechnology (UD) – Hungary

Giant reed (*Arundo donax)* is a plant that is invasive in most tropical and Mediterranean part of the world. The reason for this is the high adaptability and tolerance of the plant. It is a perennial, rhizomatous grass, with phytoremediation capability, which is generally applied in many ways, such as bio-ethanol, biomass, and feed. It is an extemporal neophyte known as ornamental plant in Hungary. Species of *Poaceae* are known for high silica accumulation but they are differences between them. Phytolith assemblage is very characteristic and useful for the taxonomic identification, which can be applied in environmental reconstruction and archeobotanical researches. The main goals of this paper are : (1) to study phytolith assemblage of giant reed in different leaf types (2) and to make a comparison between phytolith assemblages of various ecotypes of giant reed. Two ecotypes of temperate (namely Pelso, STM from Hungary) and two ecotypes of Mediterranean (Blossom-USA, Esp-Spain) were examined, including three types of leaf (low-mid-upper) for each. After cleaning and drying we applied dry ashing method and measured biogen silica content. Ashes coming from each types of leaf were used to make an average sample and 200-210 photos were taken by light-microscope on each (Zeiss Axioskop 2+). Phytolith morphotypes were identified according to ICPN 1.0. We took 2435 microscopic photos in total. Eleven out of the main 15 identified morphotypes were short-cells. The most typical morphotypes were bilobate, assisting findings by CHAUHAN (2011). Epidermal long-cells were represented by elongate, polilobate, saddle and carinate, but in low portion. Every ecotypes included the following morphotypes such as bilobate, blocky, rondel, bulliform, and elongate in the lower types of leaf, as well as in the upper ones. Excluding bilobate morphotype, all of the morphotypes were found in higher portions in the low leaves. There are higher frequency of short cells for Hungarian ecotypes, compared to the other two. Ecotype specific morphotypes as trigonal pyramid were found in low leaves of Blossom, and scutiform was found only in Pelso. Descending morphotype diversity is the follow: Blossom, Pelso, Esp, STM. We detected some new morphotypes such as blocky, rondel, and prickle, which had not been described in the literature so far. As a summary we can state that there are differences between phytolith assemblages of ecotypes of various climates, and there are ecotype specific morphotypes of *Arundo donax.*

Keywords: Leaf, Poaceae

*Speaker

Phytolith assemblage and silicon distribution in nine organs of Poa pratensis L.

Zsuzsa Lisztes-Szabó * [1], Akos Pető [2], Ibolya O. Tóth [1], Hanga Kiss [1], Szilvia Kovács [1]

[1] University of Debrecen, Department of Agricultural Botany, Crop Physiology and Biotechnology (UD) – Debrecen, Hungary

[2] Szent István University, Institute of Nature Conservation and Landscape Management (SzIU) – Gödöllő, Hungary

The amount and form of biogenic silica in vascular plants has been most extensively studied in the *Poales*, which species accumulate more silicon than in any other order. Silica bodies in the grass leaf are used for taxonomic descriptions of the *Poaceae* family since fundamental studies of Prat (1936) and Metcalfe (1960). This study aims to characterise the amount and morphology of phytoliths in important tissues of different organs in *Poa pratensis*. This species is considered a 'model' grass for grasslands in the Carpathian Basin. Five *Poa pratensis* 'Szarvas 59' specimens were collected from experimental plots and five specimens were collected from wet meadows (Hungary) after flowering in 2014. Intact specimens were lifted from a depth of 20 cm of the soil. Plants were cleaned and dried between filter papers. Phytolith extraction and biogenic silica content measurement were accomplished through the dry-ashing technique. Ashes were mixed thoroughly, mounted in immersion oil and observed at x1000 magnification. The cross sections of the stem, root and leaf as well as the spectra and map of elements were studied using an AMRAY 1830I type scanning electron microscope. About 170-920 phytoliths per plant organ were counted. Morphological classification was accomplished based on Twiss et al. (1969) and others, whilst the denomination of morphotypes follows the International Code for Phytolith Nomenclature 1.0. Differences between samples of the organs were in the proportions of silica particles rather than the presence or absence of phytolith types. The most frequent phytoliths in the seminal roots were elongated forms certainly with vascular origin, and an irregular form, with a characteristic protrusion. Latter morphotype may origin from the parenchymatic cortex. Silica concentrated in the outer tangential wall of the endodermis. Nodal roots contained small amount of phytoliths, mainly short cells and irregular forms with protrusion. The most frequent form in the stem is the irregular parenchymatic cell, and concave polygon that can only be found in the stem. Elongate phytoliths were isolated in inflorescences. Papillae are the characteristic phytolith morphotypes in the spikelets, and intercellular silica can also be found here in the largest amount. The number of short cells was similar in the leaf sheaths and blades of lateral shoot and stem leaves. But, the number of elongate phytoliths was at least twice bigger in the blade than in the sheaths.

Keywords: epidermis, SEM

*Speaker

Phytolith analysis of ceramic thin sections: description and morphometric approach in 'fixed analytical environment'

Zsuzsa Lisztes-Szabó [1], Akos Pető* [2], Luc Vrydaghs † [3], Terry Ball [4]

[1] University of Debrecen, Dept Agricultural Botany, Crop Physiology and Biotechnology – Debrecen, Hungary
[2] Szent István University, Institute of Nature Conservation and Landscape Management (SzIU) – Gödöllő, Hungary
[3] CReA - Patrimoine ULB, Université Libre de Bruxelles – Bruxelles, Belgium
[4] Brigham Young University – Provo, UT, United States

Phytolith analysis, both as a paleoenvironmental and archaeobotanical proxy, is widely used within different types of studies. Apart from a few geographically isolated case studies, to date, not much emphasis has been given to the description and identification of plant opal phytoliths in one of the most abundant archaeological finds: ceramics. Opal phytoliths observed in ceramic thin sections can be used as a proxy for identifying characteristics of ceramic production and the temperature of pottery firing. Furthermore, plant opal phytoliths may shed light on the vegetal material used for temper. Analysis of phytoliths in ceramic thin sections presents researchers with unique challenges and advantages. Often poor visibility of phytoliths in thin sections due to taphonomical circumstances that appear in the ceramic fabric and the nature of phytolith analysis in a two-dimensional environment can hinder their precise quantification and identification. Moreover, phytoliths incorporated into ceramics are not liberated from the plant tissue before entering the fabric, as it often the case in other micro-environments. Rather, the organic plant tissue incorporated into the ceramic fabric is burnt out during firing, leaving the inorganic phytoliths behind. Therefore the visibility of plant opal in thin sections is dependent on the perfection of the firing process. Furthermore, phytoliths may appear in thin section in various positions, which can help or hinder their observation and identification. In a best-case scenario a phytolith appears in a top view, which indicates that the polishing of the surface of the section reached the precise level of the phytolith. Since phytoliths in thin sections cannot be rotated for the sake of three dimensional observation, morphotype identification, description can be difficult. In spite of these challenges, researchers can gain much information from analysis of phytoliths in thin sections. Extensive analyses of ceramics obtained from numerous Early Neolithic sites on the Great Hungarian Plain in Hungary have been conducted. These analyses have shed light on the varying presence, distribution, spectra composition and conservation of phytoliths in ceramics, and helped to refine the identification of the clay sources, the tempering material and the temperatures reached during the firing process of the ceramics. The so called 'chaff-tempered' pottery of the Early Neolithic provides an excellent material for thin section phytolith analysis. In this contribution we present the preliminary results of the morphometric analysis of articulated dendritic phytoliths observed in the thin sections.

Keywords: morphometry, vegetal temper, Early Neolithic

*Corresponding author: peto.akos@mkk.szie.hu
†Speaker

Readily soluble silicon pools and distribution of phytoliths in rice and sugarcane soils of Karnataka, South India

Sabyasachi Majumdar *† [1], Doris Barboni [2], Prakash Nagabovanalli [1], Kadalli Gundappa [3], Jean-Dominique Meunier [2]

[1] University of Agricultural Sciences, GKVK, Bangalore - 560065, India – India
[2] Centre Européen d'Enseignement et de Recherche en Geosciences de l'Environnement (CEREGE) – Aix Marseille Université, CNRS UMR7330, IRD UR161 – Technopole Abrois-Méditerranée, Aix en Provence, France
[3] College of Agriculture, Hassan - 573225, University of Agricultural Sciences, Bangalore – India

Rice and Sugarcane are major silicon (Si) accumulator crops. There is no database on readily soluble Si pools and systematic description of phytoliths in rice and sugarcane soils in India. This study aims at quantifying the components of readily soluble Si pools viz., calcium chloride extractable Si (plant available Si), acetic acid extractable Si (plant available Si + adsorbed Si), and sodium carbonate extractable Si (amorphous Si) for soil samples collected from the surface and sub-surface of rice and sugarcane crop sites from Karnataka, South India. Sites are from the humid coastal zone with precipitations > 2500 mm/yr and 4 months dry season, and the central dry zone with precipitations 0.75 %) in surface soils and decreased with depth in both rice and sugarcane crop sites. Acetic acid extractable Si content was higher in most of the soils compared with calcium chloride extractable Si as the former primarily extracts dissolved Si along with adsorbed Si. Amorphous Si (ASi) content in most of the soils was below detection limit, and indicated depletion of phytoliths in cultivated rice and sugarcane soils. The phytoliths percentage was higher in sugarcane (1.16 to 2.12 %) than in rice soils (0.08 to 0.64 %) at the surface. In the soil profile, it increased with depth in rice soils, whereas it decreased with depth in sugarcane soils. The microscopic observation of the biogenic silica extracted from the crop soils will be analysed under the microscope to evaluate the proportion of phytoliths versus sponge spicules and diatoms constituting the biogenic silica pool. The microscopic analysis will also reveal the status of preservation of phytoliths in the soils versus that of aquatic organisms like diatoms and sponges.

Keywords: Phytoliths, Rice and Sugarcane soils, Silicon pools

*Speaker
†Corresponding author: sabyasachiuasd@gmail.com

Tracing early-middle Holocene subsistence economies in eastern Maghreb: first phytolith and calcitic microfossil evidence from Tunisia

Portillo Marta * [1,2], Mulazzani Simone [3], Belhouchet Lotfi [4], Aouadi Nabiha [4], Eddargach Wassel [5], Morales Jacob [6,7], Carrión Yolanda [8], Peña-Chocarro Leonor [9], Zapata Lydia [7]

[1] EU Horizon 2020 Marie Sklodowska-Curie Fellow, Department of Archaeology, University of Reading – United Kingdom
[2] Prehistory Rearch Group, Department of Geography, Prehistory and Archaeology, Faculty of Arts, University of the Basque Country (UPV/EHU) – Vitoria-Gasteiz, Spain
[3] Aix-Marseille Université, CNRS, LAMPEA UMR 7269, LabexMed – Aix-en-Provence, France
[4] Institut National du Patrimoine de Tunis (INP) – Tunis, Tunisia
[5] ArScAn- Archéologies Environnementales UMR 7041, Maison de l'Archéologie et de l'Ethnologie – Nanterre, France
[6] Department of Historical Sciences, University of Las Palmas de Gran Canaria – Spain
[7] †Department of Geography, Prehistory and Archaeology, University of the Basque Country, (UPV/EHU) – Vitoria-Gasteiz, Spain
[8] Department of Prehistory and Archaeology, University of Valencia – Spain
[9] GI Arqueobiología. Instituto de Historia (CCHS). Consejo Superior de Investigaciones Científicas – Madrid, Spain

The still little investigated eastern Maghreb is a key area for understanding environmental changes and cultural dynamics involving hunter-gatherers during the early and middle Holocene, with critical implications for surrounding regions including the western Mediterranean and the Sahara. Capsian populations from eastern Maghreb from around 10,000 to 7,500 BP, were among the last foraging groups in the region. Most Capsian open-air sites are defined by dark grey deposits composed of ash, charcoal, organic residues, fire-cracked rocks, lithic debris, etc., including large amounts of land snail. Capsian sites are known as *escargotières* (shell middens in French) and locally called *rammadiyat*, meaning ashy ground in Arabic. Capsian foragers have long been characterized as 'snail eaters', although recent studies suggest that plant exploitation played a more important role than previously thought.
In this study we present archaeobotanical data from a selection of Tunisian sites located between the lowland steppe and the Dorsale mountains and the eastern coast: (i) Typical and Upper Capsian El Mekta, in the south-west; (ii) Upper Capsian Kef Hamda, in the north-west; and (iii) Upper Capsian Hergla (SHM-1), in the Hammamet Gulf. As the presence of plant macroremains is usually scarce due to preservation conditions in most of the sites, the present study includes first microfossil results from phytoliths and calcitic indicators from wood ash pseudomorphs and dung spherulites, since each is influenced by different formation and taphonomic processes and may provide new insights into the role of plants.

Our results shows that inland foragers exploited a wide range of wild plant resources, including pine (*Pinus halepensis*), oak (*Quercus* sp.), legumes (*Lathyrus/Vicia* sp.), grasses (Stipa tenacis-

*Speaker

sima) and sedges. These findings suggest that pine nuts, acorns, and wild legumes could have played a role as food, while the later could relate to sources of fiber for basketry, matting, building material and fuel. Despite these sites have been systematically sampled through flotation methods, no domesticated plant has been identified. A similar pattern is suggested at SHM-1 that unfortunately have not provided direct evidence from macrobotanical remains, by findings from Pooideae grasses and dicotyledonous phytoliths, as well as from calcitic ash pseudomorphs (rhomb-shaped crystals resembling morphologies produced by *P. halepensis*, according to our pilot reference collection). Findings of pottery in the upper layers of Kef Hamda, in addition to dung spherulite indicators, show the introduction in a hunter-gatherer subsistence context of some elements widely associated to Neolithic in the threshold of food-producing economies. Ongoing research following the same methodological approach at nearby Doukanet el Kouthifa will provide a more complete picture of transitional Late Capsian-early Neolihic economies in the same area.
Although archaeobotanical data is still limited and microfossil plant and dung studies are at its early stage, these findings in integration with other geoarchaeological approaches (e.g. contextual micromorphology), may provide clues to a better understanding of Capsian foraging subsistence strategies and culture change in eastern Maghreb.

Keywords: early, middle Holocene, northern Africa, Capsian, hunter, gatherers, phytoliths, calcitic microfossils, macro, botanical, wood, charcoal, micromorphology.

Silicon and silicophytoliths in microbrewers of Argentina

Margarita Osterrieth [*†] [1], Natalia Borrelli [1,2], Fermin Frayssinet [3], Mariana Fernández Honaine [1,2]

[1] Instituto de Geología de Costas y del Cuaternario (IGCyC), FCEyN-UNMdP. Instituto de Investigaciones Marinas y Costeras (IIMyC), CONICET-UNMdP – Argentina
[2] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Argentina
[3] Cerveza artesanal Mar del Plata – Argentina

Although silicon is the third most abundant trace element in the human body, its properties on human health have begun to be considered just two decades ago. Grasses, particularly cereals, are important providers of silicophytoliths, and are used for the production of beverages, mainly beer, which represents the 3rd most consumed beverage in the world. Beer with highest silicon content is obtained from the fermentation of barley. It is is an old process that dates back to 7000 years ago. The aim of this study was to determine the silicon content in the production stages of beer and its relationship with the input from silicophytolith dissolution in different varieties of microbrews consummed in Argentina. The content of silicophytoliths (% dry weight) in the malted barley *(Hordeum distichon*) and hops *(Humulus lupulus*) was determined by calcination. The pH and content of SiO2 was determined through UV-Vis spectrophotometry by the silicomolybdate method, in all stages of beer processing (mashing solution: 70% reverse osmosis water+ 30% running water + salts (MgSO4, 70-75% CaCl2, CaSO4) + H3PO4; mashing of malted barley; fermentation of barley and hops, maturation and gasification). Malted barley showed typical silicophytolith morphologies of inflorescences (dendriform elongated cells, isolated and articulated rondels, and papillae), while hops was characterized by the presence of trichomes, trichomes with cystoliths, fragments of epidermal cells, fragments of epidermal cell with cystoliths, stomata, trichomes or tracheids. The silicon content in running water was high (110 ppm), and then decreased after reverse osmosis process (35 ppm). The addition of malted barley and hops during the maturation process increased the silicon content in solution (271 and 306 ppm respectively) due to its silicophytolith content (0.76 and 5.37% by dry weight, respectively). The beer varieties showed different silicon content after processing in relation with the proportion of malted barley used. An increase in the silicon content from the lager beer (310 ppm) to the red and dark beers (385 and 389 ppm, respectively) and to the Barley type beer (413 ppm) was observed. Both tap water and reverse osmosis water have pH values near neutrality (6.7-7), but the addition of phosphoric acid generated an acidic solution throughout the process (4.04-4.3). The knowledge of the silicon content in the microbrews, and its variation according to the type of beer and processing, may be of interest due to the positive effects that Si has on the growth and development of the skeletal system, skin, and blood vessels, and on reducing Al bioavailability, one risk factor for Alzheimer's disease. This work was supported by the Agencia Nacional de Promoción Científica y Tecnológica, Ministerio de Ciencia y Técnica (PICT 1583-2013) and Universidad Nacional de Mar del Plata (EXA 741/15).

Keywords: Beer, silicon ingestion, barley, hops, Mar del Plata

[*]Speaker
[†]Corresponding author: mosterrii@hotmail.com

Silicophytoliths and silicon studies by field assays in mollic epipedons of the southeastern Pampean plains, Argentina

Margarita Osterrieth *† [1], Celia Frayssinet [1], Maria Laura Benvenuto [1], Natalia Borrelli [1], Patricio Heiland [2], Mara De Rito [1], Mariana Fernández Honaine [1]

[1] Instituto de Geología de Costas y del Cuaternario (IGCyC), FCEyN-UNMdP. Instituto de Investigaciones Marinas y Costeras (IIMyC), CONICET-UNMdP. Buenos Aires, Argentina. – Argentina
[2] Instituto Superior de Formación Docente y Técnica Nº 31, Necochea, Provincia de Buenos Aires – Argentina

Silicon is the second most abundant element in the earth's crust. It is essential for the normal development and growth of plants, and plays a key role in the physical, chemical and biological soil properties. Silicon is important in the formation of inorganic matrix and supporting structures, which in turn condition the availability and mobilization of basic elements,such as C, O, P, Al, and trace elements. Amorphous silica biomineralizations (silicophytoliths) constitute a significant source of silicon to the soil-plant-atmosphere system, as they dissolve faster than silicate minerals. However, their role in agronomic aspects related to the loss of physical, chemical and biological fertility is still poorly documented. Research on the importance of silicon nutrition in order to promote plant growth has been reported in many countries, but not in Argentina. Given the negative effects that the intense agricultural activity has been causing on soils of the Pampean Plain, this work aimed at evaluating the silicophytoliths and silicon contribution in natural and experimental soils sowed with two varieties of wheat (Aviso and Baguette), and with the application of solid (Silfix) or liquid (Quicksoil) silicon fertilizers. The content of silicophytoliths (% dry weight) in wheat was determined by calcination, and the content of SiO2 in soil solutions was determined through UV-Vis spectrophotometry by the silicomolybdate method. Wheat plants (*Triticum aestivum*) produced 27 Kg silicophytoliths.ha-1 in the vegetative stage, and 738 Kg silicophytoliths.ha-1 in the maturity stage. Media values of silicon in soil solutions varied from 1100 μmol/L in natural soils, to 722 μmol/L in plots with solid silicon fertilizer and 635 μmol/L in plots with liquid silicon fertilizer. These results, showing a substantial Si content decrease in cultivated soils, are important in order to advance into the knowledge of inputs and losses of silicon in agro-ecosystems. Specially, given the increase of the production of some crops that are not commonly producers of silicophytoliths/silicon (like soybean) in the Pampean Plain of Argentina. The Argentinian perspectives on agriculture application of silicon fertilizers and silicon enhancement of crops quality were also discussed. This work was supported by the Agencia Nacional de Promoción Científica y Tecnológica, Ministerio de Ciencia y Técnica (PICT 1583-2013) and Universidad Nacional de Mar del Plata (EXA 741/15).

Keywords: Triticum aestivum, soil solutions, silicon fertilizer, crops quality

*Speaker
†Corresponding author: mosterrii@hotmail.com

Paleoenvironmental considerations since the Middle Holocene in the Cadeado range, Ortigueira – Paraná State

Mauro Parolin * [1], Gulherme S. Pires [2], Heloisa Coe [3,4], Mayara Dos Reis Monteiro† [1], Ana Paula Colavite [1], José Stevaux [5], Marcelo Galeazzi Caxambu [6], Kita Macário [4], Amanda Pacheco Seixas [4]

[1] Universidade Estadual do Paraná (UNESPAR) – Av. Comendador Norberto Marcondes, 733 - Campo Mourão, Paraná, Brasil. CEP - 87302-060, Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – UERJ, Av. Sao Francisco Xavier, 524, Maracana, 20550-900, Rio de Janeiro, Brazil
[3] Universidade do Estado do Rio de Janeiro (UERJ) – Departamento de Geografia, Faculdade de Formação de Professores, Universidade do Estado do Rio de Janeiro, Rua Dr. Francisco Portela, 1470, São Gonçalo, Rio de Janeiro, CEP: 24435-005, Brazil
[4] Universidade Federal Fluminense (UFF) – Campus do Gragoatá Av. Gen. Milton Tavares de Souza s/nº - Gragoatá Campus da Praia Vermelha Niterói – RJ Cep: 24210-346, Brazil
[5] Universidade Estadual do Paraná (UEM) – Brazil
[6] Universidade Tecnológica Federal do Paraná (UTFPR) – Brazil

We analyzed the phytolith content of a sedimentary core sample (130 cm deep) obtained in an unnamed pond, located in the Morro da Pedra Branca, Ortigueira/Paraná/Brazil (1.200m), containing about 30cm of peaty material on top. In addition to this sample, we analyzed the phytoliths preserved in a 47cm deep soil profile (cambisol) obtained in top area about 300m northeast of the studied pond (1,205 m). The vegetation in the area is composed of montane and upper montane mixed-araucaria forest with enclaves of altitude grasses. We recovered, identified and quantified phytoliths (13 samples) and performed 14C dating at a depth of 30cm – 5,372 cal. years BP (Center for Applied Isotope Studies - Georgia/USA). The samples were processed using 2g of material, every 2cm, for phytolith analysis. The samples were treated with hydrochloric acid (10%) and subsequently heated to boiling point in a potassium hydroxide solution (10%). After heating, the samples were immediately washed with distilled water, once every hour, until reaching a neutral pH (7.0). Dense fluid (ZnCl2 = 2.2g/cm3) was used to separate the inorganic and organic substances. After chemical treatment, the resulting material was dripped on microscope slides (50μl), which after dried were covered with Entellan® and cover slips. The slides were cataloged and deposited in the Paleoenvironmental Studies Laboratory at Fecilcam (Lepafe). The phytoliths were quantified and grouped into indexes (Arboreal Coverage Density – Dicotyledonous/Poaceae, Water Stress – Bi, and Humidity Index - IU - established by the sum of phytolith types - tree, globular, cone shaped - divided by the phytoliths characteristic of the Poaceae). The analysis of the results allowed us to identify that the area studied was drier during the Middle Holocene, reaching more humid conditions today. Three 14C-AMS datings were carried out (LAC-UFF, Brazil) at 47cm (4,836 cal. years BP), 28cm (2,205 cal. years BP), and 12cm (346 cal. years BP). In addition to the carbon dating, we analyzed the δ13C value of 4 samples (0-4cm= -23.12; 8-12cm= -21.07, 28-32 cm = -15.39 ; = 44-47cm -14.02). The extraction of phytoliths in the soil was conducted in 13 samples (4 cm intervals),

*Speaker
†Corresponding author: mayarareismonteiro@gmail.com

following the same chemical protocol used for the sedimentary core samples from the pond. The results indicate a low level of D/P (between 0.2 and 0.4), lower temperatures and low water stress (about 20%), however increasing with depth, with a value of 49% around 2,205 and 4,836 cal. years BP, when the isotopic analysis indicates predominance of C4 plants, reinforcing the results found in the pond. The interpretations outlined in this study corroborate other existing paleoenvironmental studies in the State of Paraná, which also highlighted the existence of a drier period in the Middle Holocene. [The authors thank the Araucaria Foundation and the State University of Paraná for financial support.]

Keywords: phytolith, paleoenvironmental reconstruction, Quaternary, Holocene

Phytoliths as paleoenviromental indicator of Bandeirantes Island formation phases, Upper Paraná River, Brazil

Mauro Parolin [1], Giliane Rasbold* [2], Heloisa Coe † [3], Leandro Luz [4], José Stevaux [2], Isabel Leli [5], Mayara Dos Reis Monteiro [4]

[1] Laboratório de Estudos Paleoambientais da Fecilcam, Universidade Estadual do Paraná (Lepafe/Unespar) – Campo Mourão, Paraná, Brazil
[2] Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais, Universidade Estadual de Maringá (PEA/UEM) – Maringá, Paraná, Brazil
[3] Universidade do Estado do Rio de Janeiro (UERJ) – Maracana, Rio de Janeiro, Brazil
[4] Programa de Pós-Graduação em Geografia, Universidade Estadual de Maringá (PGE/UEM) – Maringá, Paraná, Brazil
[5] Programa de Pós-Doutorado Stricto Sensu em Geografia, Universidade Estadual do Oeste do Paraná (PPGG/Unioeste) – Marechal Cândido Rondon, Paraná, Brazil

The river channel of the upper Paraná River is of the anabranching type, composed of multi-channel divided by vegetated islands. Such islands are important records of environmental and climatic events during the Late Pleistocene and Holocene. The qualitative and quantitative analysis of phytoliths assemblages recovered by acid solution in a sedimentary record of 240 cm, obteined in the central portion of the Bandeirantes Island, enabled the understanding and definition of five formation phases of the paleoisland lake: a) Phase I, Pleistocene sediments with age (14C) between 14,620 cal. years BP (240 cm) and 14,306 cal. years BP (195 cm), characterized by the predominance of the characteristic phytoliths of Podostemaceae family (40%), species of this family are adapted to environments with high water flow. Other morphotypes were recorded at lower abundance, such as Short cells (10-30%), Elongate psilate (15-30%), Bulliforms (15-20%) and Globular (> 1%). The phytolith assemblages indicate that during this phase the sediments accumulated were in the form of a sand bar, directly influenced by the channel flow; b) Phase II, the phytoliths deposited in this phase do not express direct relationship with any taxonomic group, and the observed morphotypes (Elongate psilate 50-60%) can be considered redundant, possibly with allochthonous origin; c) Phase III, it is composed of Middle Holocene sediments (7,382 cal. years BP in 97 cm deep) and has a higher occurrence of microfossils compared with the previous phases, with concentrations ranging 1600-2000 grains. The assemblage is composed mainly by Elongate psilate (30%), Short cells (21%) and Bulliforms (16%) morphotypes, possibly associated with the period of formation and isolation of lacustrine environment bordered by herbaceous vegetation; d) Phase IV, sediments of Late Holocene (1220 cal. years BP - 70 cm). Predominance of Bulliform morphologies and deposition of indicative phytoliths of Poaceae (Short cells). The Bulliform morphologies may indicate vegetation influenced by water stress due to the lower soil humidity; e) Phase V, corresponding to the last 10 cm of the sediment core, in this interval occured the largest deposit of phytoliths (2,188 grains) with a predominance of morphotypes Short cells (35-40%), followed by Elongate psilate (22-25%) and Bulliforms (22-23%). Among the morphotypes Short cells there were predominance of Bilobate morphotypes characteristic of Panicoideae subfamily (C4 grasses adapted to highly

*Corresponding author: grasbold@gmail.com
†Speaker

humid conditions). In this context, it can be inferred that the Phase V reflects the current environmental conditions, lowland area periodically flooded by the overflow of the river, rainfall or rise of the groundwater level. These results confirm previous studies that have determined that the Bandeirantes Island originates from the formation of the lake island and detail the phytoliths assemblages deposited in the respective formation phases. [The authors thank the PROEX/CAPES].

Keywords: Biogenic Silica, Podostemaceae, Anabranching

Mastication derived changes to phytoliths

Robert Power * [1,2], Michael Berthaume [3]

[1] Department of Archaeology, Max Planck Institute for the Science of Human History (MPI-SHH) – Jena, Germany
[2] Plant Foods in Hominin Dietary Ecology Research Group, Max Planck Institute for Evolutionary Anthropology (MPI-EVA) – Leipzig, Germany
[3] Max Planck Weizmann Center for Integrative Archaeology and Anthropology Max Planck Institute of Evolutionary Anthropology (MPI-MPWC) – Leipzig, Germany

Archaeological and palaeoecological phytolith research relies on the identification of the morphotypes of the identified phytoliths. The identification of the phytolith morphotypes allows the inference of specific plant parts and taxa that produced the phytolith. However, research has shown that diagenetic changes to phytolith morphology can prevent identification, or even cause misidentifications that greatly affect interpretation (Cabanes et al., 2011). Different types of diagenetic changes may alter phytoliths in varying ways, often influencing individual phytolith morphotypes differently (Wu et al., 2012; Cabanes and Shahack-Gross, 2015). The impact of digestion on phytolith morphology is unknown, though preliminary evidence indicates that phytoliths are commonly altered and shattered in non–human mammal digestive systems (Baker et al., 1959; Walker et al., 1978). This makes determining the impact of the mechanical processes of digestion crucial as phytoliths that have passed through digestive systems form a significant portion of the phytolith assemblages in certain contexts. This project seeks to assess whether human mastication impacts phytolith morphology. The project involves a number of human subjects masticating a phytolith-rich leaf of one edible plant species for a set number of chews. It seeks to determine whether the powerful mechanical force generated by the masticatory muscles in the act of chewing food, a force absent from elsewhere in the digestive system, could affect phytolith morphology. This workflow exposes phytoliths embedded in their plant structure of origin to mastication in a controlled setting. This mimicked digestion will help to explain some of the processes that influence how archaeologists and palaeoecologists interpret phytoliths.

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Keywords: taphonomy, digestion, diagensis, morphology

*Speaker

Phytoliths of plants and soils in the Atlantic forest of Ilha Grande (Rio de Janeiro, Brazil)

Carlos Rangel *† [1], Yame Ramos [1], Heloisa Coe [2], André Silva [2], Emily Gomes [2], Leandro Sousa [3], Sarah Ricardo [2], Karina Chueng [1], Raphaella Dias [2]

[1] Universidade Federal Fluminense – Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – UERJ, Av. Sao Francisco Xavier, 524, Maracana, 20550-900, Rio de Janeiro, Brazil
[3] Universidade Federal Rural do Semi-árido (UFERSA) – Brazil

This study aimed to characterize the phytoliths of plants and soils in the Atlantic Forest biome to assist in the understanding of paleoenvironmental conditions on Ilha Grande. This island is located off the south-east coast of Brazil and, at 193kmˆ2, is the largest island of the southern coast of Rio de Janeiro state. The predominant vegetation is Atlantic Forest, a complex and exuberant group of ecosystems with "*restinga*" (salt marsh), mangrove swamps, the vegetation of rocky outcrops and of slopes at different levels of regeneration. Originally the island was covered by tropical forest. Now it is preserved mostly in the central south of the island thanks to environmental restrictions. In the north and north-east of the island forest has been replaced by trourist resorts and private residences. The relief on Ilha Grande is very mountainous, reaching altitudes of over 500m in the central-east area. The climate is tropical, with an average temperature of 20 - 26°C and high levels of rainfall of about 2,000mm/year. Despite the ecological importance resulting from local biodiversity, studies aimed at improving knowledge of the paleoenvironmental conditions are scarce and even inexistent. As such, it is necessary to establish modern reference collections of phytolith assemblages of plants and soils for posterior comparison with fossil assemblages extracted from soil profiles. So far, samples of a modern soil assemblage and 23 local plants from different families predominant in the area have been analyzed. The plant phytoliths were extracted using acid and soil phytoliths through the elimination of carbonates, organic matter and iron oxides and densimetric separation with ZnCl2. The phytoliths identified in the plants vary in quantity and type. In three plants (*Miconia latifolia*, *Tibouchina* sp. and *Ouratea cuspidata*) phytoliths were not observed. The families that stand out as large producers are Myrtaceae (jigsaw-puzzle, globular granulate, stomates, tracheids), Bromeliaceae and Hypoxidaceae (globular echinate), Fabaceae and Meliaceae (globular granulate, jigsaw-puzzle, polyhedral and tracheids), Clusiaceae (globular granulate, elongate and tracheids) and the pteridophyte *Acrostichum danaeifolium* (jigsaw-puzzle and stomates). Others presenting lower production are Rubiaceae (globular granulate, elongate), Araceae (polyhedral), Melastomataceae (tracheids, elongate, globular psilate, polyhedral) and Nyctaginaceae (polyhedral and elongate). In the surface soil samples amid the open forest vegetation close to the beach, globular granulate and psilate (53%) and bulliform (34%) predominate. In the fossil assemblages the same morphotypes were found as those in the modern assemblages and most of the plants: globular granulate and globular psilate, characteristic of forests, besides bulliform. However, the phytoliths of the fossil assemblages were found to be profoundly altered or broken,

*Speaker
†Corresponding author: carlos2011@uol.com.br

indicating intense erosive processes in the region, related to high rainfall and relief, which makes preservation of more fragile phytoliths difficult. The results of this work are still preliminary and will be complemented with isotopic and pedological analyses and dating, with the objective of bringing new knowledge to different areas of scientific research performing paleoenvironmental reconstruction studies, contributing to the preservation of the diverse ecosystems of Ilha Grande.

Keywords: Ilha Grande, Atlantic Forest, Brazil

Paleoenvironmental characterization of the Itaipuaçu coastal plain, Maricá (Rio de Janeiro, Brazil), through the biomineralizations of amorphous silica

Catia Santos * [1], Heloisa Coe† [1,2], Margarita Osterrieth [3], André Luiz Da Silva [2], Mauro Parolin [4], Karina Chueng‡ [1], Sarah Ricardo [2], David Machado [2], Carolina Silvestre [1]

[1] Universidade Federal Fluminense (UFF) – Gragoatá Campus da Praia Vermelha Niterói, Rio de Janeiro, Brazil
[2] Universidade do Estado do Rio de Janeiro (UERJ) – Departamento de Geografia, Faculdade de Formação de Professores, Universidade do Estado do Rio de Janeiro, São Gonçalo, Rio de Janeiro, Brazil
[3] Universidad National de Mar del Plata (UNMdP) – Mar del Plata, Buenos Aires, Argentina
[4] Universidado do Estado do Paraná (UNESPAR) – Campo Mourão, Brazil

This work aims to characterize the paleoenvironmental conditions related to the evolution of the Itaipuaçú coastal plain in Maricá (RJ-Brazil) during the Holocene. The geomorphology of this coast is marked by the presence of barrier-lagoon systems, formed in the Late Pleistocene and Holocene, as a result of fluctuations in the sea level. The current predominant vegetation on the plain is "restinga" (salt marsh), as well as remnants of Atlantic Forest in the areas of soils formed through alteration of the crystalline basement. Biomineralizations of amorphous silica contained in muddy sediments – phytoliths, sponge spicules and diatom frustules – were used as indicators. The probing carried out on the rear of the holocenic barrier reached 12m in depth. 42 samples were analyzed for their silica content after the elimination of carbonates, organic matter and iron oxides, and granulometric and densimetric separation with sodium polytungstate. The biomineralizations were indentified under optic microscope with magnification of up to 630x. Phytoliths were classified according to the ICPN, the sponge spicules were classified based on the specialized literature and the reference collection of the Laboratory for Paleoenvironmental Studies (Lepafe/UNESPAR) and the classification of the diatom frustules aimed to identify the environment (marine or freshwater). The results of the microscopic analyses indicated: (1) between 12m and 11m, a significant presence of marine sponge spicules (tylostyles) and marine diatom frustules associated with a low occurrence of phytoliths, especially bulliform parallelepipedal and elongate psilate, suggesting a period of strong marine influence; (2) between 11m and 8m, a progressive reduction in the quantity of spicules (only a few fragments), with concomitant increase in the quantity of phytoliths and diatom frustules; (3) between 8m and 5.3m, the occurrence of sponge spicules and diatom frustules is rare and there is a predominance of phytoliths, especially globular granulate and echinate, suggesting dominance of terrestrial vegetation, possibly connected to lower marine influence; (4) between 4m and 3m, there is a significant and concomitant presence of sponge spicules (freshwater and marine), diatom frustules and phytoliths, with a predominance of globular granulate type and, in lower quantities, trapeziform and bulliform parallelepipedal (indicative of grasses from the

*Speaker
†Corresponding author: heloisacoe@yahoo.com
‡Corresponding author: karinachueng@yahoo.com.br

lagoon margin), suggesting an increase in marine influence. From 3m to the surface, a gradual reduction in the occurrence of mineralized tissues was verified. The predominance of globular granulate and echinate phytoliths between 8m and 5.3m, respectively produced by woody dicotyledons and palm trees, suggests a period of lower marine influence associated with the expansion of forest on the coastal plain. A large part of the biomineralizations of amorphous silica are found to be fragmented, possibly due to the intense wind action; or through exposure to the action of high energy waves, when they affect these environments through occasional tidal channels or when they pass over the barrier during the occurrence of large storms – overwash. Such considerations, despite being preliminary, have demonstrated that the biomineralizations of amorphous silica may be effective proxies for the environmental reconstruction of coastal areas subject to variations in sea level.

Keywords: Itaipuaçu coastal plain, Brazil, silica biomineralizations

Eneolithic vegetation reconstruction of northern Kulunda based on phytolith analysis of Novoilinka archaeological sites

Marina Solomonova * [1], Marina Silanteva [1], Natalya Speranskaya [1]

[1] Altai State University (ASU) – 656049, Barnaul, pr. Lenina 61, Russia

The use of scientific research methods for studying archaeological sites allows for expanding the knowledge of cultural characteristics of the ancient peoples and the environment of certain phases of history. Since the Eneolithic period of Kulunda has not been studied thoroughly, the two synchronous settlements of that time Novoilinka-3 and Novoilinka-6 are of great historical value. The reconstruction of plant communities has been conducted on the results of phytolith research. To compare the results of phytolith analysis of the ancient soil horizons with modern plant formation the phytoliths of the plants currently growing in the area as well as the phytolith spectrums of background soils of different communities have been studied. Six sediment columns at the settlement Novoilinka-3 and two sediment columns at the settlement Novoilinka-6 were examined for the purpose of reconstruction with geobotanical research also being conducted in the territory of these settlements. The specific morphotypes of grass phytoliths were identified by comparison with phytoliths extracted from modern plants. The representatives of the thistle family (Centaureae, *Artemisia*) were marked by phytoliths of non-specific shapes. The phytolith composition of modern plants is related to the phytoliths of modern soils. Phytoliths extracted from the Novoilinka-3 sediment columns were of two types. In one sediment column steppe grass phytoliths decreased with deepth and meadow and forest grass phytoliths increased. The lower layers of the cultural horizon are also marked by a large quantity (20%) of conifer phytoliths. It is significant that conifer phytoliths are present under the findings of horizontally lain bones, and we consider this layer as the ancient soil surface. With another group of sediment columns (with less prominent or lacking an occupation layer) the phytolith assemblages are more homogenous. The phytoliths of steppe grasses predominate in similar phytolith cross sections across the whole depth, and only the lower layers are characterized by a slight increase of meadow grass phytoliths. The phytoliths of steppe grasses and phytoliths in the form of elongate cells without systematic specificity predominate in the upper layers of the phytolith cross section of Novoilinka-6. The number of phytoliths of meadow and forest grasses rises at a depth of the occupation layer. Conifer phytoliths start to appear in the cultural horizon but in a smaller amount. Thus, in the Eneolithic period the territory of both settlements Novoilinka-3 and Novoilinka-6 was characterized by more mesophytic communities. There might have been a broken forest with pine and birch in the territory of Novoilinka-3. Its disappearance and the subsequent steppification can only be verified by an anthropogenic factor. Pratal communities were largely developed at Novoilinka-6. The steppification of the settlement was presumably connected with human economic activities.

Keywords: phytolith, reconstruction, Eneolithic, paleobotanic, archaeology

*Speaker

Development of a modern soil phytolith assemblages reference of Northern Guatemala rainforest and wetlands (Petén region, Naachtun).

Marc Testé *† [1], Aline Garnier [2], Louise Purdue [3], Cyril Castanet [4], Enecon Oxlaj [5]

[1] Laboratoire de géographie physique (LGP) – CNRS UMR8591, Université Paris I - Panthéon-Sorbonne, Université Paris-Est Créteil Val-de-Marne (UPEC) – Meudon, France
[2] Laboratoire de géographie physique (LGP) – CNRS UMR8591, Université Paris-Est Créteil Val-de-Marne (UPEC) – Meudon, France
[3] Culture et Environnements, Préhistoire, Antiquité, Moyen-Age (CEPAM) – Université Nice Sophia Antipolis [UNS], CNRS UMR7264, Campus Saint-Jean-d'Angély, Nice, France
[4] Laboratoire de géographie physique (LGP) – CNRS : UMR8591, Université Paris VIII - Vincennes Saint-Denis – Meudon, France
[5] Sociedad Civil Organización Manejo y Conservacion (OMYC) – Uaxactun, Petén, Guatemala

The Guatemalan Maya lowlands are known for their archaeological sites mainly located in the Petén rainforest. Despite numerous knowledges about the Maya populations, human impacts on this fragile ecosystem and the management of plant resources are still poorly understood. As part of the Franco-Guatemalan archaeological project "Naachtun-Peten Norte", directed by P. Nondedeo (ArchAm - UMR 8096), we focus on reconstitution of landscape dynamics of the Naachtun territory. This Classical Maya site (150 CE - 950 CE), is bordered to the north and south by two large topographical depressions, named *Bajo*, characterized by seasonal water stocks (karstic polje). If these wetter environments enabled palynological studies in the Mayan lowlands (El Mirador, La Joyanca), the tests reveal a bad preservation of this materiel type in the Naachtun sediments. Phytoliths appear as a good alternative for reconstructing past vegetation in such deposits, because we find them in the *bajo* sediments with a good preservation. However, the literature about phytolith associations is poor in Central America. In order to precise and improve our interpretation of fossil phytoliths assemblages, we decided to conduct a preliminary study of the current tropical vegetation in the Naachtun territory. The aim is to understand the ecological signal of the phytolith assemblages and to develop this bio-indicator for this geographical zone. This study is based on two essential aspects: the ecology of the distribution of plant communities and the link between phytoliths assemblages and associated vegetation. To do so, we decided to study the vegetation cover and its variability based on two transects, from the southern to the northern *bajo,* crossing the hills and the archaeological site. Our field approach combines the description of the vegetation and the species composing it, the digging of auger pits to describe edaphic conditions, and soils surface sampling. Along the two transects 21 soils surface samples have been prepared and observed for phytoliths analysis. The first results show that the distribution of plant communities is related to topography, soil water content and soil types. The vegetation in the highest zones, on the archaeological site itself, is dominated by a sempervirent forest. Locally, bamboos zones or areas with many Arecaceae suggest wetter soil conditions. In the northern *bajo*, the vegetation is more hydrophilic as we

*Speaker
†Corresponding author: marc.teste@lgp.cnrs.fr

approach perennial surface water bodies (*civales*) during the dry season: it evolves from an open forest with hydrophilic trees to an aquatic plant zone. For the phytoliths, we found an important concentration of sclereid phytoliths and globulars in the forest samples. In the *civales*, phytoliths correspond to more open vegetation with GSCP (Grass Short Cell Phytoliths) and Cyperaceae types. This work on central-American phytoliths contributes to develop a new paleoenvironmental tool for studies about the vegetation on a local scale. It shows that even without pollen, it is possible to work precisely on plant dynamics. This study brings new data on the interpretation of phytolith assemblages in predominantly woody zones. This biological reference could be improved in a multiproxy approach, with adding of new bioindicators such as gastropods or micromorphology.

Keywords: Biogeography, Landscapes reconstitution, Maya lowlands, Modern soils, Phytoliths, Woody coverage

Phytolith analysis of a Neolithic site in Northern Vindhyas, India

Deepika Tripathi *† [1], Anil Pokharia [1], Jagannath Pal‡ [1]

[1] Department of Botany, University of Allahabad – Allahabad, India

This paper deals with analysis of major phytolith year Neolithic site, Tokwa. Tokwa is Situated in Northern Vindhyan Plateau. Vindhyan Northern Plateau is an archeologically richest area of the country. The archaeological site of Tokwa is Situated at an elevation of 146 m MSL (Lat 24 ◦ 54'20 ". N;. Long 83 ◦ 21'65" E) at the confluence of the rivers Belan and Adwa in Mirzapur District of Uttar Pradesh. The southern margin is facing the Adwa River while the northern margin of the website is flanked by the Belan River. The excavations at archeological relics Provide Tokwa of three cultures are qui, Neolithic, Chalcolithic and Early Iron Age. The Site Was excavated by Prof. JN Pal, Department of Ancient History, Culture and Archaeology, University of Allahabad During two field seasons of 2003 and 2000. Phytoliths Possess better chances of preservation due to ict inorganic in nature. Owing to this the phytolith analyzes contribuer definitely a more refined knowledge of farming practices and vegetation. In Tokwa, a rich assemblage phytolith Was retrieved from Each stratum, not only indicates qui agriculture practices aim aussi Revealed kind of crop processing. Rice phytoliths Were abundant along with wood phytoliths. Presence of wood phytoliths in the assembly is Useful to indicate indication surrounding vegetation. Here the phytolith analysis complements the fragmentary knowledge provided by this site from early studies eg, macro plant remains and wood charcoal.

Keywords: Tokwa, Phytolith, Neolithic, Rice, Crop processing

*Speaker

†Corresponding author: deepika.env@gmail.com

‡Corresponding author: jnpal@hotmail.com

Traces of rice trade or production in Marseille in the XIIIth century: The phytolith evidence

Pascal Verdin * [1]

[1] Culture et Environnements, Préhistoire, Antiquité, Moyen-Age (CEPAM) – Université Nice Sophia Antipolis [UNS], CNRS UMR7264, Campus Saint-Jean-d'Angély, Nice, France

Phytolith analysis of a sample from a silo in the rue Trinquet in Marseille revealed that a small part of the assemblages consisted of rice bulliform and short cells phytoliths. The rest of the assemblage was more classical, mainly consisting of pooideae Poaceae phytoliths, with an important part of dendriform phytoliths, probably coming from wheat and/or barley husks.
Other types of archaeological structures that were studied at this site, the oldest ones dating from the Vth century BC, didn't show this specific assemblage.
This part of Marseille belonged to the episcopal town. Between the Xth et le XIIth centuries, a group of silos was linked to the "Annonerie Haute" (wheat market), texts localizing them in this district. This storage area was covered after 1363 by the Sainte-Claire's convent.
Theses silos were thus filled up and were not used anymore between the end of the XIIth century and the begining of the XIVth century.
The rice phytolihs observed could come from the Near East, or North Africa, the quantity was certainly low, but this data, if we follow the trade hypothesis, shows, as other sources do, that even in a period of Crusades, that will stop in 1291, food trade in the mediterranean sea was still ongoing.
But in France, the oldest document concerning rice is dated from 1285 and is from Perpignan, and after that first source, other texts will follow and describe more and more rice production in Provence.
First archaeobotanical data of rice production in southern France, or first data of rice import in this region? That is the question.

Keywords: Rice, Marseille, Middle ages, Phytolith, silo

*Speaker

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