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(Above) Martin Jones at West Stow, 1972 (with thanks to Ian Alister, Lucy Walker, Leonie Walker, and West Stow Environmental Archaeology Group); (Below) Martin Jones in a millet field, Inner Mongolia, 2010. (Photograph: X. Liu.)
Far from the Hearth
Essays in Honour of Martin K. Jones

Edited by Emma Lightfoot, Xinyi Liu & Dorian Q Fuller
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Acknowledgements

The initial idea of editing this volume grew out of a conversation between Xinyi Liu and Graeme Barker at St John’s College, Cambridge in June 2016. The editors subsequently discussed the provisional layout of the volume. By April of the following year, our list of agreed contributors was complete. Abstracts followed, and the chapters themselves soon after. First of all, the editors would like to pay tribute to our 36 authors, whose excellent work and timely contributions made it all possible.

For the last two-and-a-half years, the volume has been known as ‘Fantastic Beasts’ in order to keep it a secret from Martin. As we enter the final stage, we wish to extend our thanks to all who have ensured Martin remains blissfully unaware, including Lucy Walker, and we offer her our sincere thanks. We are extremely grateful to Harriet Hunt, Diane Lister, Cynthia Larbey and Tamsin O’Connell, who are kindly organizing the gatherings to mark Martin’s retirement and the publication of this volume.

With respect to the volume’s production, we would like to thank the McDonald Institute for Archaeology Research for financial support. The McDonald Monograph Series Editor James Barrett oversaw and encouraged all aspects of this project, and we offer him sincere thanks. We would also like to acknowledge the support of Cyprian Broodbank, not least for allowing us to host the workshop at the institute, but also for his encouragement throughout all phases of the volume’s implementation. Particular thanks must go to several key individuals: Anne Chippindale, Ben Plumridge, Emma Jarman, Simon Stoddart and Samantha Leggett. Finally, we are also grateful to the anonymous reviewers who recommended changes that have greatly enhanced the final version of this volume.

Xinyi Liu, Emma Lightfoot and Dorian Fuller
August 2018
Foreword

The 28-year term of Martin Jones as the first George Pitt-Rivers Professor of Archaeological Science witnessed, and in part created, a transformation in the fields of environmental and biomolecular archaeology. In this volume, Martin’s colleagues and students explore the intellectual rewards of this transformation, in terms of methodological developments in archaeobotany, the efflorescence of biomolecular archaeology, the integration of biological and social perspectives, and the exploration of archaeobotanical themes on a global scale. These advances are worldwide, and Martin’s contributions can be traced through citation trails, the scholarly diaspora of the Pitt-Rivers Laboratory and (not least) the foundations laid by the Ancient Biomolecules Initiative of the Natural Environment Research Council (1989–1993), which he chaired and helped create. As outlined in Chapter 6, Martin’s subsequent role in the bioarchaeology programme of the Wellcome Trust (1996–2006) further consolidated what is now a central and increasingly rewarding component of archaeological inquiry. Subsequently, he has engaged with the European Research Council, as Principal Investigator of the Food Globalisation in Prehistory project and a Panel Chair for the Advanced Grant programme. As both practitioner and indefatigable campaigner, he has promoted the field in immeasurable ways, at critical junctures in the past and in on-going capacities as a research leader.

The accolades for Martin’s achievements are many, most recently Fellowship of the British Academy. Yet it is as a congenial, supportive—and demanding—force within the Pitt-Rivers Laboratory that the foundations of his intellectual influence were laid. Here, each Friday morning, the archaeological science community would draw sticks to decide who would deliver an impromptu research report or explore a topical theme. Martin is among the most laid-back colleagues I have worked with, yet simultaneously the most incisive in his constructive criticism. As a provider of internal peer-review he was fearless without being unkind. The themed Pitt-Rivers Christmas parties were equally impactful—one occasion Alice Cooper appeared, looking ever so slightly like our professor of archaeological science.

Martin’s roles as a research leader extended to several stints as head of the Department of Archaeology, chairing the Faculty of Archaeology and Anthropology and serving as a long-term member of the Managing Committee of the McDonald Institute for Archaeological Research. Having started his professional career as an excavation-unit archaeobotanist in Oxford, he was a long-standing proponent of the highly successful Cambridge Archaeological Unit. In the wider collegiate community, he is a Fellow (and was Vice-Master) of Darwin College and was the staff treasurer of the Student Labour Club. In all roles he fought valiantly and often successfully for the interests of his constituency. His capacity to fight for deeply held priorities while recognizing the value of diverse perspectives was of utmost importance. His nostalgic enthusiasm for the debate with archaeological science that was engendered by the post-processual critique is one signal of an underlying appreciation of plurality. His active support for the recent merger of the Divisions of Archaeology and Biological Anthropology, within our new Department of Archaeology, is another. As a scientist (Martin’s first degree, at Cambridge, was in Natural Sciences) he values the peer-reviewed journal article above all scholarly outputs, yet has authored as many highly regarded books as a scholar in the humanities. His Feast: Why humans share food has been translated into several languages and won Food Book of the Year from the Guild of Food Writers. He views academia and society as a continuum, campaigning for archaeobotanical contributions to global food security (e.g. by promoting millet as a drought-resistant crop) and working with world players such as Unilever to encourage archaeologically informed decisions regarding food products.

That Martin’s achievements and influence merit celebration is clear. That his colleagues and students wish to honour him is equally so. Yet does the McDonald Conversations series publish Festschriften? This is a semantic question. As series editor I am delighted to introduce a collection of important papers regarding the past, present and future of archaeobotany, representing its methodological diversity and maturity. That this collection concurrently pays respect to a treasured colleague is a very pleasant serendipity.

Dr James H. Barrett
Chapter 4
Phytoliths and the Human Past: Archaeology, Ethnoarchaeology and Palaeoenvironmental Studies

Carla Lancelotti & Marco Madella

In this chapter we will explore the evolution of phytolith studies since its inception in Europe. We will bring together the historical development of the methodological approach and the current contribution of this proxy to our understanding of plant use, the origin of agriculture and agricultural techniques in the past.

A brief history of phytolith studies

Microscopic hydrated silica particles formed in plants have over the years been referred to as ‘opal phytoliths’, ‘biogenic silica’, ‘silica phytoliths’, ‘plant opal’, ‘biogenic opal’ and simply ‘phytoliths’. The first observation of mineral particles from plants was reported by Leeuwenhoek in 1675, though he used the term phytoliths to describe calcium oxalates (Mulholland & Rapp 1992). The term phytolith for defining microscopic opaline bodies deposited in plants initially appeared in a paper by Ruprecht (cited in Baker 1959a,b), but their discovery and description dates back to the first half of the nineteenth century. According to Powers (1992 and references therein), the history of phytolith studies can be divided into four periods.

Discovery and exploration period: (c. 1835–1900)
Struve, a German scholar at the University of Berlin, in 1835 produced a dissertation on silica in plants (cited in Powers 1992), thus placing the ‘scientific discovery’ of phytoliths one year before that of pollen. A decade later Ehrenberg, another German scholar, observed, described and classified silica particles he found in sediment samples, calling them ‘Phytolitaria’ (from the greek φυτόν/phutón ‘plant’ and λίθος/lithos ‘stones’). It was Ehrenberg himself who identified phytoliths in the samples of dust collected by Darwin on the deck of HMS Beagle (Darwin 1846).

Botanical research period (c. 1895–1936)
Towards the end of the nineteenth century and during the first half of the twentieth, phytoliths were recognized as particles produced within plants and studies related to production, taxonomy and morphology flourished (Grob 1896; Haberlandt 1914; Mobius 1908). It is in this period that the first applications of phytolith analysis to archaeological studies appear (Netolitzky 1900; 1914; Schellenberg 1908). As for the previous period of discovery and exploration, the German school dominates phytolith studies and the body of literature is therefore published in German.

Ecological and paleoecological research (c. 1955–1975)
During the 1950s and 1960s, scholars from the United States, the United Kingdom and Australia started investigating phytoliths, thus producing the earliest body of literature in English. In this period morphology is examined in more detail and in many more plant families, resulting in studies that are considered the bases of phytolith classification and they are still in use (e.g. Metcalfe 1960; Twiss et al. 1969). Studies in archaeology also proliferate, with researchers starting to work on different types of deposits and materials (e.g. Helbaek 1961; 1969: working on ashes and ceramics from the Near East) and in different areas of the world (e.g. Watanabe 1955; 1968; 1970: identifying rice phytoliths in prehistoric deposits from Japan). A seminal publication, which contributed to increase phytoliths visibility in Quaternary studies, was the review of the potential of phytoliths in palaeoecological reconstruction published by Rovner (1971) in the journal Quaternary Research.

Modern period (c. 1978–2000)
The last two decades of the twentieth century are characterized by an exponential increase in phytolith studies (Fig. 4.1), both geographically and in scope. Specific studies on families or species become routine: Cucurbitaceae (Bozarth 1987; Piperno et al. 2000), Fabaceae (Bozarth 1990) and Cyperaceae (Ollendorf 1992; Ollendorf et al. 1987) become a focus of interest, as well as some dicotyledonous species for their inter-
Maize (Mulholland et al. 1988; Piperno 1984; Piperno & Pearsall 1993), rice (Houyan et al. 1997) and wheat/barley (Ball et al. 1993; 1999) occupy, for their economic interest, a prominent spot in this area of studies. The geographical zones investigated in phytolith studies also expand, with research in Africa (Alexandre et al. 1997; Barboni et al. 1999; Jansen & van Iperen 1991; Mercader et al. 2000; Runge & Runge 1997), Central Asia (Madella 1997) and South East Asia (Bowdery 1999; Kealhofer & Penny 1998) appearing together with New Zealand (Kondo et al. 1994), Israel (Albert et al. 1999; 2000), China (Yongji 1991) and Brazil (Alexandre et al. 1999). The scope of research also widens and phytoliths are used as activity markers to study irrigation (Rosen & Weiner 1994), identify dietary practices from dental calculus (Ciochon et al. 1990; Danielson & Reinhard 1998; Fox et al. 1994) and infer function of stone tools (Anderson 1980; Jahren et al. 1997; Kealhofer et al. 1999; Sobolik 1996) and the formation of pastoral sites (Brochier et al. 1992). New techniques such as the isotopic study of phytoliths are also introduced (Fredlund & Tieszen 1997; Kelly et al. 1998; McClaran & Umlauf 2000; Shahack-Gross et al. 1996; Webb & Longstaffe 2000). Phytolith studies also assume the character of a mature discipline with the proliferation of meta-studies, in particular on extraction methods (Lentfer & Boyd 1998; Madella et al. 1998; Middleton & Rovner 1994; Powers & Gilbertson 1987).

In the next paragraphs, we will outline some of the major breakthroughs and developments in phytolith research in archaeology and palaeoenvironmental studies and, especially, in ethnoarchaeology.

Methodological advances

The stage of maturity reached by the discipline in the last 15 years is testified by the number of works published since 2000 that critically reflect on the methodology itself. At the same time, technological improvements and the introduction of more sophisticated analytical tools contributed to an increase in research involving isotopic and genetic analysis of phytoliths.

Phytolith extraction, identification and interpretation

On the one hand, phytoliths from archaeological sites have been used to document crop plants, plant food, plant-made objects like mats and baskets, fuel types and construction materials. On the other hand, phytoliths from natural sequences have been used to understand vegetation changes between major ecological types (e.g. savannah, forest, grassland, etc.) or the dynamics of soil-formation processes. Several authors, however, have concentrated on extraction methods, either proposing new and improved techniques (Lombardo et al. 2016), concentrating on specific and problematic types of sediments (Calegari et al. 2013), combining extraction of several micro-remains (Horrocks 2005), improving the efficiency both in time and cost (Katz et al. 2010), comparing the results of different extraction methods (Parr 2002), or assessing the best extraction method for specific analyses for example isotopic studies (Asscher et al. 2017; Corbineau et al. 2013) or genetic analyses (Kistler 2012). Other methodological aspects on which researchers have concentrated are counting and nomenclature. Strömberg (2009) and Zurro (2017) question whether changing the count size
influences the interpretations of results and propose minimum count size as well as statistical techniques to ensure the robustness of results. The creation in 2000 of the International Committee on Phytolith Morphology responded to the need of the phytolith communities to standardize the terms that were used to describe phytoliths. The main result of this committee was the publication of the first International Code for Phytolith Nomenclature in 2005 (Madella et al. 2005). In 2014 the International Society for Phytolith Research appointed a new International Committee for Phytolith Taxonomy to continue this effort. Their first output was the publication of standardized guides for morphometric analysis of phytoliths (Ball et al. 2016b). Another important issue that has been deeply addressed in recent years concerns the role of taphonomic processes on the composition of phytolith assemblages. Madella and Lancelotti (2012) have offered a comprehensive review of the possible impacts of various taphonomic processes and proposed some ways of counterbalancing them in the analysis. At the same time, Cabanes and Shahack-Gross (2015) have performed experiments to assess phytolith preservation fully in sediments and understand the role of dissolution on the robustness of interpretations.

Isotopes and DNA
Isotopes from archaeological sites have been used for understanding, among other things, climatic and environmental change, past human diet, nutrition and mobility, past animal and crop management practices, and to build reliable chronologies. The isotopic analysis of occluded carbon in phytoliths, both for dating as well as for palaeoenvironmental reconstruction purposes, is an issue that has been abundantly debated in recent years (Piperno 2016). Studies have been performed to understand soil carbon sequestration in phytoliths (Parr & Sullivan 2005; Song et al. 2016), as well as the incidence of atmospheric carbon occluded in phytoliths (Carter 2009). Some of these publications have generated a debate centred on the validity of carbon isotopic analyses in phytoliths and what exactly is the signature measured through this technique (Santos & Alexandre 2017; Santos et al. 2016). Hodson and colleagues (2008) explored the potential of oxygen and silicon isotopes alongside carbon on the same plants of Triticum sp. and concluded that silicon and carbon are the most promising isotopic systems to be used in palaeoenvironmental studies, while more work on oxygen isotopes was needed to explain its patterns of variation. Following this, several groups have been working on oxygen isotope methodology (Chapligin et al. 2011; Crespin et al. 2008) up to the point where this technique has been fully validated for palaeoenvironmental studies (Alexandre et al. 2012). Work on silicon isotopes, on the contrary, is much rarer, although the potential of this technique is gaining recognition (Leng & Sloane 2008; Leng et al. 2009), to the point that Hodson (2016) recognizes it as a commonly used technique.

Ancient DNA in archaeology has been used to understand human evolution and, when extracted from plants and animals, as a way to understand the processes involved in domestication. The extraction of DNA directly from phytoliths is related to the possible presence of organic material occluded within the silica. However, this seems to be a problematic avenue of study, as observed by Elbaum et al. (2009). An interesting side of DNA studies and phytoliths is the exploration of the genetic mechanisms involved in phytolith production. Despite the evidence that silicon is fundamental for plant growth, as it provides strength, detoxification and protection from animals (Piperno 2006), the exact mechanism for phytolith formation is still not fully understood. Piperno et al. (2002) indicate that phytolith formation in Cucurbitaceae is regulated by a dominant genetic locus previously associated with the production of lignin. The same research establishes that this locus also has an important role in phytolith morphology, constituting a major breakthrough in the understanding of phytolith formation and taxonomy.

Phytoliths in archaeology
The process of domestication of plants and the setting and spread of agriculture was a transformational moment in the socio-ecological history of our species. Currently, the archaeological record shows that, starting around 12,000 years ago, plant cultivation and domestication developed independently in several regions of the world and then spread via cultural or demic diffusion into most geographical areas (Larson et al. 2014). Archaeobotany has focused on developing methods for identifying the domestication process, the cultivation of plants and fully fledged agriculture from wild plants and crops remains. During the last 20 years, phytoliths in all regions of the world have become an important proxy in this research, alongside macro remains, pollen and starch grains (e.g. Pearsall 2015b; Piperno 2006; 2009). After many years of work focused on the standardization of identification characteristics based on reference collections and morphometric analysis of phytoliths from wild species and crops, the discipline has finally reached sound and replicable procedures. Piperno (2006) performed the first review of crop phytoliths, followed by more recent endeavours from Piperno (2012) and Ball et al. (2016a).
Phytoliths have been used in a number of different ways to understand agricultural origin and dispersal:

1) as direct proxies for cultivation and domestication of certain species
2) as part of a multi-proxy research to identify past crops or wild species
3) as low-level taxonomic identifiers (e.g. species level) or identifiers of plant structures (e.g. inflorescences, leaves) less visible with other fossils
4) as proxies for the expansion of ancient crops.

Phytoliths significantly increase the traceability of several Old and New World crops, including taxa that are normally invisible in the charred record, such as some fruits or root crops, as well as enabling the identification of different plant structures pertaining to the same crop (e.g. Corteletti et al. 2015; García-Granero et al. 2015a,b; Iriarte et al. 2012; Madella et al. 2014). The level of taxonomic significance of phytoliths will differ from species to species in the same manner as other fossil indicators of plant exploitation, such as charred remains of seeds.

In Table 4.1 we summarize the present understanding of crop identification based on phytoliths and in the following text we discuss the utility of phytoliths for identifying major crops and therefore agricultural origins and crop dispersal.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Phytolith production</th>
<th>Taxonomic specificity</th>
<th>Plant Part</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Southwest Asia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Triticum</em> spp. (einkorn, emmer, other species)</td>
<td>Very high</td>
<td>Genus</td>
<td>Inflorescence bracts (glume, lemma and palea)</td>
</tr>
<tr>
<td><em>Hordeum</em> spp. (barley, other wheats)</td>
<td>Very high</td>
<td>Genus</td>
<td>Inflorescence bracts (glume, lemma and palea)</td>
</tr>
<tr>
<td><strong>East Asia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oryza sativa</em> (rice)</td>
<td>Very high</td>
<td>Species</td>
<td>Glume, Leaf (bulliform cells)</td>
</tr>
<tr>
<td><em>Setaria</em> spp. (foxtail millets)</td>
<td>Very high</td>
<td>Genus</td>
<td>Glume</td>
</tr>
<tr>
<td><em>Panicum</em> spp. (broomcorn millets)</td>
<td>Very high</td>
<td>Genus</td>
<td>Glume</td>
</tr>
<tr>
<td><strong>South and Southeast Asia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Musa</em> spp. (bananas)</td>
<td>High</td>
<td>Genus, Section, Species</td>
<td>Leaf, Seed</td>
</tr>
<tr>
<td><em>Benincasa hispida</em> (wax gourd)</td>
<td>Very high</td>
<td>Genus (?)</td>
<td>Fruit rind</td>
</tr>
<tr>
<td><em>Cocos nucifera</em> (coconut)</td>
<td>Very high</td>
<td>Family or Subfamily</td>
<td>All plant parts</td>
</tr>
<tr>
<td><strong>Africa</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Zea mays</em> (maize)</td>
<td>Very high to low</td>
<td>Species</td>
<td>Cob (glume/cupule), Leaf, Husk</td>
</tr>
<tr>
<td><em>Cucurbita</em> spp. (squashes and gourds)</td>
<td>Very high/high</td>
<td>Family, Genus, Species</td>
<td>Fruit rind, Leaf</td>
</tr>
<tr>
<td><em>Lagenaria siceraria</em> (bottle gourd)</td>
<td>Moderate</td>
<td>Species</td>
<td>Fruit rind</td>
</tr>
<tr>
<td><em>Ananas comosus</em> (pineapple)</td>
<td>Very high</td>
<td>Family</td>
<td>Leaf, Seed</td>
</tr>
<tr>
<td><em>Canna edulis</em> (achira)</td>
<td>Very high</td>
<td>Genus (?)</td>
<td>Leaf</td>
</tr>
<tr>
<td><strong>Americas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Maranta arundinacea</em> (arrowroot)</td>
<td>Very high</td>
<td>Species</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Calathea allouia</em> (llerén)</td>
<td>Very high to Moderate</td>
<td>Species</td>
<td>Seed, Rhizome</td>
</tr>
<tr>
<td><em>Phaseolus vulgaris and lunatus</em> (common/lima bean)</td>
<td>Moderate</td>
<td>Genus</td>
<td>Pod</td>
</tr>
<tr>
<td><em>Helianthus annuus</em> (sunflower)</td>
<td>High</td>
<td>Family (Genus?)</td>
<td>Achene</td>
</tr>
<tr>
<td><em>Arecaceaee</em> (palms)</td>
<td>Very high</td>
<td>Family, Subfamily, Genus (?)</td>
<td>All parts</td>
</tr>
</tbody>
</table>

Table 4.1. Phytolith production and taxonomic specificity for the world’s major crops.
lae; trichomes; and trichome bases. These bodies are very characteristic and can be diagnostic at genus level when a morphotypic and morphometric approach is used (e.g. Ball et al. 1999; 2009). There has also been some success in identification to species level, primarily based on the morphometric differences observed in the short cell (rondel), dendritic and/or papillae phytoliths (e.g. Ball et al. 1999; Rosen 1992; Tubb et al. 1993). Moreover, features of the anatomy displayed in the silicified epidermal tissues of cereals can be used to distinguish plant parts.

Setaria and Panicum millets (foxtail and broomcorn millets) and other small millets
Phytoliths from the inflorescence of Setaria and Panicum are extremely useful for identifying Setaria italica (foxtail millet), Setaria viridis (green foxtail) and Panicum miliaceum (common or broomcorn millet) and thus documenting the earliest history of domesticated millets in Eurasia (García-Granero et al. 2015a,b; Zhang et al. 2011; 2013). Important features to distinguish these taxa are the silica body shape, papillae characteristics (including presence/absence), epidermal long cell patterns and glume surface sculpture (Lu et al. 2009). A cautionary note is due when differentiating crop phytoliths from their Panicoid weedy wild relatives in archaeological contexts, as this can be a challenge due to similarities of identifiable Panicoid husk morphotypes. Strict identification criteria must therefore be followed for correct identifications. The discrimination between S. italica and its wild ancestor, S. viridis, is based on the morphometry of phytoliths in the upper lemma and palea (Zhang et al. 2011), although some uncertainty remains and more studies are needed to detect the presence of other potentially diagnostic features. Morphological and basic morphometric studies of glumes of other minor millets also show the potential of phytoliths for differentiating these important crops in the prehistory of Eurasia and Africa (Madella et al. 2014).

Oryza sativa (rice)
Phytoliths play a very important part in the archaeological study of rice domestication and cultivation. Currently, three distinct phytolith morphotypes are used to identify rice: double-peaked glume cells from the rice husk; bulliform cell phytoliths from the leaves; and articulated bilobate phytoliths from stems and leaves (Gu et al. 2013; Piperno 2006). Double-peaked glume cell phytoliths are unique to the genus Oryza and can discriminate domesticated rice from wild rice species of South and Southeast Asia on the basis of linear discriminant function analysis of glume cell measurements (Zhao & Piperno 2000) or three-dimensional measurements (Gu et al. 2013). The morphological characters of bulliform cell phytoliths seems to be under genetic control, therefore reflecting taxonomical significance (Gu et al. 2013), and some features such as surface ornamentations have been employed to distinguish domesticated from wild rice (Huan et al. 2014; Wang & Lu 2012). Phytoliths can also be used as a tool for understanding the development and spread of rice (Oryza sp.) arable systems using arable weed ecologies as pioneered by Fuller and Weisskopf (2011).

Musa spp. (true bananas) and Ensete ventricosum (Ethiopian/Abyssinian banana)
The domestication and spread of true bananas (Musa spp.) is difficult to untangle. Current domestic bananas derive from the Eumusa (Musa acuminata [AA] and Musa balbisiana [BB]) and Australimusa (M. maclayi) sections of Musaceae through intra- and interspecific hybridization, polyploidization and somaclonal mutations, which resulted in seed sterility and parthenocarpy (De Langhe et al. 2009). Prehistoric and historical human populations spread domesticated Eumusa throughout the tropics and any evidence for Musa phytoliths outside Asia is indicative of cultivation (Vrydaghs & De Langhe 2003). Phytoliths can be produced in various plant tissues and organs of bananas (e.g. Chen & Smith 2013), with seed and leaf phytoliths being the most studied to date. In Musa and Ensete leaves, the silicification of cells from around the vascular tissue produces volcaniform (volcano-shaped) phytoliths (Ball et al. 2006). Both morphotypic (e.g. Vrydaghs et al. 2009) and morphometric studies (e.g. Lentfer 2009; Vrydaghs et al. 2009) have been carried out to be able to identify different Musa and Ensete species. The results show that volcaniform phytoliths can be discriminated at the genus level (distinguishing bananas from Ensete in archaeological records: e.g. Lentfer 2009; Mbida et al. 2001), but reliable identification at the species level is still wanting.

Sorghum bicolor (sorghum), Pennisetum glaucum (pearl millet)
A certain number of recent studies have showcased phytolith production in African domesticated grains and their wild progenitors (Logan 2012; Madella et al. 2014; Novello & Barboni 2015; Out & Madella 2017; Radomski & Neumann 2011). However, there are currently too few studies on phytolith production in the wild grasses inflorescences (Novello & Barboni 2015) to be able to identify specific morphotypes diagnostic to the genus or species level.

Zea mays (maize)
Maize is native to the central Balsas River region of tropical southwest Mexico (see van Heerwaarden et
and represents the main cereal crop of the Americas. More than three decades of focused research have demonstrated that phytoliths produced in the leaf and cob of maize are diagnostic, and distinguishable from those of teosinte (its wild ancestor) and other wild non-Zea grasses native to North, Central and South America (Ball et al. 2016a). The criteria used for the identification of maize phytoliths employ both size and morphology and, as with phytoliths from other crop plants, vegetative and inflorescence structures can be distinguished (leaf, stalk and seed chaff).

Cucurbita squashes and gourds and other Cucurbitaceae Squashes and gourds pertaining to the genus Cucurbita, as well as other types of Cucurbitaceae, were important early plants of the Americas, and they produce phytoliths of high taxonomic information to document their archaeological history. Many parts of the squash/gourd plants are high phytolith producers and the phytoliths obtained from fruit rinds are the most diagnostic. Morphotypic and morphometric studies have been used to discriminate between wild and domesticated Cucurbita species, with domesticated fruits often producing much larger and thicker phytoliths (Piperno 2006). Bottle gourd (Lagenaria siceraria) is indigenous to Africa, but spread to other continents by the early Holocene, and its large, scalloped phytoliths from fruit rinds have been recovered from early Holocene and later deposits in Central and South America (e.g. Piperno 2011).

Maranta and Calathea (arrowroot and ilerén, Marantaceae); Canna (Achira, Cannaceae); Manioc (Manihot esculenta, Euphorbiaceae) These tropical root crops (roots, rhizomes, tubers and corms) are today of minor importance, with the exception of manioc. The plants from the Zingiberales (Marantaceae and Cannaceae) generally produce (abundant) phytoliths that can be taxonomically diagnostic at order, family, genus and species level (e.g. Pearsall 2015a). Manioc, today one of the major root crops of the Americas, is a low silica accumulator (Piperno 2006), but by processing considerable quantities of tissues it was possible to identify silicified secretory bodies in the root rind, leaf, stem and fruit (Chandler-Ezell et al. 2006).

Modern comparative approaches

Phytolith studies with an ethnoarchaeological or modern comparative approach started to become widespread from the late 2000s. This type of research concentrates on the analysis of phytoliths—often combined with other proxies—extracted from modern or historical ethnographic contexts. The aim of these studies is to build strong reference collections of phytolith assemblages produced by specific activities or materials. The rationale, grounded in middle-range theory, is that phytolith assemblages observed in ethnographic contexts can be linked directly to the anthropic or natural activity that produced them, thus offering interpretative values for archaeological and natural assemblages. The main themes in which ethnoarchaeological research on phytolith have been concentrated are:

1) The creation of plant and soil reference collections
2) Subsistence practices and other plant-related activities, such as crop processing
3) Use of space and spatial activities
4) The use of non-food plant resources, with a special focus on the identification of dung.

Plant and soil reference collections
Although not normally considered part of ethnoarchaeological research, the creation of reference collections responds to the general aim of creating a middle-range theory approach that help interpreting the archaeological (or environmental) record. Several studies have been devoted to the morphological and morphometric analyses of phytoliths produced by some of the major crops: Triticaceae and Avenae (Ball et al. 2009; 2017; Portillo et al. 2006); millets and sorghum (Lu et al. 2009; Madella et al. 2016; Out & Madella 2016; 2017; Tripathi et al. 2013; Zhang et al. 2011); and banana (Ball et al. 2006; Vrydaghs et al. 2009). Fewer studies have concentrated on non-domesticated species, focusing on phytolith production in wild grasses (Babot et al. 2017; Neumann et al. 2017), in dicotyledonous species (Collura & Neumann 2017; Mercader et al. 2009) or in a combination of plants (Tsartsidou et al. 2007). Reference collections of phytolith assemblages from sediments and soils are also investigated in order to be able to identify past vegetation cover (e.g. Blinnikov et al. 2013; Esteban et al. 2017; Gomes Coe et al. 2017; Iriarte & Paz 2009; Mercader et al. 2009). Either directed to the phytolith production of specific species or groups of species, conducted directly on the plants, or of phytolith assemblages representative of a specific vegetation type, these studies form the basis of the correct reconstruction of past plant use and plant cover.

Subsistence practices and plant-related activities
The major advances regarding subsistence practices and plant-related activities, in general, include the identification of the exploitation of wild and garden species (Weisskopf 2016) thereby addressing one of the major problems in archaeobotany, that is the vis-
ibility of so-called ‘alternative resources’. Phytoliths, being both exceedingly resistant to taphonomic alterations and plant-part specific, can be extremely useful in identifying different crop-processing steps. Harvey and Fuller (2005) showed how the chaîne opératoire of processing of millets and rice produces phytolith assemblages exclusive for each step. Specific stages of the crop-processing chain can also be investigated: Liu et al. (2017) analyse the use-wear effect of phytoliths on lithic tools, an approach that can offer fundamental insights to our understanding of pre-domestication processes. Ruiz-Perez et al. (2016) analysed phytolith assemblages from two ethnographic threshing floors, showing that the general pattern of phytolith deposition on the floor mirrored the circular movement of the activity performed.

Spatial analyses of anthropic activities
One of the most novel aspects of phytolith research in ethnoarchaeology is the application of multi-proxy and statistical methods for the identification of spatial distribution of activities. Briz Godino et al. (2011) and Zurro et al. (2017) use phytoliths in combination with other proxies to detail the formation processes and distinguish between specialized and generic activities in a shell-midden context in Tierra del Fuego. Hunter-gatherer contexts are especially difficult to study as they leave much more scanty evidence on the ground in respect to settled villages. Thus the work by Friesem et al. (2016) is particularly important in that it outlines a methodology that allows the identification of activity areas and their maintenance even in hostile preservation environments, such as tropical rainforests. On the other hand, settled farming villages produce assemblages that are much richer and often better preserved so that activities are recognizable at both domestic and village level (Jenkins et al. 2017; Portillo et al. 2014; Tsartsidou et al. 2008; 2009).

Use of non-food resources: dung and mud bricks
Amongst the plant non-food resources, much research has been invested in using phytoliths as one of the proxies for the identification of animal dung. Dung is widespread in archaeological contexts, although it is not always easy to identify as sometimes it leaves ephemeral traces and the most common proxy for dung — spherulites — is not always reliable (Lancelotti & Madella 2012). The correct identification of animal dung is fundamental for the implication that the use of this material has on the interpretation of human behaviour, on the one hand, for the correct identification of husbandry practices and pastoral sites (Elliott et al. 2015; Shahack-Gross et al. 2003; 2004) and on the other hand, for its importance as a fuel resource in arid and semi-arid environments, where its presence and constant use can indicate signs of environmental degradation and wood-resource overexploitation. Ethnographic fireplaces have thus been intensively investigated in recent years in order specifically to identify signatures of dung (Portillo et al. 2017) or with the aim of discriminating various fuel sources (Friesem et al. 2017; Gur-Arieh et al. 2013; Lancelotti et al. 2017). All of these studies have highlighted the potential of phytoliths, as part of a wider set of proxies, and with the right statistical treatment of data, for the identification of fireplaces and fuels, including fuels alternative to wood. Lastly, a few studies have concentrated on the analysis of construction materials, such as mud bricks (Friesem et al. 2014; Jenkins et al. 2017), to be able to distinguish between the signature left by their degradation and that of other intentional human activities.

Environmental reconstructions and past land use
Phytoliths have been successfully used as a proxy for reconstructing Quaternary vegetations, especially in depositional environments where other organic proxies are poorly preserved, such as alluvial deposits and soils (e.g. Bremond et al. 2017; Calegari et al. 2017; McMichael et al. 2013; Wallis 2001) and rocks (e.g. Strömberg et al. 2007). Phytolith assemblages from ancient superficial sediments reflect deposition from local vegetation and therefore local climatic characteristics, making it possible to use them to infer palaeoclimate and palaeoenvironments. However, precise assessment of past environments might be hampered by pre- and post-depositional processes that tend to alter the original plant community production. A diverse set of approaches supported by multivariate statistical methods, such as phytolith indexes (Bremond et al. 2005; 2008) and modern analogues analysis (Watling et al. 2016), were recently developed partly to solve this problem. The application of these qualitative/quantitative techniques has made it possible to determine which vegetation and environmental factors are dominant in influencing phytolith type distributions and to identify these parameters in the fossil phytolith assemblages on the basis of modern assemblages.

Earth system models help in understanding the earth system as a whole and the drivers of change and assist in envisaging our future. A major research question that cross-cuts the social, biological and physical sciences is to understand the scope of early human land use, the resultant changes in land cover and the consequent feedbacks to climate and human cultural systems during the Holocene and Anthropocene. There remains disagreement over the forms,
scope and intensity of prehistoric land use and the
degree to which early anthropogenic land-cover
change affected the global climate system. Researchers
agree that the intensity and extent of human land use
increased during the Holocene, when hunter-gatherer
societies gave way to early pastoral and agricultural
societies, which in turn increased in complexity. These
effects of human land use on terrestrial ecosystems
were profound at local to regional scales, but there is
uncertainty about how important they were at global
scale, and this uncertainty is fostered by the lack of
high-quality data-based syntheses of global land use
and anthropogenic land-cover change for the last
12,000 years. Phytoliths have been useful in extend-
ing on- and off-site high-quality datasets to supply
more refined synthesis of land use in areas such as
understanding the irrigation of crops (Madella
et al. 2009), arable land (Golyeva & Svirida 2017), past
agricultural systems (Meister et al. 2017) and forest
management (Levin & Ayres 2017; Levis et al. 2017;

Final remarks

Phytoliths were observed, as part of mineral particles
produced by plant tissues, more than 340 years ago,
but it was Struve who pioneered the first scientific
study in 1835. Research on phytoliths has seen vari-
ous moments of interest, such as the early works on
plant studies and (palaeo)ecology, but it was within
archaeology that phytoliths gained momentum and
widespread acknowledgement. This ‘popularity’
originate in the new avenues opened by phytoliths to
investigate central archaeological questions, with the
possibility of identifying previously unrecognizable
(or difficult to discern) plants in the archaeological
record, as well as human activities (e.g. crop
processing). The development and refinement of phytolith
systematics and crop identification via a double
morphotypic and morphometric approach were major
endeavours that stemmed from archaeology. Future
advances should look at augmenting the comparative
collections available together with their accessibility to
researchers and refining the field-sampling approach
and laboratory processing to further standardization,
and push on the ethnoarchaeology and experimental
archaeology work to provide a framework for a bet-
ter understanding of the relationship between human
activities and phytolith signatures.

Acknowledgements

Martin, during his career as an archaeobotanist, has
always been a visionary in the field and often engaged
with new developments and research strands. The
same happened with phytolith research when he
supported both of us working in this new area, and
he happily embarked on helping develop what came
to be the next generation of archaeobotanical prox-
ies. During our doctoral research, he was a constant
optimist, even when we could not see ‘the light’ of
our work, as well as the instigator of many parties,
including those with dance lessons!

References

Albert, R.M., O. Lavi, L. Estroff, S. Weiner, A. Tsatskin, A.
Ronen & S. Lev-Yadun, 1999. Mode of occupation of
Tabun Cave, Mt Carmel, Israel during the Mousterian
period: A study of the sediments and phytoliths. Jour-
nal of Archaeological Science 26(10), 1249–60.
Phytoliths in the Middle Palaeolithic deposits of
Kebara Cave, Mt Carmel, Israel: study of the plant
materials used for fuel and other purposes. Journal of
Archaeological Science 27(10), 931–47.
Alexandre, A., J.D. Meunier, A.M. Lézine, A. Vincens & D.
dynamics during the late Holocene in intertropical
Africa. Palaeogeography, Palaeoclimatology, Palaeoecology
Late Holocene phytolith and carbon-isotope record
from a latosol at Salitre, South-Central Brazil. Qua-
ternary Research 51(2), 187–94.
Hilbert, 2012. The oxygen isotopic composition of
phytolith assemblages from tropical rainforest soil tops
(Queensland, Australia): validation of a new paleoenvi-
Anderson, P.C., 1980. A testimony of prehistoric tasks: diag-
nostic residues on stone tool working edges. World
Archaeology 12(2), 181–94.
for extracting the insoluble occluded carbon in
archaeological and modern phytoliths: detection of
14C depleted carbon fraction and implications for
radiocarbon dating. Journal of Archaeological Science
78, 57–65.
archaeobotanical perspective in the study of inflo-
rescence phytoliths of wild grasses from arid and
semi-arid environments of Argentina. Quaternary
International 434, 129–41.
Baker, G., 1959a. Opal phytoliths in some Victorian soils
and ‘Red Rain’ residues. Australian Journal of Botany
7, 64–87.
Baker, G., 1959b. Fossil opal phytoliths and phytolith
and morphometric study of variation in phytoliths
form einkorn wheat (Triticum monococcum). Canadian
Journal of Botany 71(9), 1182–92

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Corteletti, R., R. Dickau, P. DeBlasis & J. Iriarte, 2015. Revisiting the economy and mobility of southern proto-Jé (Taquara-Itaráre) groups in the southern Brazilian highlands: starch grain and phytolith analyses from...
the Bonin site, Urubici, Brazil. *Journal of Archaeological Science* 58, 46–61.


Piperno, D.R., 2016. Phytolith radiocarbon dating in archaeo logical and palaeoecological research: a case study of phytoliths from modern Neotropical plants and a


Watanabe, N., 1968. Spodographic evidence of rice from prehistoric Japan. *Journal of the Faculty of Science of the University of Tokyo* 3(3), 217–34.


