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# Phytoliths in modern plants and soils from Klasies River, Cape Region (South Africa)

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ABSTRACT

The archaeological site of Klasies River 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. The Main Site deposits (dated to ca. 115 to 55 ka) include botanical remains such as seeds and charcoal, which suggests that micro-plant particles like phytoliths could also have been deposited. Yet, no phytolith reference collection based on both modern plant and soil material has been produced for Klasies River, which complicates attempts of phytolith analysis of the site's 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 processed phytoliths from 24 modern plant specimens and 16 soil samples from different vegetation patches, all located today in a perimeter <5 km$^2$ around the Main Site. Our analyses indicate that ovate/orbicular and/or tabular polygonal 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 all eudicotyledoneous taxa. Regarding the Cyperaceae, Restionaceae, and one of the Proteaceae species (*Leucadendron spissifolium*, a fynbos shrub), they each produce distinct phytolith assemblages: the Restionaceae leaf/culm assemblage is dominated by psilate and decorated globular/spheroid phytoliths (94%), whereas the Cyperaceae leaf/culm content and the Proteaceae leaf content are both dominated by silicified papillae (-like) bodies (54% and 63%, respectively). Besides, both globular/spheroid and papillae (-like) phytoliths account for 34% and 8% in the fynbos soil collected. Our analyses also show that ovate/orbicular and/or polygonal phytoliths occur in very small amounts (<2%) in modern soils of the area although they are numerous in most of the eudicotyledoneous leaf tissues we analyzed. Conversely, grass silica short cell phytoliths are found abundantly in the soils collected in close proximity to the Main Site (>66%), where grasses do however occur sparsely in the current vegetation.



## 1. Introduction

The archaeological site of Klasies River (34°6′29.69″S, 24°23′25.95″E) consists of a series of distinct caves distributed along the coast of the Indian Ocean, in the western part of the Eastern Cape Region in South Africa. The Main Site is made of two open-air caves and two overhangs (Wurz, 2008) that were filled and emptied numerous times with the rise and fall of sea-levels during interglacial and glacial times in the late Pleistocene (Wurz, 2002). Sea regression stages notably allowed humans to settle many times at the site, and this resulted in alternating occupation and non-occupation deposits inside and between the two caves (Deacon, 2008). About 20 m of middens including numerous remains of food debris (e.g., bones, shells), artefacts, and fire hearths were deposited between 115 and 55 ka (Vogel, 2001; Wurz, 2002). Klasies River is especially famous for its very well-preserved, abundant, and diverse tools of the Middle Stone Age (Singer and Wymer, 1982; Wurz, 2002) and also evidence for complex behaviours (Wurz, 2013). This is suggested, for example, by the

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extensiveness of the production procedures of the tools in stone and bone, and the presence of ochre in the deposits, perhaps used as symbolic material (Wurz, 2016).

At the Main Site, there is evidence for significant changes in human habits and behaviours during the late Pleistocene, and these are likely related to modifications of their habitat. The taxonomical composition of the large and micro-mammals varies in time (Klein, 1976; van Pletzen, 2000; Hillestad-Nel, 2013), which suggests a turnover of the resources available during the successive occupations of the site. Moreover, vegetation is interpreted as shifting from dominant open grasslands and marshlands during the ca. 115-110 ka time interval to more closed canopy conditions between ca. 101 ka and 85 ka based on macro- and micro-faunal remains (van Pletzen, 2000; Vogel, 2001). Shellfish were consistently collected, but changes in the species representation indicate clear environmental modifications through time (Thackeray, 1988). Hunting and gathering behaviours thus took place under changing habitat conditions through time (Thackeray, 1988; Wurz, 2012).

Another approach for assessing vegetation changes at Klasies is to study the plant remains that accumulated in the cave deposits. In particular, the blackened deposits of some layers of the Main Site are very rich in organic residues (food waste) and debris (charcoal and seeds) (Deacon, 1993, 2008), suggesting that much smaller botanical remains like phytoliths may also have been preserved over time. Phytoliths are micro-particles of silica produced by plants, which are naturally deposited in soils and sediments after plants die and decay (Piperno, 2006). In the context of inhabited caves, the signal carried by phytoliths is firstly anthropogenic. In such a context, phytoliths have the potential for documenting what plants people transported into the cave and eventually consumed (e.g., Tsartsidou et al., 2015), or used for other various purposes, such as making fires (e.g., Albert and Weiner, 2001; Cabanes et al., 2010) or bedding (Cabanes et al., 2010; Wadley et al., 2011). In parallel, phytoliths provide indirect information about the environment (type of vegetation, climate) in which the people were living (e.g., Esteban et al., 2017a; Rossouw, 2016). Finally, part of the phytoliths can be related in particular cases to post-depositional (non-anthropogenic) factors, such as wind, water flow, and animals transport into the cave (Zurro et al., 2016). As an example, phytoliths were successfully used at Pinneacle Point, another South African archaeological site contemporaneous to Klasies River, to provide information about human behaviours and uses of plants, and also to reconstruct the environment in which people were taking their resources (Albert and Marean, 2012; Esteban, 2016). Similarly, several occupation layers from the Klasies River Main Site were investigated for the presence of phytoliths. This exploratory processing confirmed their presence in the form of occasional non-grass particles, in varying states of preservation. However, their potential could not be properly tested due to the absence of specific modern phytolith reference material (A. Novello, com. pers.).

Already in 1988, modern grass phytolith data from Klasies River were produced with the aim of using them as a reference tool for interpreting the potential phytoliths that could have been preserved in the cave deposits (Schuurman, 1988); yet no non-grass plant taxa were studied in parallel. In fact, grasses have been indirectly the most studied for phytoliths in South Africa (Cordova, 2013; Cordova and Scott, 2010; Rossouw, 2009; Esteban, 2016; Esteban et al., 2017c). Researchers focused on grass phytoliths to utilise in combination with current rainfall and temperature gradients (Rossouw, 2009; Cordova, 2013), or else with grass photosynthetic pathways (Rossouw, 2009) for reconstructing southern African climate and its variations during the Pleistocene (Rossouw, 2016). For example, Cordova (2013) analyzed the grass phytolith content of 128 modern soil phytolith assemblages distributed across different regions of South Africa, whereas Rossouw (2009), Cordova and Scott (2010), and Esteban et al. (2017c) respectively analyzed the phytolith content of 309, 30, and 15 Poaceae species from southern Africa. Restionaceae, which are very common graminoid representatives of fynbos vegetation in the Cape Region (Manning, 2001), have also been studied (Cordova and Scott, 2010; Esteban et al., 2017b, 2017c). Abundant “discoidal shape” phytoliths, only illustrated by rough drawings, were first described from the silica content of Restionaceae (Cordova and Scott, 2010), until other studies provided finer-resolution photographs and descriptions of the phytolith types produced by this family (Esteban et al., 2017b, 2017c). Instead of “discoidal shape” morphotypes, these authors described abundant spheroid-shaped phytoliths produced by the parachenchyma sheath cells of the Restionaceae culms. Noticing the lack of phytolith data for non-graminoid taxa, Esteban et coll. also studied the phytolith content of eudicotyledoneous, hereafter eudicots (24 species) and non-graminoid geophytes (13 species) from the Cape Region (Esteban et al., 2017c). In their conclusions, these authors observed the absence of diagnostic phytoliths in non-graminoid geophytes, while polyhedral shape phytoliths and silicified tracheids appear to be the most abundant morphotypes observed in the leaves of eudicot species (Esteban et al., 2017c). Moreover, 72 modern soils collected in the Cape provinces and that can further assist in paleoscape reconstruction were also studied for their phytolith assemblages (Esteban et al., 2017b).

This study aims to continue the work engaged in by Esteban et coll. on plant taxa and modern soils from the Cape Region, with the difference that it focuses on plant material and soils from the specific area of Klasies River in order to provide relevant and contextualised background material for interpreting the non-grass phytoliths preserved in the cave deposits. Phytolith analyses were performed on 22 modern plant species (including eight non-graminoid families) and two Restionaceae species (graminoids) collected in the vicinity of the Main Site. In addition to this plant dataset, 16 modern soil samples collected in different vegetation areas surrounding the site were studied for their phytolith content. The following questions are addressed:

i -What are the phytolith types produced by the modern plants around the Klasies River Main Site? Are some of these phytoliths diagnostic, or at least produced in significant quantities by some species?
ii -Are the phytolith types observed in Restionaceae comparable with what has been described in previous studies?
iii -How are phytoliths incorporated in modern soils under natural processes? Do modern phytolith assemblages allow for the discrimination of the different vegetation types occurring today in the Klasies River area?

### 1.1. Regional setting

The archaeological site of Klasies River is located on the southern Cape coast in the western part of the Eastern Cape Region. Precipitation includes both non-seasonal and seasonal rainfall, and is therefore all year round. Seasonal rainfall is usually variable in quantity from one year to another, occasionally torrential, and brought by south-east winds during the autumn and spring (Weldon and Reason, 2014). Non-seasonal rainfall mostly occurs during the winter months, when cold fronts and winds from the Western region transport rain to the Eastern Cape Region (Manning, 2001). The average annual rainfall recorded at Klasies River is 911 mm according to the Climate Research Unit records (New et al., 2002, 1961–1990 period), which is consistent with values recorded on the southern slopes of the nearby Tsitsikamma