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A PHYTOLITH ANALYSIS OF BOKONI SOILS

Tanya Hattingh

A Dissertation submitted to the Faculty of Science, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science

Johannesburg, 2013

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

30th day of January 2014 in Origins centre.

ABSTRACT

In spite of the extensive agricultural terracing relatively little is known about the agricultural practices of the people of Bokoni. The aim of this project was to determine what crops were grown by the people of Bokoni in order to establish whether the introduction of intensive agricultural methods, such as the terracing of hills and hillsides, was due to the introduction of new non-indigenous crops for example *Zea Mays*. I sampled the terraces at two Bokoni sites namely Komati Gorge Homestead 1 (KG1), which represented phase one sites with the earliest evidence of intensive agriculture, and Buffleskloof Private Nature Reserve Homestead 1 (BFK1), a site which represents terminal phase occupation sites, and analysed soil samples for phytoliths to establish what was cultivated at each site. By determining which crops were present at each site it was possible for me to establish whether the cultivation of *Zea mays* was responsible for the introduction of terracing or whether other factors caused the use of this intensive agricultural method. Phytolith analysis of the BFK1 samples also provided information of the agricultural practices of the Bokoni people during the last period of their occupation of Bokoni sites.

To my Friends and Family

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CHAPTER 1 - GENERAL INTRODUCTION

The Bokoni[1] archaeological zone, located between Ohrigstad and Carolina in the Mpumalanga province of South Africa (Fig.1.1) is characterized by stonewalled settlements. These settlements comprise homesteads connected by a network of roads, and vast areas of terraced hills (Evers 1975:76; Collett 1979:79; Maggs 2008:173). Research by, among others, Evers (1975), Collett (1979, 1982), Maggs (1995, 2008) and Delius and Schoeman (2008) suggested that the people of Bokoni were pre-colonial agriculturalists and that the terraces were used for agricultural purposes.

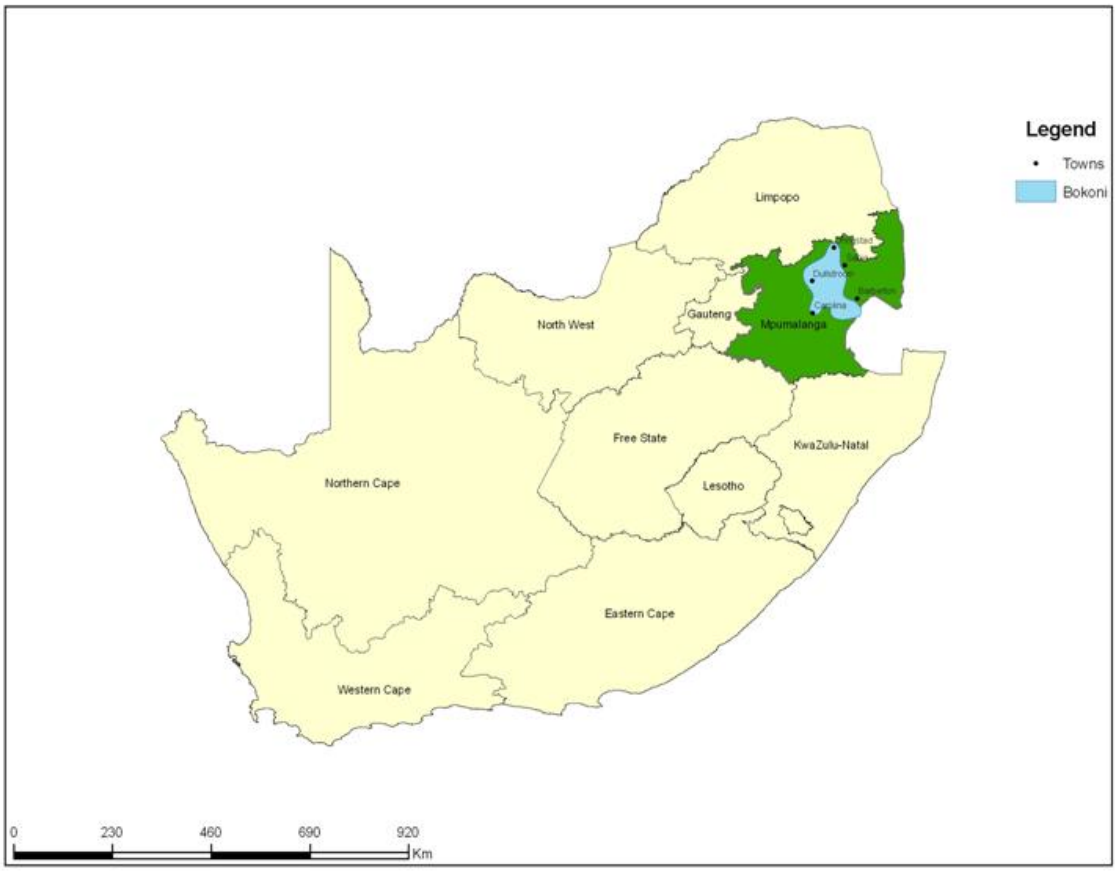


Figure 1.1. Known spatial location of Bokoni (after Coetzee 2008:1).

[1] The term Bokoni denotes the place of Koni, whereas Bakoni would refer to Koni people. The term Bakoni, however, has ethnic implications which have been rejected by the Bokoni archaeological project (for a more detailed discussion see Delius & Schoeman (2008).

Agriculture played an important role in the lives of pre-colonial farmers, because not only was it one of the factors which determined where settlements were located (Hall 1987; Delius & Schoeman 2008), but it also influenced settlement layout (Marker & Evers 1976), impacted on regional vegetation (Hall 1987; Van Zinderen Bakker1980) and various aspects of farmers' daily lives, for example their diet. Detailed information on agriculture in Bokoni is limited, because previous research conducted in the area focused mainly on aspects such as the identity of the people (Delius & Schoeman 2008), site patterns and locations (Coetzee 2008; Maggs 2008) and trade. In spite of the small amount of direct data, it has been suggested that Bokoni might be a site of intensive agriculture (Maggs 2008).

Research on eastern and southern African agricultural systems by Widgren and Sutton (2004) identified a number of features that indicate agricultural intensification. These features include terracing of hillside fields, crop rotation, irrigation and the adoption of a new or specific crop type (Widgren & Sutton 2004). The introduction of intensive agriculture in Bokoni could have been due to a number of factors. It has been posited that the change of existing agricultural systems and the use of new agricultural techniques, for instance terracing, could be the result to the introduction of new crops (Maggs 2008). In addition, growing populations, for example, would have necessitated the use of new farming methods in order to increase crop yields (Delius & Schoeman 2008:163).

Before it is assumed, however, that the Bokoni system was a form of intensive agriculture, it is essential to understand the various aspects that form part of farming systems in order to gain a comprehensive understanding of the communities that utilized them. While terracing is present at many Bokoni sites, it is unclear whether the Bokoni people utilized any of the other agricultural techniques linked to intensive agriculture (Maggs 2008). The primary aim of this project is to determine which crops were grown during the phase when evidence of intensive agriculture, namely terracing, start appearing as well as the terminal phase of Bokoni site occupation. The secondary aim is to identify the indigenous plant growth of the area, so that I could explore the regional climate at specific times in Bokoni history.

The types of crops cultivated would have affected various aspects of agriculture, such as the amount of labour needed for cultivation and processing of grains. Consequently, determining what plants were grown on Bokoni terraces is essential to understanding agriculture in

Bokoni. Thus far the only direct evidence of crops in Bokoni is sorghum (*Sorghum bicolor*), which was found at a Bokoni site near Lydenburg (Collett 1982:40). Evidence found at various other farming community sites, including Silver Leaves, Limpopo province, and Shongweni shelter, KwaZulu Natal, as well as historical accounts written by missionaries, such as Robert Moffat, about Later Farming Communities (LFC), however point to a range of crops such as finger millet (*Eleusine coracana*), pearl millet (*Pennisetum glaucum*) and vegetables such as cowpeas (*Vigna unguiculata*) which were cultivated by Early (EFC), Middle (MFC) and Later Farming communities (Klapwijk 1974; Davies 1975; Hall *et al*. 2008). In addition there is evidence for the adoption of maize (*Zea mays*) by LFCs (see e.g. Hall *et al.* 2008). It is possible that the Bokoni people also cultivated these crops, but without direct evidence it is impossible to be certain.

One way to determine the presence of crops at archaeological sites is through the use of phytolith analysis. Phytolith analysis has not been used in many southern African archaeological studies, however, it has been employed in a number of international studies to determine the presence of domesticated plants, for example *Z. mays* at archaeological sites in South America (see e.g. Piperno 1984; Pohl *et al.* 2007).

The study of phytoliths in archaeological contexts requires comparative collections. Phytoliths produced by African cultigens such as *S. bicolor* have been recorded by Rossouw (2009), but little substantial work has been done on the other crops cultivated by pre-colonial farming communities. In this project I drew on botanical studies conducted in southern Africa as well as studies of phytolith morphology and taxonomy (see e.g. Twiss *et al.* 1969; Pearsall 2000; Piperno 2006), in order to make reference collections for the phytoliths produced by *E. coracana, P. glaucum, S. bicolor* and *V. unguiculata.* The resulting reference collections were used in combination with pre-existing comparative data to determine which crops were cultivated at Komati Gorge and Buffelskloof Private Nature Reserve as well as the indigenous vegetation growing at each site.

Excluding this introductory chapter, this thesis consists of five chapters. In chapter two I discuss the studies consulted to gain a better understanding of phytolith analysis, including its uses and limitations. I also explore the agricultural techniques used by pre-colonial farming communities, the evidence for domesticated plants found at southern African sites and the

factors which influenced settlement location. I highlight key aspects of the regional vegetation and climate of the areas in which the sites, chosen for sampling, are located and give a short description of each grass subfamily and the phytoliths associated with each.

Chapter three is devoted to explaining the methods used to sample sites and extract phytoliths from soils, as well as the methods used to analyse the samples taken from the two sites chosen for sampling. This chapter, also, includes a brief explanation of the rational used when selecting techniques.

In chapter four I discuss and illustrate the reference collections for the various indigenous and imported crops. I also present the results of my analysis of the samples collected at Komati Gorge Homestead 1 (KG1) and Buffelskloof Private Nature Reserve Homestead 1 (BFK1).

My research results are discussed and placed within the regional and archaeological context in chapter five. I highlight key interpretations and put forward possible reasons why the people of Bokoni might have cultivated certain plants, as well as the impact that their agricultural practises might have had on their environment.

In the last chapter I highlight the main achievements and challenges of this project.

CHAPTER 2 - BACKGROUND

Introduction

In southern Africa the earliest evidence of the presence of farming communities dates to approximately AD 200 (Hall 1987:1). Numerous research projects have looked at aspects of EFCs, MFCs and LFCs, such as their origins (e.g. Huffman 1980; Greenberg 1955), economies (e.g. Denbow 1983, Denbow 1990), social structure and social interactions (e.g. Wadley 1996, Hobart 2003). While several studies (see e.g. Seddon 1968; Van Zinderman Bakker 1980; Marshall & Hildebrand 2002) focussed on the origins and intensification of agriculture (Smith 2005), our understanding of the agricultural practises of EFCs, MFCs and LFCs is still incomplete.

In this chapter, I highlight key aspects of EFC, MFC and LFC occupations in southern Africa by drawing on studies done on archaeological sites in southern Africa, which contained evidence of domesticated plants. I also discuss the possible cultivars used by the people of Bokoni, as well as the modern flora in the study area. Lastly, I review studies in which phytolith analysis has been used in southern Africa, and I discuss the limitations of phytolith analysis as well as the factors that influence preservation and the diagnostic value of certain phytolith morphotypes.

The First Farmers

Hunter-gatherer and pastoralist communities occupied large sections of southern Africa when the first farming communities moved into the region. Archaeological evidence suggests that, rather than completely displacing hunter-gatherer communities, farmers and hunter-gatherer communities lived together harmoniously in some areas (Maggs & Whitelaw 1991:18; also see Schoeman 2013).

A number of factors influenced the distribution and location of farming community settlements. Marshall and Hildebrand (2002) suggested that because mixed farming was practised by early farmers, they avoided areas where tsetse flies and other parasites, which caused livestock diseases, were present. Adequate grazing areas for livestock and water also played a major role in where farmers settled; therefore the first farming settlements in South Africa are mostly clustered around large bodies of water, rivers, as well as along the coastline

(Greenfield *et al*. 2005:308; Maggs 1980:7). It is likely that soil type and annual rainfall was taken into consideration when establishing settlements, because inadequate rainfall and leached soils causes stunted crop growth resulting in smaller harvests. Consequently, areas with fertile alluvial or colluvial soils and an annual rainfall of 500mm or more were preferred by farmers (Greenfield *et al.* 2005:308-309; Smith *et al.* 2007: 115). A lack of evidence for irrigation suggested to researchers that dry-land cultivation was practised, which implies that farmers were totally reliant on rainfall to meet the moisture requirements of their crops. Crops were therefore chosen with great care, and often a range of crops were planted, to ensure the best possible yields under favourable and unfavourable conditions, such as drought and extreme temperatures. It is possible that a variety of cropping strategies, for example mono-cropping and inter-cropping, were also used to maximize yields (Smith 2005:48).

Crops were cultivated using a range of agricultural systems, involving for example the slash and burn (swidden) technique (Hall 1987:11; Van Zinderen Bakker 1980:71). More wooded areas inhabited by farmers, such as woodland areas near rivers and coastlines on the eastern half of southern Africa, were probably cleared using this technique to create secondary grazing for cattle (Hall 1987:11), and the shifting nature of slash and burn agriculture helped farmers to avoid a decline in soil fertility.

Archaeological evidence, from various sites in southern Africa, suggests that EFCs cultivated a number of different cereals, as well as beans and gourds (Greenfield *et al.* 2005:310). EFC sites, such as Lanlory (Zimbabwe), a seventh century site, and an excavation of a house at Leopard's kopje, dating to the ninth century AD, have yielded *V. unguiculata* (Maggs 1980:6). Plant remains have also been found in shelters, such as Shongweni dry rock shelter, Kwa-Zulu Natal. This type of shelter tends to have better preservations conditions for plant material than open air farming homestead sites. At Shongweni a unit, which was radiocarbon dated to the late second century AD, yielded *E. coracana* and *P. glaucum*; while an eight century AD unit provided evidence of *E. coracana*, *Lagenaria siceraria* (bottle gourd) and *S. bicolor*. *S. bicolor* and *Citrullus lanatus* (Tsamma melon) was also found in a third unit which was dated to the 1300s (Davies 1975:657-658; Maggs 1980:5).

While direct evidence of plant cultivation is absent from many EFC sites in Mpumalanga, indirect evidence is present in the form of lower grindstones at the Lydenburg head site

(Evers *et al*. 1982: 27) and casts of *P. glaucum* at Silver Leaves (Klapwijk 1974:22). Maggs (1980:6) suggested that *E. coracana* and *P. glaucum* were among the first crops cultivated by EFCs and that *S. bicolor* and *V. unguiculata* were only introduced later.

The Start of Intensive Agriculture

Several factors, including trade and intensive agriculture, facilitated the rise of complex societies in southern Africa (Schoeman 2006b:39). The first evidence of intensive agriculture appeared at approximately AD 900-1000 when MFCs developed in present day southern Africa (Huffman 2000; Smith 2005). MFCs, similar to EFCs, practised mixed farming (Schoeman 2006b:154), and thus the factors which influenced EFC settlement location still applied. In, for example, the Shashe-Limpopo Confluence Area (SLCA), MFC settlements were concentrated in river valleys where the soil moisture content was the highest (Smith 2005:189). Substantial amounts of grain would have been needed to sustain increasing SLCA population numbers (Schoeman 2006a:163), and the kinds of crops cultivated, as well as the types of cropping strategies employed would have played an important role. It is possible that MFCs used the same cropping systems as EFCs, however, they also adopted a number of new techniques, for example flood plain agriculture (Smith & Hall 1999; Smith 2005:189) in order to increase crop yields.

Unlike colluvial soils, flood plains are able to hold water for longer periods of time, which meant that MFC agriculturists would not have been solely reliant on rainwater to irrigate their crops. The continued inflow of flood water would also have boosted soil fertility, which would have permitted MFCs to utilize plots for longer (Smith & Hall 1999; Huffman 2000:25-26; Smith 2005:189).

Several SLCA sites including, M3S (site 2229 AD30), EH Hill (site 2229 AD 35) and Mapungubwe hill have yielded remains of *S. bicolor*, which suggests that this was one of the principal crops grown by MFCs (Schoeman 2006b:158 & 159). In addition, *V. unguiculata* was found at Mapungubwe hill, which could indicate that beans were also grown in the area (Seddon 1968:493). MFC sites with evidence of intensive agriculture have not been found in the Mpumalanga province.

Later Farming Communities

LFC material culture signatures start to appear on the Highveld in the 12th century, and during the 15th century on the Lowveld (Evers 1974:x; Marker & Evers 1976:160; Makuru 2008:97-117). In the Mpumalanga province the transition from EFCs and MFCs to LFCs is marked by the expansion of farming communities beyond the coastal plains and wooded valleys, into thorn scrub and grassland areas, as well as a shift in settlement location from river banks to hillsides (Maggs 1994/95). These shifts could have been due to growing population numbers (Marker & Evers 1976:160), high calcium–magnesium cation ratios in the Mpumalanga River Valley soils which can cause stunted crop growth (Delius & Schoeman 2008:163) and the location of trade routes, rivers and resources (Coetzee 2008).

Differences between EFC and LFC occupations can clearly be discerned in the archaeological record, for example LFCs used stone walling, which was absent during the EFC period, to demarcate areas such as homesteads (Marker & Evers 1976:160; Maggs 1995, 2008:174). Regional variation can be seen in LFC artefacts, such as ceramics, as well as in settlement layout and architecture (Maggs 1980; Maggs & Whitelaw 1991:18).

The Bokoni People

The Mpumalanga province was inhabited by a number of LFCs, one such society lived in Bokoni. This region stretch over the area located between Ohrigstad in the north and Carolina in the south of Mpumalanga, and is characterized by stonewalled settlements which comprise vast areas of agricultural terraces, roads and homesteads (Evers 1975; Collett 1979, 1982; Maggs 1995, 2008:173).

Academic research on these settlements has been sparse and studies include Van Hoepen (1939), Mason (1968), Evers (1971; 1975), Collett (1979; 1982), Maggs (1995, 2008), Coetzee (2008), Delius and Schoeman (2008; 2010), and Delius, Maggs and Schoeman (2012). Some of the studies, such as Van Hoepen (1939) focussed on the layout, size and architecture of the settlements. Others, including those conducted by Mason (1968) and Evers (1971; 1975), used aerial photographs to research site location and use. Several homesteads were excavated to supplement the data gathered through surveys, and while terraces were not the main focus of these projects, key aspects, including their nature and

location, were noted (Evers 1971; 1975; Collett 1979:82; Delius & Schoeman 2008:138).

In terms of chronology, the Bokoni sites can be divided into four phases. Phase one sites are located in the extreme south of the Bokoni archaeological zone, which include the sites in the Komati River valley. These settlements were situated in open areas, which would have been well suited to agriculture, however since they were not geared towards defence, they would have been vulnerable to attack. It has been suggested that they were abandoned during the 1700s, when slave raiding and political unrest in the area forced the people of Bokoni to relocate north (Delius & Schoeman 2008:158; Delius *et al*. 2012: 404).

Similar to phase one sites, phase two settlements were located in open areas on gentle sloping hills and hillsides. These sites have a similar layout to those from phase one, and range from simple sites with an isolated stone circle to complex settlements with large central enclosures surrounded by numerous smaller enclosures which are connected by cattle tracks and surrounded by terracing (Delius *et al.* 2012:405; Marker & Evers 1976:160-161; Maggs 2008:177-178).

During the late 18th century and early 19th century hostile groups, for example the Ndwandwe led by Zwide, entered the region. At this time open valley sites, which could not be defended, were abandoned in favour of phase three settlements, namely sites in inaccessible kloofs and mountains (Delius & Schoeman 2008:149; Delius *et al*. 2012:406). These sites, similar to phase one and two sites were composed of circular enclosures, cattle tracks and terraces. The layout and structure of these settlements were determined by space limitations. Steep slopes would also have influenced the size and shape of settlement features, for example the terraces (Maggs 1980: 174). It, however, is not clear if the terraces were used for agricultural or residential purposes.

Phase three sites were not inhabited for long periods of time, because large numbers of people could not be sustained at these settlements. The fourth and last phase of Bokoni site occupation took place during the 19th century, after conflict in the area subsided, when several new communities, some including fragments of Bokoni communities re-used defensive sites (Delius *et al*. 2012:406-407).

The notion that the Bokoni people were agriculturists and that the terraces were used for

agricultural purposes (Evers 1975:76), is widely accepted among archaeologists. Exotic alternative explanations for the use of the sites, however, have been suggested by non-scholars, for example Heine and Tellinger (2008). Marker and Evers (1976) noted that terraces were located on hill slopes and the stone walls roughly followed the natural contours of the hills. Additional rows of stone, which were placed perpendicular to natural contours, demarcated individual plots (Marker & Evers 1976:160).

It has been suggested that terracing was first introduced as a method to reduce erosion and to clear more space to plant crops (Delius *et al*. 2012:404). Based on the research conducted in eastern Africa Widgren and Sutton (2004) suggested that terracing is an indicator of agricultural intensification. Therefore, it is possible that terracing was introduced in Bokoni to optimize crop yields to support growing populations (Delius & Schoeman 2008:163; Maggs 2008).

Collett (1979) was the first South African archaeologist to excavate Bokoni terraces. Based on survey data, he noted that homesteads were located within terraced fields (Collett 1979:79) and his excavations of complex ruins recovered carbonized sorghum (*S. bicolor*), which he suggested was cultivated on the terraces (Collett 1982:40). Evidence of domesticated plants, such as *E. coracana, P. glaucum* and *V. unguiculata*, has not been found at Bokoni sites (Maggs 2008:180), but because these plants were widely used by EFCs, MFCs and LFCs (see for example Hall *et al*. 2008:74), it is possible that the people of Bokoni also cultivated them.

It is also possible that maize (*Z. mays*) was cultivated at Bokoni sites. Maize, a crop indigenous to Mesoamerica (Holst *et al.* 2007:17607), was possibly introduced into southern Africa as early as the 16th century. Oral traditions, however, suggest that it was not cultivated in substantial amounts until the late 18th century at LFCs sites in the KwaZulu-Natal province and not until the early 19th century at sites in the Gauteng, Limpopo, Mpumalanga and North-West (Transvaal) provinces (Boeyens 2003:74; Hall *et al*. 2008:74; Maggs 2008:180). If maize was adopted this late in Bokoni, it would mitigate against its role as a causative factor in terrace introduction in Bokoni.

A number of the above mentioned domesticated plants might have been planted

simultaneously at Bokoni sites. Similar to farmers elsewhere in southern Africa, they could have used an assortment of cropping strategies, such as inter-cropping, mono-cropping and mixed-cropping, to improve yields (Smith 2005:45). In addition to employing various cropping strategies, the people of Bokoni may also have practised crop rotation and have fertilized fields with manure and ash to optimize crop yields (Maggs 2008: 180; Delius *et al*. 2012: 411).

African Domesticated Plants

The crops used at Bokoni sites would have depended on a range of selection criteria. For example, in order to optimize yields, crops which were adaptable to varying soil and weather conditions, as well as crops which were resistant to damage brought on by pests and disease could have been chosen for cultivation. Social and cultural beliefs might also determine which crops are grown and consumed, for example the Asathehene in Ghana did not eat grains because this food was perceived as being of inferior status (Logan 2012:320-1), and some of the Venda ancestors associated with rain-control ceremonies are said to like raw sorghum and millet (Schoeman 2013: pers. comm.).

Sorghum (*S. bicolor*), a robust, cane-like grass, is one of the most versatile African crops. Several types of sorghum exist and while these variants differ remarkably, they are all classified under the umbrella term *S. bicolor* (National Research Council 1996:142; Van Wyk 2005:352). While the stem and leaves are used as forage and hay or for building and weaving (National Research Council 1996:128), at present sorghum is mostly cultivated for its grains (Van Wyk 2005:352). Sorghum can be prepared a number of ways. Research has shown that contemporary communities mainly boil the grains, in a manner similar to rice, use the malted seeds to make beer and grind the grains to make flatbread or porridge (Quin 1954; National Research Council 1996:128; Van Wyk & Gericke 2000:14). It is possible that the people of Bokoni prepared sorghum in a similar fashion.

While sorghum's nutritional value is one of the advantages of the cultivation of the crop, its natural adaptive abilities remain the main reason why farming communities might have chosen to continue cultivating it after the introduction of maize. Most of the sorghum variants are drought tolerant. This is a result of sorghum's deep penetrating roots and ability

to turn down its metabolic processes. Furthermore, several types of sorghum are slow maturing which allows them to flourish in infertile soils (National Research Council 1996:146), while other varieties mature fast and thus make multiple harvests a year possible. Some variants are able to withstand periods of high rainfall which allows farmers to cultivate it in temperate as well as tropical regions (National Research Council 1996:128). The type of sorghum farmers choose to cultivate is usually determined by the climate, the nature of the soil and other factors such as local pests. The cropping strategies employed by a community are an additional factor that determines whether sorghum is cultivated and which type is chosen (National Research Council 1996:180-191).

While sorghum is well adapted to dry, hot climates it is less drought tolerant than pearl millet (*P. glaucum*), also known as bulrush millet or candle millet. *P. glaucum* is a robust grass indigenous to Africa (Van Wyk 2005:283), and is often planted in marginal zones where daily temperatures exceed 30˚C, rainfall is lower than 700mm a year or where farmers are unable to implement irrigation systems (National Research Council 1996:79). *P. glaucum* has relatively small yields, because less than twenty percent of the plant consists of grains, but some African farmers still favours it over higher yielding crops such as *S. bicolor* and *Z. mays*, because it often survives under environmental conditions that cause other cultigens to fail. Furthermore, *P. glaucum* has a high nutritional value, is less prone to damage brought on by insect activities, and is not as adversely affected by diseases as other crops (National Research Council 1996:81 & 97). The diversity of *P. glaucum* extends its to use. The seeds are usually ground up to make porridge and bread, and its high sugar content makes it ideal for brewing beer (Quin 1954; Van Wyk & Gericke 2000:12; Van Wyk 2005:283). The rest of the plant is also utilized; during dry seasons the leaves can be used as fodder for livestock, and the stalks make good building materials and fuel (National Research Council 1996: 100).

P. glaucum, however, has a number of drawbacks, for example, it is sensitive to cold temperatures, high rainfall and water-logging, as well as damage by birds. The amount of damage suffered by the plants is determined by the variant used. Different variants of *P. glaucum* determines not only physical aspects such as plant and seed size, but also the maturing rate of the crops and the amount of grain each plant yields (National Research Council 1996:90). All the different variants are incorporated under the scientific name *P.*

glaucum.

Finger millet (*E. coracana*) is not as drought tolerant as *P. glaucum*, but can be grown in dry, hot climates (National Research Council 1996:42) and, in some cases, is preferred to *P. glaucum*. *E. coracana* is a small tufted grass (Van Wyk & Gericke 2000:10; Van Wyk 2005:187) that is adapted to grow in a wide variety of environments and under a large number of conditions (National Research Council 1996:41-42). *E. coracana* has the remarkable ability to grow in most soil types (Smith *et al.* 2007:123), and many types are adapted to grow in tropical regions where the heat and humidity is high. *E. coracana* thrives at altitudes between 1000 and 2000 meters above sea level, and grows best in areas where rainfall is between 500 and 1000mm (National Research Council 1996:40-42).

Recent research has shown that unlike many of Africa's major crop types *E. coracana* contains high levels of amino acids and other nutrients needed to prevent malnutrition. It is also more palatable than *S. bicolor* (National Research Council 1996:39-40), and the ground grain can be used to prepare bread, gruel and porridge, while beer can be produced from the malted grains (Quin 1954; Van Wyk 2005:187). *E. coracana* seeds are small which is both an advantage and disadvantage. The size of the seeds limits damage caused by insects and birds, consequently the seeds can be stored for years, but it is difficult to handle the seeds and thus planting and processing the grains is extremely time consuming. Weeding fields of *E. coracana* is also labour intensive (National Research Council 1996:40) and cultivation of the crop can cause soil erosion (National Research Council 1996:51), which could cause fields to become infertile.

V. unguiculata is often inter-cropped with *E.coracana, P. glaucum*, *S. bicolor* and other African cereal cultivars to reduce erosion and promote crop health (National Research Council 2006:107). *V. unguiculata,* a legume indigenous to Africa, is an annual crop that consists of a number of types, which can be described as climbers, semi-upright (National Research Council 2006:115) or bushy legume plants (Van Wyk 2005:383). *V. unguiculata* is, at present, grown for several reasons. Firstly, *V. unguiculata* is highly nutritious and contains high levels of protein and small amounts of other important minerals that help prevent malnutrition. Secondly, *V. unguiculata* raises soil nitrogen levels, its dense leaves help to preserve moisture, and the climber variety protects crops form weeds by growing around

them and crushing the weaker plants. *V. unguiculata* is also adapted to tolerate dry climates and infertile soils. (National Research Council 2006:107).

Usually the entire plant can be used. Seeds, pods and leaves are mostly boiled in a manner similar to vegetables (Van Wyk 2005:383), but can also be dried and ground and added to soups and other dishes. *V. unguiculata* plants are often used as forage and can be dried, rolled into bundles and used at a later stage (National Research Council 2006:109). It is possible that pre-colonial farming communities cultivated *V. unguiculata*, because of all of the above mentioned reasons, but *V. unguiculata* could also have been cultivated for religious and medicinal reasons. Medicines made from *V. unguiculata* have traditionally been taken for fevers, as an antidote for snakebites and as a cure for problems related to female infertility. *V. unguiculata* has also been used as a key ingredient in love potions (Scott *et al*. 1996:146; Schoeman 2006:270).

While it is possible that the people of Bokoni cultivated one or several of the above mentioned indigenous crops, it has been suggested that they might have adopted non-indigenous crops, for example maize (*Z. mays*) (Maggs 2008:180). *Z. mays* fares well in tropical regions with moderate and high rainfalls (Pohl *et al.* 2007:6870) and, unlike *S.bicolor*, *P. glaucum* and *E.coracana*, which are adapted to dry climates, *Z. mays* is less adversely affected by prolonged rain and water-logging (National Research Council 1996:91).

Z. mays contains high levels of starch and sugar, which makes it ideal for brewing beer and making alcohol. It also can be used as feed for animals, and porridge can be produced from flour made from the grains. Some varieties can be eaten both raw and boiled, as well as from the cob (Quin 1954; Van Wyk & Gericke 2000:16; Van Wyk 2005:388). There are, however, several drawbacks to using *Z. mays* instead of African cereals. *Z. mays*, for example, is low in amino acids and other nutrients and it is prone to diseases that can cause crop failure (National Research Council 1996:81). Furthermore, it can only be grown in certain soil types and quickly depletes soil nutrients.

Despite its limitations, *Z. mays* was adopted widely by South African farming communities in the twentieth century. This adoption might be the result of *Z. mays'* ability to produce high

yields under favourable circumstances, namely wet conditions, and because it is easier to harvest and suffers less from bird damage than African cultivars (Van Wyk & Gericke 2000:16).

Farming communities, however, were not only reliant on domesticated crops, they also used non-domesticated plants for a variety of reasons, for example plants such as *Sclerocarya birrea* (Marula) were eaten, *Acacia karroo* (sweet thorn) and *Melianthus comosus* were exploited for medicinal purposes (Van Wyk *et al*. 1997; Hutchings 1996), while *Sclerocarya birrea* (Marula) and certain *Aloe* species were used in ritual contexts because of the cultural meanings or values attributed to them. Indigenous plants also were used as building materials, for example *Hyparrhenia hirta* (common thatching grass), cosmetics (made from *Aloe ferox* for example) and various other products such as dyes and storage vessels, for example baskets.

Regional Vegetation

While it is important to understand the limitations, uses and adaptive abilities of crops and other plants that might have been used by the Bokoni people, it is also essential to be familiar with the climate and types of vegetation currently growing in the sampling areas. This knowledge is vital in order to understand the factors that might cause phytolith movement, decay and sample contamination.

The area in which Bokoni is situated comprises a number of different biomes, for example the Northern Mistbelt Forest Biome, the KaNgwane Montane Grassland Biome, the Lydenburg Thornveld biome and the Northern Escarpment Dolomite Grassveld Biome. Differences in vegetation relate to differences in climate, altitude and soil types, which result in ever changing landscapes and an area which contains thousands of different plant species (Mucina & Rutherford 2006).

Komati Gorge, which is located in southern Bokoni, is situated in a region which is made up of several distinct habitats (Fig. 2.1) with remarkably different plant types. The section of Komati Gorge that was sampled (KG1) is, at present, part of the KaNgwane Montane Grassland Biome (Mucina *et al*. 2006b:404), but Acocks (1988) suggests that this area was once bushveld or thornveld of which parts of vegetation can still be seen in the current biome.

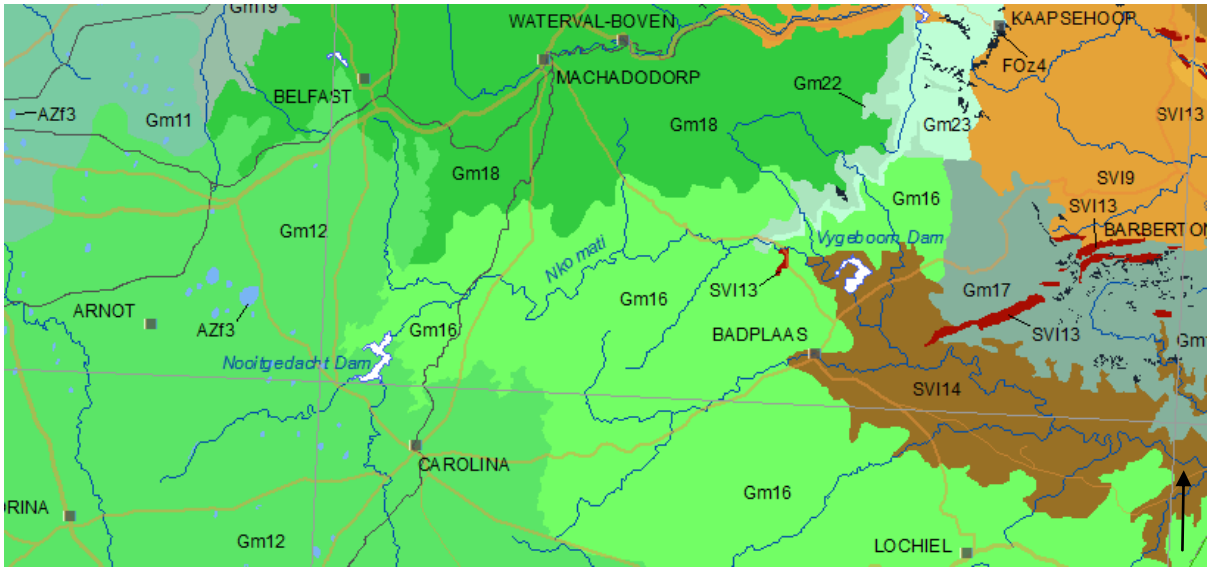


Figure 2.1. Map showing the different biomes in the area in which KG1 is located. The KaNgwane Montane Grassland Biome is represented by the alphanumerical code Gm16 (after Mucina & Rutherford 2006).

Gentle slopes and undulating hills characterise the KaNgwane Montane Grassland Biome (Mucina *et al*. 2006b:404) and altitudes range between 800 and 1700 m (Acocks 1988:115). The Komati Gorge area receives a moderate summer rainfall of 800 to 1250 mm (Mucina *et al*. 2006b:404), which has a profound effect on the vegetation that grows in the area. The mean annual temperature in this biome is 16 degrees Celsius (Mucina *et al*. 2006b:391). Graminoids dominate the landscape, while shrubs, ferns and herbs are common. Trees are rare. Common taxa include: *Themeda triandra* (red grass), *Alloteropsis semialata subsp. eckloniana*, *Brachiaria serrata* and *Setaria nigrirostris* (refer to Appendix C for full list of taxa common in the KaNgwane Montane Grassland Biome and Appendix D for a list of taxa common in the Komati Gorge area) (Acocks 1988:115; Mucina *et al*. 2006b:404).

The Northern Mistbelt Forest Biome, in which BFK is located (Fig.2.2), differs remarkably from the biome in which KG1 is located. BFK1 is located in northern Bokoni and is a good example of how drastically a landscape can change in a few decades. While the section of BFK1 which was sampled is currently a forest, this was not always the case. Due to reforestation, vegetation associated with forest biomes have systematically replaced the grassland vegetation which once grew in the kloof (Burrows 2012: pers. comm.).

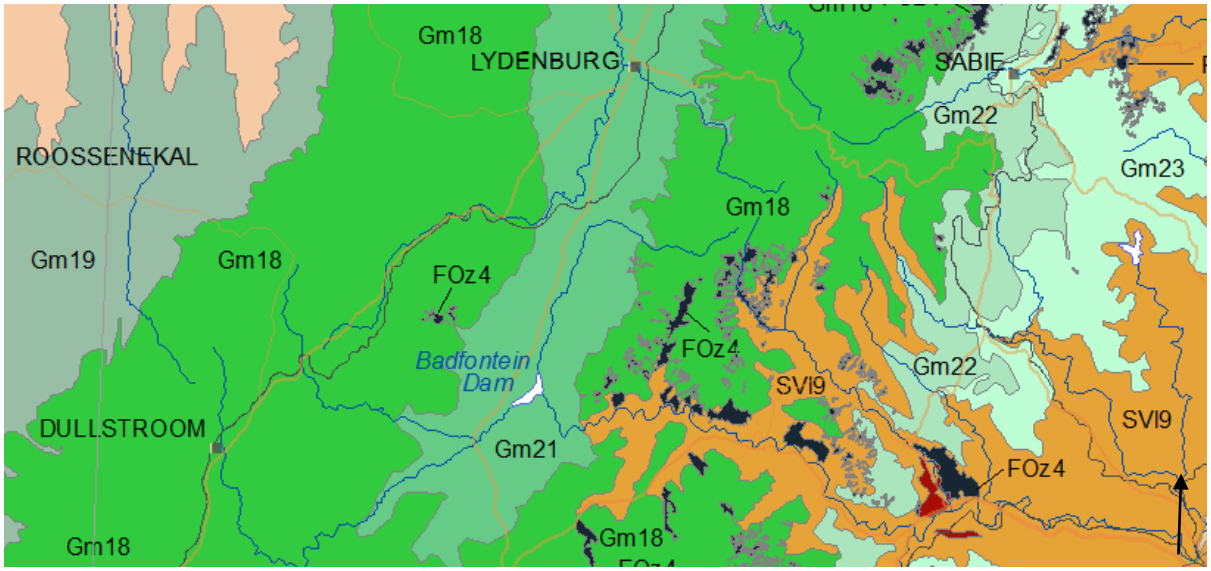


Figure 2.2. Map of the section of Mpumalanga in which BFK1 is located. The alphanumerical code FOz4 represents the Northern Mistbelt Forest Biome (after Mucina & Rutherford 2006).

Northern Mistbelt Forests, characteristically occur in small patches along east-facing and moist sheltered kloofs at altitudes of between 1050 and 1650 meters. This biome has high mean annual precipitation of approximately 1084mm per year and a mean annual temperature of 16.7 degrees Celsius (Mucina *et al*. 2006a:592). Northern Mistbelt Forests contain a diversity of species of which the bulk is of subtropical provenance. Canopy trees, shrubs and herbs are common while graminoids are rare or often absent in this biome. Trees that commonly occur in the mistbelt forest biome include: *Xymalos monospora, Schefflera umbrellifera, Combretum kraussii, Brachylaena transvaalensis* and *Podocarpus latifolius* among others. *Galopina circaeoides, Hypoestes triflora, Carex spicato-paniculata* and *Dryopteris inaequalis* also occur in this region (refer to Appendix E for the complete list of species common in the Northern Mistbelt Forest Biome and Appendix F for a list of taxa common in the BFK area). These forests often border either Sourveld grasslands or Bushveld biomes (Mucina *et al.* 2006a:601-602).

The factors which influenced current vegetation at KG1 and BFK1 would also have determined plant growth at the sites during the periods when they were occupied. Phytoliths of non-domesticated plants have been used in numerous studies (e.g. Thorn 2004) to provide information on past climates as well as regional vegetation, however, in order to correctly

interpret phytolith assemblages, the processes underlying phytolith production and preservation need to be understood (Piperno 2006:108).

Phytoliths

Phytoliths, also referred to as biogenic opals, are minute hydrated silica units that form within or between the cells of living plants (Piperno 2006:1). Since their discovery by German botanists at the end of the 1800s phytoliths have been employed to answer archaeological and palaeontological questions and numerous studies (e.g. Rovner 1971; 1983, Piperno & Pearsall 1998) have been done to determine its uses, limitations, morphology and taxonomy.

In the Americas there have been numerous studies focussing on the domestication of maize, and other major food crops (see e.g. Piperno 1984; Eubanks 2001; Pohl *et al.* 2007). In East Asia a substantial amount of research has been conducted on rice, wheat and barley (Rosen 1992; Pearsall *et al.* 1995; Zhao *et al.* 1998). In addition attention has been paid to non-dietary use of plants (Madella *et al*. 2002; Rosen 2005).

In Africa researchers have used phytoliths in a number of palaeobotanical projects. In East Africa studies by Bamford *et al*. (2006) and Albert *et al*. (2006; 2009) investigated palaeontological plant growth at Olduvai Gorge. In central Africa Runge (1999) undertook research to create a classification scheme for phytolith assemblages in order to characterize forest and grassland vegetation, while Mercader *et al.* (2000) extracted phytoliths from late Pleistocene and Holocene sediments to use as a proxy for palaeovegetation dynamics in Ituri forest, Congo.

In southern Africa Oberholster (1968) conducted some of the earliest phytolith research and his results explained phytolith occurrence in soil profiles from the Springbok Flats of South Africa. Subsequently researchers used phytoliths as a proxy for palaeoclimatological processes at the Tswaing crater (McLean & Scott 1999) and Scott and Rossouw (2005) employed phytoliths to re-examine botanical evidence of palaeoenvironments at Florisbad.

In spite of phytoliths having been used extensively in southern African studies to aid in the reconstruction of palaeoclimatic shifts and palaeoenvironmental conditions (Rossouw 2009:5-9), phytolith analysis has not been used in many southern African archaeological

research projects. Among the few studies that have employed phytoliths is a study by Schiegl and Conard (2006), who used phytoliths to identify hearth features at Sibudu cave, South Africa, and the recent study by Rossouw (2009) which focused on the development of a standardized model for interpreting grass silica short cell (GSSC) phytolith assemblages. This research resulted in a reference collection for several common South African grass species.

Thus far, limited work has been done on the phytoliths produced by African cultivars. Part of the problem is a lack of understanding of the phytolith analysis techniques, phytolith limitations, as well as the processes that form and preserve phytoliths (Shillito 2013:72). Phytoliths are formed through metabolic and physical processes during which soluble silica is absorbed through plant roots along with groundwater and other minerals, transported via the xylem and then deposited in inter-cellular and extracellular locations (Piperno 2006:5; Shillito 2013:71). A multitude of plants produce phytoliths, for example Poaceae (grasses), Cucurbitaceae (gourds and squashes) and *Lagenaria* (bottlegourds) produce large numbers of phytoliths, while phytolith production varies greatly in plants belonging to Fabaceae (legumes) and phytoliths are rare or uncommon in Cactaceae (Cacti) (Piperno 2006:7).

It is unclear why only certain taxa create phytoliths, but it is likely that plant physiology and environmental factors play a role in phytolith production. One theory is that plants produce phytoliths to improve plant structure and expose more leaf area to sunlight, thus maximizing photosynthetic activity (Piperno 2006:14). Another theory is that phytoliths provide protection against herbivores. Studies by Massey and Hartley (2006) proposed that silica is one of the main defence mechanisms of grasses. Silica, deposited in the form of phytoliths, determines abrasiveness as well as the digestibility of plant materials, which affects the overall health of animals (Massey & Hartley 2006:2299; Massey *et al.* 2007:414-424) and provides plants with a certain level of protection against animals.

Environmental factors that may influence the production of phytoliths include: soil nature and the availability of soluble silica in groundwater, as well as plant age and the environment of growth (Piperno 2006:5). Of course, environmental factors not only influence phytolith production within plants, but also phytolith preservation in soils and sediments (Piperno 2006:108).

The factors that influence phytolith preservation have been a main area of investigation in studies grappling with understanding phytolith distribution. Phytoliths, which are inorganic, resist a multitude of environmental conditions which inhibits the preservation of other botanical remains. Most organic materials require anaerobic conditions to resist rapid decomposition and are vulnerable to moisture, specific soil types and micro-organisms (Piperno 2006). The nature of phytoliths has led various researchers to debate the reliability of phytolith assemblages and at one point it was thought that since phytoliths are the result of soluble silica deposited in plants, it would easily dissolve when exposed to moisture, which would limit its durability in soil (Rovner 1983:235). This however, was found to be untrue, because not only are phytoliths abundant in lake sediments, but they resist moisture better than pollen and other macrobotanical remains (Piperno 2006:107-108).

While phytoliths preserve well under a wide array of soil conditions (Rovner 1983:236), several factors, including soil pH can influence phytolith dissolution. Alkaline soils with a pH of nine and above often accelerate phytolith decay, especially in hot, humid climates (Piperno 2006:108), thus areas such as middens, which contain considerable amounts of ash, often lack phytolith evidence. Phytolith assemblages from garden and agricultural field deposits can also be affected by soil alkalinity, Pearsall and Trimble (1984) and Piperno (1985; 1988) have, however, recovered well preserved phytoliths from such settings.

Dunn (1983) was less concerned with the effects of alkaline environments on phytolith preservation and focussed on the mobility of phytoliths within sediments and how it affects interpretations based on phytolith evidence. She reports finding little or no phytoliths in soil samples from archaeological fields and irrigation canals in Moche Valley, Peru, and since pollen was present in later samples, she concluded that phytoliths are extremely mobile in sediments and therefore phytoliths cannot be tied to specific archaeological settings (Dunn 1983). Studies by Osterrieth *et al*. (2009) and Fishkis *et al*. (2009; 2010) also stress the high mobility of phytoliths, however, Pearsall (2000) disagrees with these studies and argues that since diatoms and pollen are similar in size to phytoliths, they would be equally affected by downwards movements. An abundance of pollen in soil samples from Moche Valley, Peru indicates that other factors are responsible for the absence of phytoliths (Pearsall 2000:495). These factors could include the amount of iron (Fe) and aluminium (Al) absorbed to phytolith

surfaces, the surface area of phytoliths and the particular taxon that is silicified (Piperno 2006:108).

While phytolith mobility within sediments is an important factor to consider when analysing samples, other aspects which influence phytolith movement such as wind, water and animal activities should also be considered. Wind and water have the ability to transport phytoliths considerable distances from their source, as was demonstrated when samples taken from ship sails were shown to contain phytoliths (Darwin 1909). Animal activities also have the potential to relocate phytoliths over long distances; burrowing and grazing, for example, can lead to the transport and introduction of phytoliths into microenvironments (Carrión *et al.* 2000:248; Ghosh 2008). Human activities, for example the fertilization of fields with manure, digging and the building of structures can also redistrubute phytoliths (Piperno 2006:83).

Though phytoliths can be highly mobile, there are a number of advantages to using phytoliths as appose to other botanical remains such as pollen. Phytoliths are released into soil as the plants decompose and are thus good representatives of plant growth and use in micro-environments (Piperno 2006:1). Pollen, on the other hand, reflects macro-environmental vegetation, because it is released from plants and is more easily transported by wind and water (Rovner 1983:236; Rovner 2001:119), than phytoliths, which are bound to organic matter not only while the plant is alive, but also during plant decay. The trapped phytoliths are thus less randomly deposited than pollen and seeds (Pearsall 2000:495).

Phytoliths, as well as, pollen are produced abundantly by plants, which can be problematic when analysing phytolith assemblages. Unlike pollen which is produced in a single repetitive form (Rovner 1983:226), a single plant species often produces a multitude of different phytolith morphotypes. Also some phytolith shapes are highly redundant which can lead to an over representation of taxa or a misinterpretation of data (Piperno 2006:25). The nature of grass leaf epidermis in Poaceae, for example, gives rise to a complex assortment of phytoliths, many of which can only be distinguished from one another through close inspection of the morphology of two- and three-dimensional structures. Poaceae consists of some 10 000 species and 700 genera, which includes domesticated plants such as *E. coracana, P. glaucum, S. bicolor* and *Z.mays* as well as their ancestors and other closely

related grasses (Piperno 2006:27).

Eight Poaceae subfamilies, namely Aristidoideae, Arundinoideae, Bambusoideae, Chloridoideae, Danthonioideae, Ehrhartoideae, Panicoideae and Pooideae, have been identified in southern Africa. The distribution of plants belonging to these subfamilies is determined by a number of factors for example temperature, rainfall and altitude. Aristidoideae is a small subfamily which consists of plants which are annual or perennial and are mostly herbaceous grasses. Grasses belonging to this subfamily grow in tropical or xerphytic temperate zones and are often found in open habitats. Aristidoideae comprises both C3 and C4 grasses (Gibson 2009:28).

Only C3 grasses belong to Arundinoideae (Cross 1980:286), which is made up of perennial herbaceous and 'woody' plants. Plants which form part of this subfamily mostly grow in temperate and tropical habitats. Plants belonging to the Bambusoideae, such as Arundidoideae grasses, are herbaceous and 'woody'. They predominantly occur in temperate and tropical forests, high montane grassland and savannah biomes as well as near riverbanks. Bambusoideae grasses possess the C3 photosynthetic pathway. Chloridoideae, unlike Bambusoideae and Arundidoideae, consists only of C4 grasses (Gibson 2009:27-28). Plants belonging to this group are adaptable to hot, dry climates (Cross 1980:286), as well as a wide variety of other environmental conditions for example high pH and saline soils. Chlorodoideae grasses can be found in dry tropical and subtropical regions (Gibson 2009:28).

Danthonoideae, in contrast with the above mentioned subfamilies occurs primarily in the southern hemisphere. Plants belonging to this subfamily grow in mesic and xeric open habitats and possess the C3 photosynthetic pathway (Gibson 2009:28). Ehrhartoideae also consists of C3 grasses. Ehrhartoideae grasses are herbaceous or suffrutescent and occur in forests as well as on open hillsides and in aquatic habitats. This subfamily consists of approximately 120 species, and is relatively small compared to the Panicoideae subfamily which contains more than 3500 species (Gibson 2009:27). Panicoideae contains both C3 and C4 grasses (Gibson 2009: 27; Glemin & Bataillon 2009:275) as well as species with C3/C4 intermediary pathways. Panicoideae grasses grow in tropical and subtropical regions (Gibson 2009:27) and are often encountered in savannah habitats. They are also adaptable to shady and moist environments (Cross 1980:284), however they are not as adaptable as plants

belonging to the Pooideae subfamily.

Pooideae grasses possess the C3 photosynthetic pathway (Glemin & Bataillon 2009:275; Gibson 2009:27) and are perennial or annual. The physiology of the plants belonging to this subfamily enables them to grow in cool temperate and boreal regions. It also enables them to survive at high altitudes for example, high mountain environments (Gibson 2009:27).

Photosynthetic pathways are one of the factors that determine where different grasses grow. Poaceae, which posses the C4 photosynthetic pathway, are adapted to environments with low atmospheric CO_2 concentrations which allow them to survive in hot, arid conditions and thus dominate ecosystems in warm climates, such as grassland and savannah environments. C3 grasses on the other hand do not use water efficiently and thus occupy cooler, wetter regions (Osbourne & Freckleton 2009:1753; Gibson 2009:59).

Photosynthetic pathway, as well as rainfall and habitat, influence which phytolith morphotypes are created by Poaceae subfamilies (Rossouw 2009:67-70). Some phytolith types, for example epidermal long cell and bulliform phytoliths are undiagnostic (Fig. 2.3), and are abundant in all Poaceae subfamilies. Various researchers, for example Twiss *et al.* (1969) and Rossouw (2009), have shown that certain phytolith morphotypes, for example short cell phytoliths, correspond to certain grass subfamilies. Bambusoideae, Chloridoideae and various other subfamilies create small numbers of bilobates, however bilobate phytoliths are most common in grasses belonging to Panicoideae and are therefore considered diagnostic of Panicoid grasses. Cross and polylobate phytoliths are also created by Panicoideae, (Fig. 2.3) (Fredlund & Tieszen 1994: 326; McClaran & Coder 2003:24).

Oblong, orbicular, rectangular and square phytoliths (Fig. 2.3) are associated with grasses from the Pooideae (Twiss *et al.* 1969). Trapezoid phytoliths are also abundant in Pooid grasses, Rossouw (2009), however, showed that they are also created in the various grasses belonging to Danthionioideae and Ehrhartiodeae (Rossouw 2009:67-70).

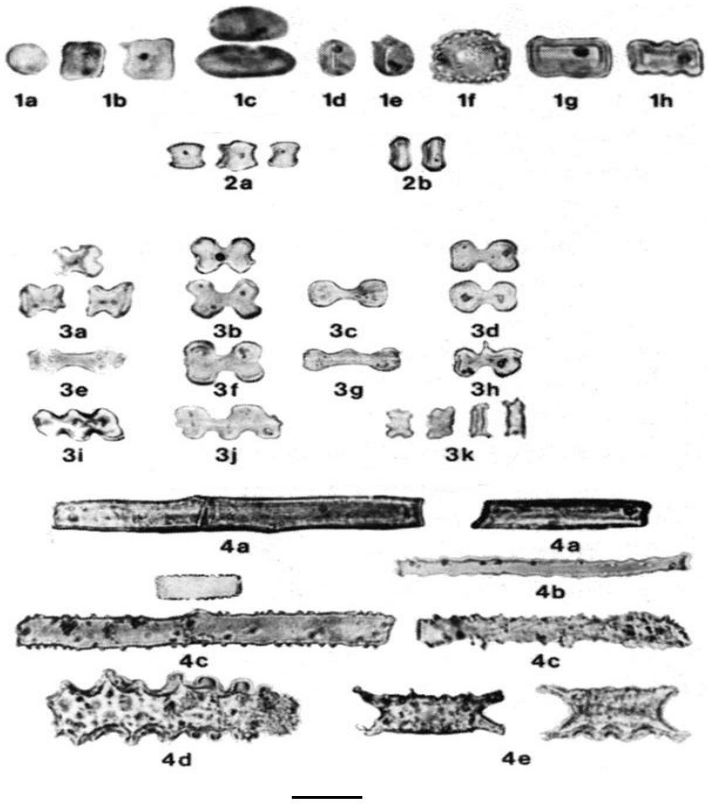


Figure 2.3. Classification of Poaceae phytoliths. (1a-h) Orbicular, retangular, square and oblong phytoliths created by Pooid grasses. (2a-b) Saddle phytoliths produced by Chloridoideae and Aristidoideae. (3a-k) Bilobate, cross and polylobate phytoliths created by Panicoideae. (4a-e). Undiagnostic phytoliths produced by all Poaceae (adapted from Twiss *et al.* 1969:111).

Squat saddles, or variant one saddles, (Rossouw 2009) are common in Chloridoid grasses, while elongated saddles (Variant 2 saddles) are common in plants belonging to the Aristidoideae subfamily (Fig. 2.3) (Russouw 2009). Elongated saddles are also produced in abundance by the Chloridoideae subfamily (Twiss *et al.* 1969). There are deviations in this typology, however the main patterns suggested by Twiss *et al.* (1969) have been validated.

While phytolith typology is, to some degree, useful during analysis, in order to determine which domesticate plants were cultivated on Bokoni terraces I had to look at the finer morphological differences in phytolith shapes. Various deviations of phytolith shapes exist. Pearsall (2000:387), for example identified eight variants of cross shaped phytoliths (Fig. 2.6)

which enabled her to differentiate between *Z. mays* and other closely related plants such as teosinte *(Z. mays ssp. Parviglumis*). Rossouw (2009) noted three different types of bilobate phytoliths (Fig.2.5.), as well as two kinds of saddle shaped phytoliths (Fig. 2.4), which could help researchers distinguish between E. coracana and the plant from which it might have been domesticated, *E. indica*. It could also help discriminate between the phytoliths created by *S. bicolor* and closely related indigenous grasses such as *S. versicolor*.

At this point few studies have focussed on African domesticates and the grasses they are related to (Piperno 2006:78-79). Research on the different types of these domesticates and how their phytoliths differ from each other is also limited. A better understanding of the various morphotypes created by each Poaceae subfamilies is required to be able to determine whether African domesticated grass phytoliths are unique.

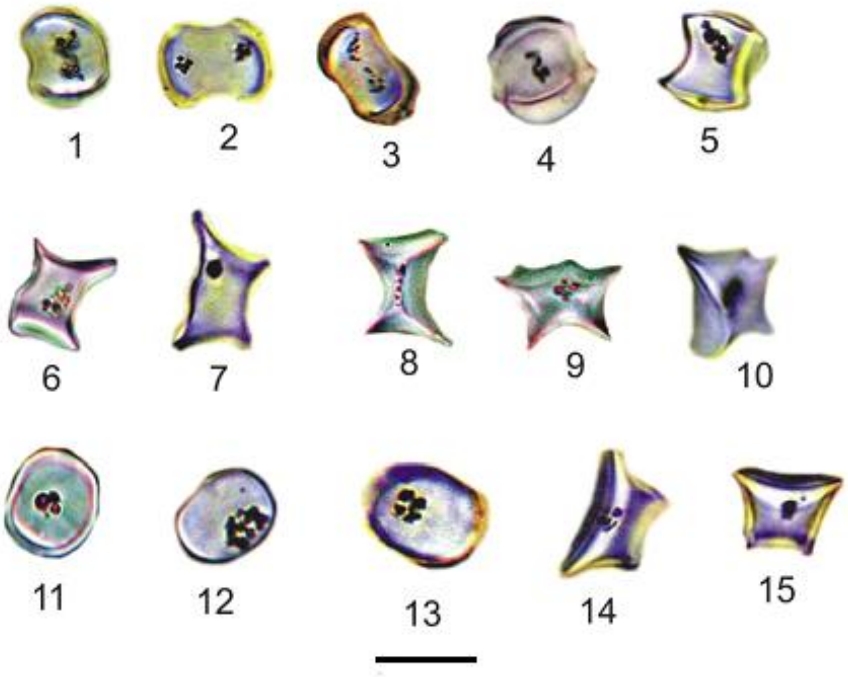


Figure 2.4. Saddle variant 1 (squat saddles): (1-5) planar view; (6-8) side view; (9) end view; (10) oblique view. Variant 2 saddles (elongated saddles): (11-13) planar view; (14-15) side view (after Rossouw 2009:53).

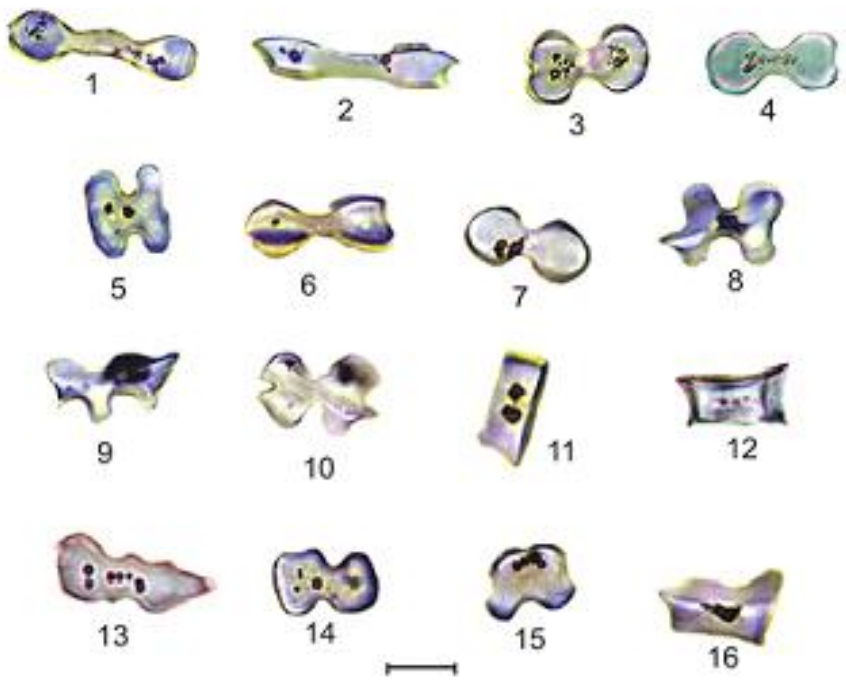


Figure 2.5. Bilobate variant 1: (1) Planar view; (2) side view. Bilobate variant 2: (3-7) planar view; (8-10) oblique view; (11-12) side view. Bilobate variant 3: (13-15) planar view; (16) oblique view (adapted from Rossouw 2009:52).

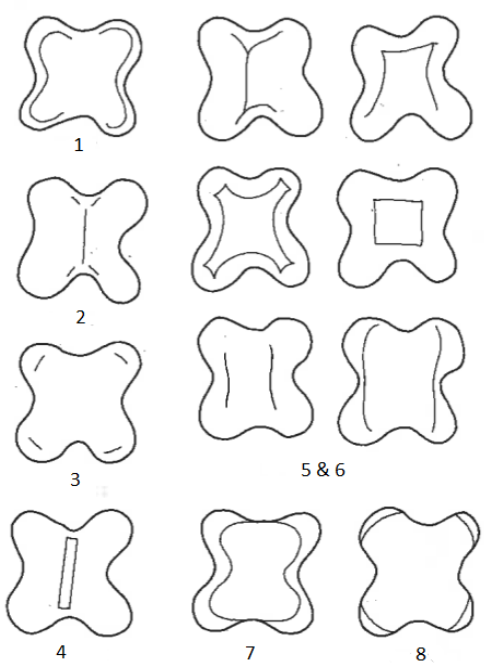


Figure 2.6. The different variants of cross shaped phytoliths (after Pearsall 2000:387).

Phytolith morphotypes

Rossouw (2009:46) suggested that bilobate phytoliths are the most diagnostic grass silica short cell (GSSC) phytolith type. Bilobates consist of two lobes separated by a neck or shank, which varies in length and thickness. The lobes are usually rounded, but the terminal margins can also have indentations. According to Rossouw (2009) the three types of bilobates can be differentiated form one another on the basis of the dimensions of the neck and the outline of the planar surface. Bilobate variant one has a neck that constitutes more than a third of the total length of the phytolith. The orbicular lobes are symmetrical in the planar as well as the lateral view (Fig. 2.5). The neck portion of variant two is smaller or equal to a third of the body and it can have orbicular or elongated lobes. Variant two has a symmetrical lateral view, and can appear tabular or trapezoidal in side view (Fig. 2.5) (Rossouw 2009:47; Fredlund & Tiezen 1994). The third variant's neck portion comprises less than a third of the total body length and the bilobate is asymmetrical in shape. When the lateral side is observed, the phytolith is trapezoidal or tabular in shape (Fig. 2.5) (Rossouw 2009:47; Twiss *et al*. 1969).

Unlike bilobate shaped phytoliths, which possess only two lobes, cross morphotypes have four lobes. These lobes can be either symmetrical or irregular in shape, and can be rounded or pointed with a small central portion (Rossouw 2009: 47). Piperno's (1984) differentiation of crosses was based on the three-dimensional characteristics of the body which can be viewed on the planar view (Fig. 2.4). The different types of crosses can be used to identify plants at or below a subfamily level (Piperno & Pearsall 1998) and if morphological aspects are combined with size attributes it is possible to distinguish between domesticated plants and wild grasses (Pearsall 2000: 388).

It is slightly harder to distinguish between the two types of saddle phytoliths, because there is little variation in form. Both variants appear trapezoidal in the planar view, with a concave base and a plateau that is rectangular or square. Variant one, however, has a tapered base and a plateau with one or two medially constricted margins (Fig. 2.4) while variant two has a plateau with rounded corners and no constricted margins (Fig. 2.4) (Rossouw 2009:48). Similar to cross and bilobate forms a combination of size and morphological attributes can be used to distinguish between species.

Other phytolith forms that are common in grasses include, as mentioned, circular, rectangular and oval shapes. Circular or rondel forms resemble a truncated cone and as the name suggests can be circular, elliptical or acicular in form (Fig. 2.7.). Rectangular or trapezoid forms are six-sided, square or rectangular with parallel sides (Fig. 2.7). Oblong phytoliths are twice as long as they are wide and parallel sided with smooth or sinute planar edges (Fig. 2.7) (Rossouw 2009: 49). Little variance has been noted with the above mentioned phytolith shapes.

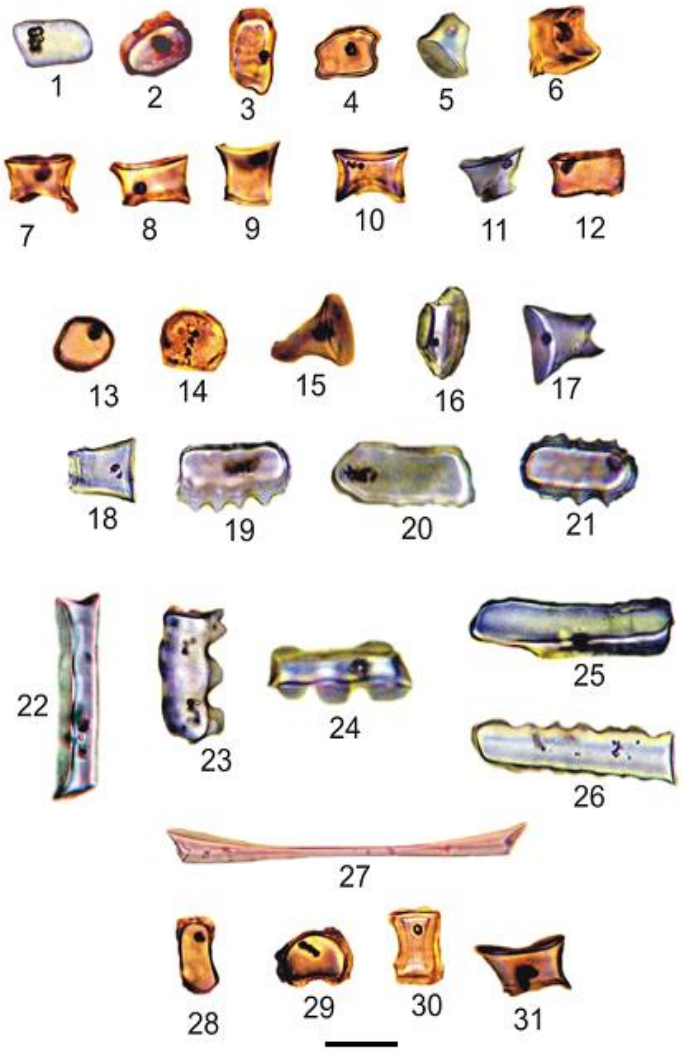


Figure 2.7. Trapezoid phytoliths: (1-4) planar view; (5-6) oblique view; (7-12) side view. Rondels: (13-14) planar view; (15-17) oblique view; (18) side view. Oblong: trapeziform sinuate, (19-21,26) planar view; trapeziform smooth, (22, 25, 27) oblique view; trapeziform polylobate, (23, 24) oblique view. Reniform: (28-30) planar view; (31) side view (Rossouw 2009:55).

Ic and Iph indexes

The ratios of different phytolith morphotypes, which correspond to certain grass subfamilies, can be used to determine a number of factors including environmental moisture and climatic temperature based on the ratios of C3 and C4 grasses. Various researchers (e.g. Alexandre *et al*. 1997; Bremond *et al.* 2005) have used paleoclimatic indexes, for example the Ic and Iph indexes, to establish past plant growth and environmental conditions.

One of the main factors which influences C3 and C4 plant distribution is temperature, which can be estimated by determining the Ic index. The Ic index is calculated by establishing the percentage of Pooid phytoliths relative to the sum of Pooid, Chloridoid and Panicoid phytoliths (Ic % = Pooideae / (Pooideae + Chloroidoideae + Panicoideae) (Bremond *et al*. 2008:214; Sjöström 2013:37). Research conducted by Bremond *et al.* (2008) and Barboni *et al.* (2007) suggests that an Ic value of above 60% is indicative of a cool climate, in which Pooideae are dominant, while an Ic value of below 40% suggests a warm or arid climate, in which plantgrowth is dominated by Panicoideae and Chloridoideae (Bremond *et al.* 2008; Barboni *et al.* 2007). Ic values between 40% and 60% designate a transition zone between C3 and C4 grasses (Sjöström 2013:37).

The Iph index, unlike the Ic index is not used to determine climatic temperatures, but is employed to establish environmental moisture. The Iph index is calculated by comparing the proportions of saddle phytoliths, produced by Chloridoideae, to the number of bilobates, crosses and polylobates, produced by Panicoideae (Iph % = Saddles / (Saddles+Bilobates +Crosses+Polylobates) (Bremond *et al.* 2008:214). Fredlund and Tiezen (1994) suggested that an Iph value of above 60% indicates xeric grasslands, while values lower than 45% is indicative of a mesic habitat. While Fredlund and Tiezen (1994) consider Iph values between 45 and 60 percent to be indicative of a transition from mesic to xeric climatic conditions, Sjöström (2013), however, suggested that in the absence of an Iph cut-off for Southern Africa values between 30% and 50% should be considered in the transition zone.

Conclusion

Research by Mucina and Rutherford (2006) established that grasses are abundant in the areas

where the Bokoni sites, from which soil samples were taken, are located. These sites are located in the KaNgwane Montane Grassland Biome and Northern Mistbelt Forest Biome and the phytoliths produced by species associated with these biomes would be distinct from the domesticated plants that were grown by the people of Bokoni. In the next chapter I discuss the methods I used to sample, process and analyze phytolith samples to determine which plants were cultivated at KG1 and BFK1.

CHAPTER 3 - METHODOLOGY

Introduction

A number of different phytolith sampling techniques, for example column sampling, as well as extraction and analysis methods. for example the 200 or 250 phytolith count, have been popular with phytolith analysts for the last two decades (see e.g. Horrocks 2005; Madella *et al.* 1998; Mercader *et al.* 2011). The effectiveness of these methods usually depends on a wide range of factors related to the nature of the site and the samples collected. Research questions and goals as well as the chemicals and equipment used during the extraction and analysis processes also play a role (Piperno 2006:89).

In this chapter I discuss the field sampling, extraction and analysis techniques used during this project. I also discuss the criteria I used during this project to select sites for sampling.

Site Selection

Researchers are often hampered by a range of constraints, such as time and monetary limitations, which prevent them from studying an entire area, site or collection (Tryfos 1996:4). In order to overcome these constraints a portion or sample of the material as a whole is selected to be studied. By sampling, a researcher is in effect choosing a portion of the study area to represent the entire range of information in a particular universe or population (Wells 2010:211). The sampling methods employed largely depend on the research questions asked and the project goals (Redman 1975:147).

There are two main methods that can be used to collect samples, namely non-probabilistic (judgement) sampling and probabilistic (statistical or random) sampling. Non-probabilistic sampling is the selection of sampling units based on informal criteria (Levy & Lemeshow 2008:19), for instance site size, accessibility or location (Redman 1975: 147-149). Probabilistic sampling (statistical or random), on the other hand, calls for the sampling area to be divided into smaller units which all have an equal chance of being selected (Wells 2010:211). Non-probabilistic sampling could incorporate a researcher's knowledge of the sampling area into the selection. This can result in a more informed sampling decision. The probabilistic sampling method, on the other hand, eliminates possible bias and it makes it possible to specify and calculate error rates (Redman 1975: 147-149; Shafer 2009:25-27).

The Bokoni archaeological zone consists of thousands of stonewalled settlements spread over the Mpumalanga province, which necessitated the use of sampling. Non-probabilistic sampling was used to determine which sites would be tested for phytolith analysis. Sites were chosen based on criteria such as settlement sequence, as well as location and the nature of the site.

Principally, the Bokoni settlement sequence was used to determine which sites would be chosen for sampling. As discussed in chapter 2, the Bokoni sites can be divided into four chronological phases. Phase one and two sites are located in open valleys, which were occupied during more peaceful periods in the Bokoni history, while phase three and four sites are located in more defendable areas, for example kloofs. I chose to sample two sites, KG1, a phase one site, which represents the earliest sites where terracing was built in southern Africa and BFK1, a phase three/four kloof site, which represents the terminal phase of Bokoni site occupation.

Secondly, the nature of the sites was considered. Bokoni sites comprise three key features, namely stone enclosures, or homesteads, roads and terraces. While many sites incorporate all three features, a number of sites consist only of isolated stone circles or homesteads with no roadways and terraces (Maggs 2008:173). For the purposes of this study, only settlements with agricultural terraces were considered for sampling. The two sites that were selected for sampling, namely KG1 and BFK1 were extensively surveyed on foot to determine the best section to take soil samples from.

Site conditions determined which locations on sites were chosen for phytolith sampling. Underground animal activities, soil movement due to water, invading plant roots from vegetation growing on the surface and human activities such as mining and digging disturb archaeological deposits which contaminate samples (Piperno 2006:86). Therefore, areas on sites that appeared not to have been disturbed were chosen for sampling.

Field Sampling Techniques

Two phytolith sampling techniques were considered for this project, namely column and horizontal sampling. Column samples, which are taken from exposed and profiled section walls, are usually collected after excavations have been completed. This technique assists in

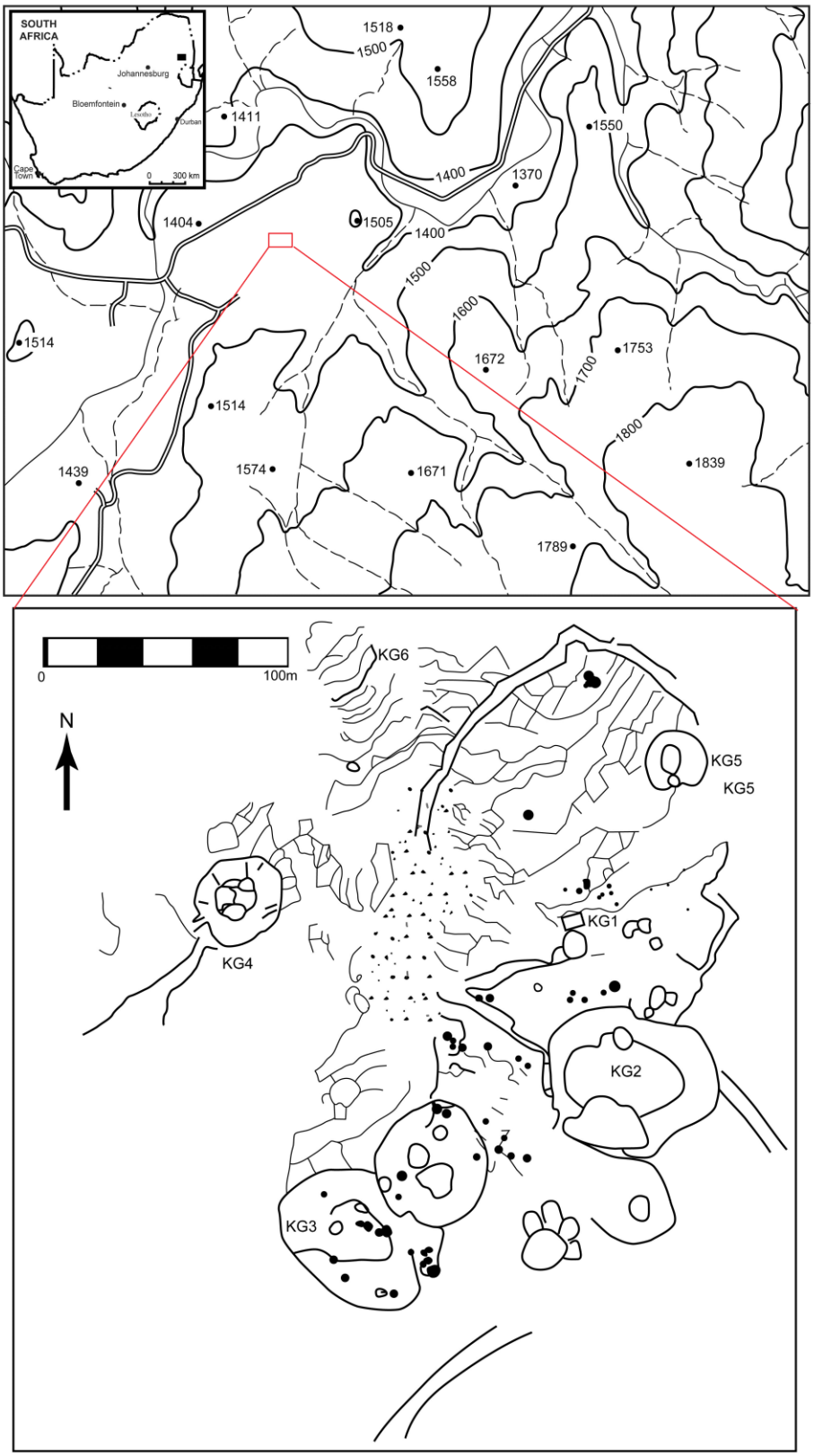


Figure 3.1. Location of KG1 test pit.

gaining an understanding of plant usage at different moments in time, as well as the average plant use at a site. These samples can also be tied into the more general site stratigraphy, which is identified through excavation. Horizontal samples, on the other hand, are taken while excavations are in progress and give a good indication of spatial usage, because it provides a sample of a particular stratigraphical area (Piperno 2006:81).

The aim of this project was to determine which crops were grown on the Bokoni terraces and whether new crops, for example *Z. mays*, were adopted. I, therefore, chose to use vertical sampling. Test pits were dug at each of the two sites chosen for sampling. The first KG1 samples were obtained from an excavation into a terrace associated with a newly established homestead at the southern end of the Komati Gorge Village. These areas formed part of a homestead, which has been excavated by archaeologists (Schoeman pers. comm. 2013) Excavations revealed the general stratigraphy and context of the site. My data would thus formed part of a larger data set.

The analysis of these samples failed, however, because the phytolith extraction procedures I used were not suitable to remove clays, and thus phytoliths were not observed on any of the microscope slides. Consequently, the site was sampled again. The original trench had been backfilled and this could have contaminated the section, therefore a new pit was excavated in homestead KG1. It was located approximately twenty meters down-slope from the original KG1 sampling location (Fig. 3.1.). Unlike the terraces at BFK1 discussed below, most of the terraces at KG1 were in good condition, and showed minimal evidence of contamination on the surface. The central section of the terrace was sampled.

At BFK1 most of the agricultural terraces were unfit for sampling due to contamination caused by plant roots and animal activities. At BFK1 the terrace chosen for sampling was located less than twenty meters down-slope of the nearest homestead (Fig. 3.2). The central portion of the terrace was excavated, because it was the only section that did not show signs of contamination and based on previous test pits dug at the site it was determined that it was the area which had the deepest soil deposits



Figure 3.2. Location of BFK1 test pit.



Figure 3.3. Test pit excavated at KG1.

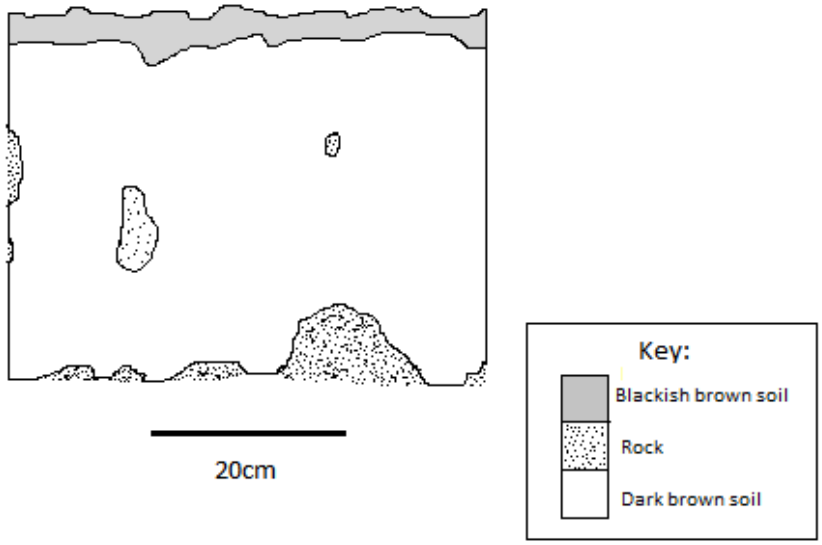


Figure 3.4. Section drawing of BFK1 test pit.

The deposit in both the KG1 and the BFK1 pits were shallow. KG1 was excavated until a layer of rocks were reached at approximately 30cm (Fig. 3.3.). The BFK1 test pit was approximately 40cm deep when a layer of rocks was reached (Fig. 3.4). Before sampling I

identified the upper and lower levels of the stratum in the test pits, and marked it with nails. I limited contamination by scraping the exposed excavation walls with a clean trowel to remove modern wind-blown phytoliths. Trowels were cleaned before taking each sample to ensure that there was no cross contamination between samples (cf. Pearsall 2000).

The surface layer of the KG1 pit contained dark brown soil (0-10cm), followed by a layer of red-brown soil (10-30cm) (Fig. 3.3). The BFK1 pit comprised two different stratigraphic layers. The first blackish brown layer started on the surface and extended approximately 5cm down. The second layer started at 5cm and continued to the bottom of the excavation at approximately 40cm (Fig.3.4). Samples were taken at ten centimetre intervals in both the KG1 and BFK1 pits. Two surface control samples were taken at each site; the first five metres from the excavated area and the second ten metres away. The control samples were collected in order to establish whether archaeological samples were contaminated with phytoliths from contemporary plant growth at the sites.

In addition to the control samples, three archaeological samples were taken at KG1 and four samples were collected from the BFK1 test pit. To avoid possible confusion, during analysis, of the samples taken from KG1 and BFK1, different coding systems were used to identify samples. An alphabetical system was used to name KG1 samples, while a numerical system was employed for BFK1, for example, 'sample A' refers to the KG1 control samples and 'sample 1 and 2' refers to the BFK1 control samples.

Each sample consisted of approximately fifty grams of soil, which had been placed in sterile plastic containers during sampling. These containers were sealed and labelled on the outside with the sample's provenance, before being placed in separate plastic bags. The samples were stored in these bags until they were processed.

Phytolith Extraction Methods

Sediment samples do not only comprise phytoliths, they also generally contain several parts, including soil particles, organic materials, and minerals, which often hamper a researcher's ability to correctly identify and quantify phytoliths. Therefore, extraction procedures are necessary before phytoliths are examined under a microscope (Piperno 2006:90).

The KG1 control samples consisted of sandy soils, which were light brown in colour. These surface samples largely comprised ash, instead of organic materials. This was due to a recent veld fire on the site. The archaeological samples collected from KG1 all consisted of dark red-brown clay soils and contained very little organic material. On the other hand, the control samples from BFK1 were a dark blackish brown and contained substantial amounts of clay particles and organic materials. The archaeological samples were also dark brown in colour, but contained less organic material and more clay particles.

The first step, in processing the samples from KG1 and BFK1, was to remove the clay particles from samples, through sedimentation. Samples were placed in test tubes, which were filled with distilled water and a solution of automatic dishwasher powder, or Calgon; shaken vigorously and left overnight to settle (cf. Horrocks 2005; Lentfer & Boyd 1999). Clay particles are 2µm or smaller (Zhoa *et al.* 1998:588) and stayed suspended in the water while phytoliths and other materials settled at the bottom of the test tube. The liquid along with the clay was decanted and the process was repeated until the water was clear (cf. Horrocks 2005; Lentfer & Boyd 1999).

The removal of the clay particles, which caused the aggregations of soils, freed the phytoliths, organic matter and minerals, which had been fused to the heavier soil particles. This made it easier to process samples and remove unwanted agents that could obscure phytoliths on microscope slides.

After the sedimentation process, samples were allowed to dry, and phytoliths were extracted using the standard laboratory techniques described by Albert *et al.* (1999). To eliminate carbonates and phosphates a 10ml solution of 3N HCl and 3N $HN0_3$ was added to a weighed aliquot (1g) of air-dried sediment for 30 minutes, before it was centrifuged at 3000 rpm for 5 minutes. After rinsing the pellet with distilled water, 30% hydrogen peroxide (H_2O_2) was added at 70^{o}C to remove organic materials. Step two was repeated for sediments with high concentrations of organic matter. The sediment was then washed, allowed to dry in an oven and weighed (cf. Albert *et al.* 1999; Bamford *et al.* 2006).

Lastly, mineral components were separated from the acid insoluble fraction (AIF) according to their densities in order to concentrate the phytolith solution. I added 5ml of sodium

polytungstate solution [$Na_6(H_2W_{12}O_{40}).H_2O$] of 2·4 g/ml density to the AIF, and centrifuged the suspension at 3000 rpm for 5 minutes. The supernatant was then transferred to another centrifuge tube; 1ml of distilled water was added and the tube was vortexed and centrifuged again. The cycle was repeated until no visible mineral particles remained in the supernatant. The heavy liquid was then diluted with distilled water to ensure that the lightest materials could be recovered (cf. Albert *et al.* 1999; Bamford *et al.* 2006).

Slides were prepared by placing approximately 1mg of the processed sample onto a microscope slide, mixing it with three to four drops of Entellan New (Merck) and placing a cover slide over the suspension (cf. Albert *et al.* 1999). Slides were allowed to dry for a week before analysis.

Phytolith Analysis

Slides were examined with an Olympus BX51 microscope at 400x and 1000x magnification under polarized light (cf. Mercader *et al.* 2009). Photographs were taken during analysis. I used a ColorView Soft Imaging System, an AxioCam ICc 1 camera, and Analysis™ software.

Diagnostic scanning was carried out during analysis. A diagnostic scan is defined as a scanning procedure where all phytoliths, identifiable at a species, genus, subfamily or family level, are identified on a slide and counted to a predetermined number (Pearsall 2000:454), in this case 200. A 200 particle count was used for this project, because it gives an accurate representation of common taxa and because little variation in percentages occurs with sums beyond 200 making this an effective and time saving method (cf. Piperno 2006:115).

Scanning was conducted in a linear manner, and slides were scanned from top to bottom. Many plants, for example those belonging to the Poaceae family, produce a whole suite of phytoliths (Carnelli *et al* 2002:346) which can result in an over representation of certain taxa (Piperno 2006:118). Therefore, only grass short cells were counted to represent grasses and highly redundant forms, such as grass epidermal cells, were not included in the count (cf. Rossouw 2009). Unknown forms were recorded in the hopes that they could be identified at a later stage.

Several descriptive terms were used to describe the abundance of phytoliths encountered. The terms 'rare' and 'low numbers' were used for phytoliths that represented less than ten percent of the sample, while phrases such as 'moderate numbers' or 'common' were employed to portray phytoliths numbers that contributed between ten and twenty-five percent of the overall phytolith tally. 'Abundant' was used to describe phytolith numbers between twenty-five and fifty percent. The term 'dominant' was employed when more than fifty percent of the sample consisted of a particular type of phytolith.

In order to correctly identify grass phytoliths, I used comparative reference material. Comparative collections can consist of photographs, drawings, descriptions of form as well as keys and expert systems. The type of reference material required is usually determined by the purposes of the study. Photographs, drawings and descriptions of form are, for example, important when establishing whether certain plants are present or absent in a sample, while keys or expert systems are of vital importance when the purpose of a study is quantification (Pearsall 2000:446).

The first step was to establish which plants might be encountered during the course of this research project, as well as if any comparative collections were available. Several reference collections have already been established for southern African plants. Rossouw (2009), for example, developed a standardized model for interpreting grass silica short cell (GSSC) phytolith assemblages, which resulted in a reference collection, consisting of photographic material and descriptions of form for the majority of indigenous grasses growing in the Mpumalanga province, including two types of Sorghum. I used this material, in combination with reference material from the Bernard Price Institute (BPI) collection, and Pearsall's (2000) descriptions and drawings of bilobate and cross shaped phytolith variations to identify grass phytoliths. I also drew on the identification systems available for non-indigenous domesticated plants including maize and sunflowers (e.g. Piperno 2006) to establish if *Z. mays* was present.

These collections, however, did not contain readily accessible photographic data, or descriptions of many African domesticated plants. The obvious exception being the inclusion of, for example *S. bicolor* in Rossouw (2009). Consequently, I created a modern reference collection for a few key domesticated plants. These were *E. coracana*, *P. glaucum*, and *V.*

unguiculata. In order to create the comparative samples, I obtained seeds and grew the plants in Johannesburg. Once the plants had matured, I collected approximately 200g of each modern plant and sorted it into leaves, stems and inflorescences.

There are two main ways to extract phytoliths from plant remains, namely dry-ashing and wet oxidation. Dry-ashing was used for this project, because while it is more time consuming than wet oxidation, it does not require the use of hazardous chemicals or a fume hood (cf. Piperno 2006:97) and, as shown by Parr *et al.* (2001), it leaves less residual plant material than other methods of plant processing.

Plant remains were rinsed with distilled water to remove soil and limit contamination, before being placed in crucibles and burned at 500 degrees Celsius for six hours. Care was taken to ensure that the temperatures did not exceed 500 degrees (cf. Parr *et al.* 2001), because phytolith morphological changes start to occur when temperatures approach 600˚C (Piperno 2006: 97). Phytoliths were extracted from the ash using the extraction methods described above and were mounted onto slides.

For the purposes of this study a morphological analysis was performed, rather than a morphometric analysis, because during a morphological analysis the form and structure of phytoliths are determined, while during a morphometric analysis focus is put onto the external measurements of a phytolith. While phytolith dimensions are important little research has focussed on the size of the phytoliths created by indigenous southern African plants, thus it would not be possible to distinguish between the phytoliths of African domesticates and non-domesticated plants based solely on size.

After analysis, the slides they were placed in microscope slide storage cases and archived in the collections room of the Archaeology division of the School of Geography, Archaeology and Environmental Studies.

Calculation of Ic and Iph Idexes

As discussed in Chapter two, Ic and Iph indexes are proxies used to establish past temperatures and moisture levels. Consequently, to establish the environmental conditions that prevailed at KG1 and BFK1 at the time of occupation, I calculated the Ic and Iph indexes

using the phytoliths identified during my analysis. The Ic and Iph indexes were determined using the formulas mentioned in chapter two.

Numerous studies (e.g. Alexandre *et al*. 1997; Fredlund & Tiezen 1997) have employed Ic and Iph indexes and have noted that they are good proxies for past climatic conditions. Bremond *et al.* (2008), however, noted that while Ic and Iph indexes are widely used several factors may influence their accuracy. For example, grass subfamilies, such as Arundinoideae and Bambusoideae, can produce phytoliths associated with Panicoideae and Chloridoideae, which can skew results. Phytolith transportation via wind and water can also lead to an over representation of certain taxa which can influence the Ic and Iph values calculated for a site (Bremond *et al.* 2008:220-221). These factors were all taken into consideration during my analysis, and therefore I only used Ic and Iph values as proxies for regional temperature and moisture levels rather than indicators of local climatic conditions.

Conclusion

There are numerous ways to collect, extract, prepare, analyse and interpret phytoliths. The methods used during this project were specifically chosen in order to determine what plants were growing on terraced areas in Bokoni. In order to correctly identify the phytolith assemblages from KG1 and BFK1, I needed a comprehensive understanding of phytolith morphology and taxonomy. It was, however, not enough to simply know the variations of phytolith shapes and to what taxa they are related. Reference material was needed to correctly identify species. Rossouw's (2009) photographic data and BPI reference material, among others, aided in the identification of domesticated plants and other plants common in the site's area. In addition, reference material was created for domesticated plants for which reference material could not be accessed easily.

CHAPTER 4 - RESULTS

Introduction

The plants cultivated by LFCs (Later Farming Communities), were discussed in Chapter two. These included *E. coracana, P. glaucum, S. bicolor, V. unguiculata* ('cowpeas') and *Z. mays*. It is possible that the people of Bokoni cultivated one or several of these plants on the terraces.

Z. mays phytoliths have been the subject of numerous studies (cf. Pearsall 1978, Piperno 1984), and a substantial amount of comparative material exists. In contrast, very little research has been done on the phytoliths produced by the southern African cultivars. Consequently, I set out to create a reference collection for the crops I was likely to encounter in the Bokoni soils. The first part of this chapter is devoted to discussing key characteristics of domesticate phytoliths in the comparative collections. I then describe the types of phytoliths observed in these domesticated plants. These descriptions were used in the analysis of the soil samples taken from agricultural terraces at KG1 and BFK1. In the second part of this chapter I present the results of this on control and archaeological samples. In the third part I link the phytoliths encountered during analysis to the grass subfamilies that they represent. In the final part I discuss Ic and Iph indexes.

Comparative Collection

The methodology used to create the comparative collection for this project was discussed in chapter three. The phytoliths observed in each domesticated plant sample are described in this section with the aid of photographic material taken during my analysis and reference material already available for *S. bicolor* and *Z. mays*. Short descriptions of the phytliths produced by grasses closely related to the Poaceae domesticates, investigated during this project, are also given.

Eleusine coracana

E. coracana is a member of the Poaceae (grass) family, which creates a whole suit of phytoliths; the most diagnostic of these being epidermal short cells (Carnelli *et al*. 2002:346). As discussed in chapter two specific phytolith shapes correspond to certain grass subfamilies.

E. coracana is a Chloridoid grass (Rossouw 2009:141) which, along with closely related grasses such as *Eleusine indica*, mainly creates saddle shaped phytoliths (Twiss *et al.* 1969:111).

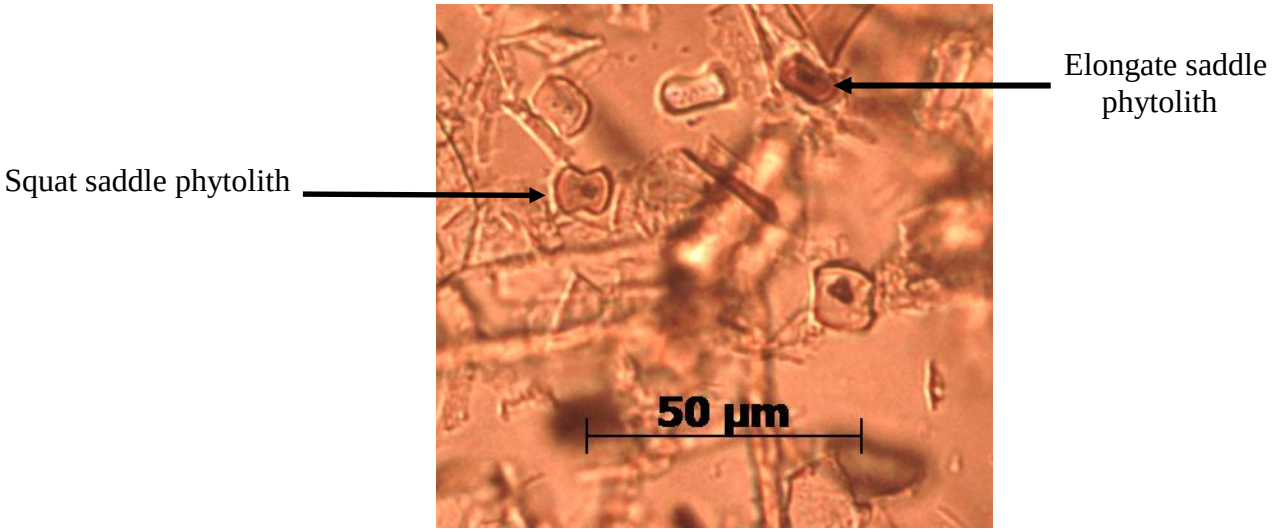


Figure 4.1. Squat and elongated saddle phytoliths from *E. coracana*.

Squat and elongated saddle phytoliths (Fig. 4.1) were present in *E. coracana* leaves, stems and roots. *E. coracana* produces two types of squat saddles. The first type (Fig. 4.2) is symmetrical in the planar view with convex anterior and posterior margins as well as concave lateral margins. It is also symmetrical in the side view. The second type (Fig. 4.3) is asymmetrical in the planar view with convex anterior/posterior edges, concave lateral margins and rounded corners. The depth of the concave indentation at the two lateral edges differs, while the curvature of the anterior and posterior surfaces varies from each other. In side view the base, plateau and lateral edges are concave, but the depth and shape of the inward curves are not symmetrical (Fig. 4.4).

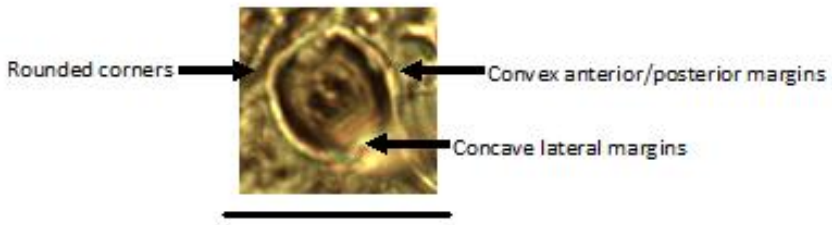


Figure 4.2. Squat saddle phytolith from *E. coracana*.

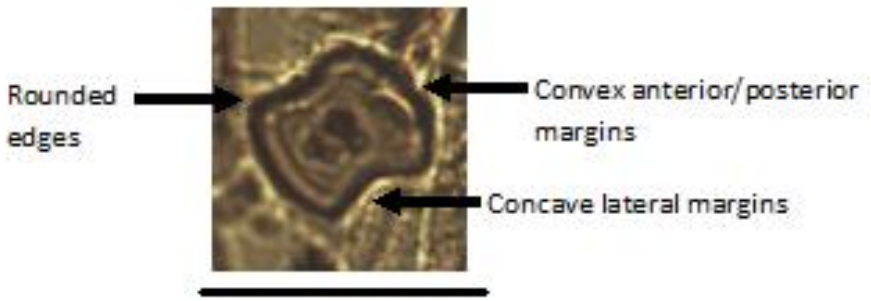


Figure 4.3. Planar view of asymmetrical, squat saddle phytolith from *E. coracana*.

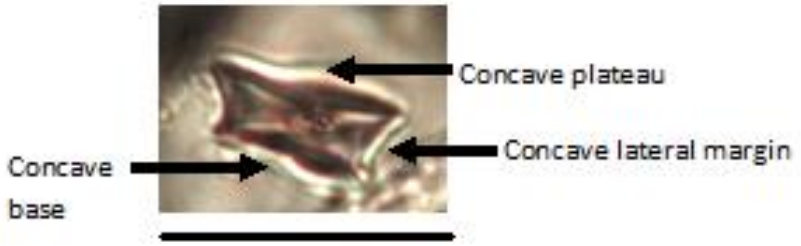


Figure 4.4. Side view of asymmetrical saddle phytolith from *E. coracana*.

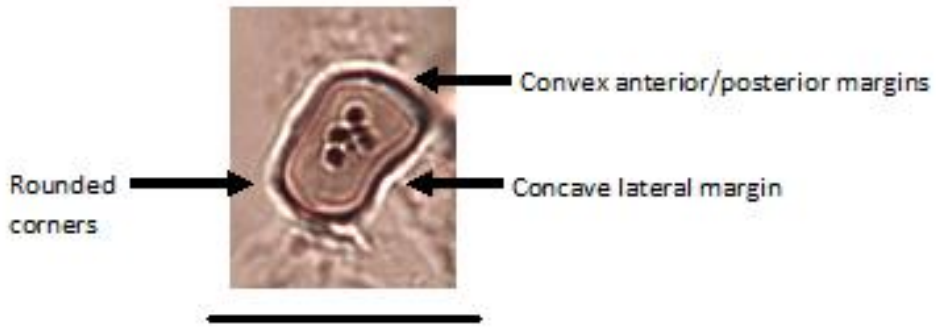


Figure 4.5. Planar view of an elongated saddle phytolith from *E. coracana*.

The elongated saddle phytoliths produced by *E. coracana* have rounded corners, asymmetrical convex anterior and posterior margins as well as concave lateral margins. The saddle phytoliths found do not exceed 20µm, but are on average larger than 10µm (Fig. 4.5).

While saddle phytoliths form the bulk of the epidermal short cell phytoliths found in *E. coracana*, a small percentage (less than 1% of the total sample) of bilobates were also

identified. These correspond to variant one bilobates described in Rossouw (2009:47), which have elongated shanks with a length greater than a third of the total body length and ovate lobes with convex outer margins. The length of the bilobate body exceeded 20µm (Fig. 4.6).

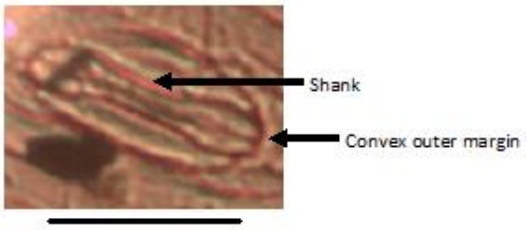


Figure 4.6. Planar view of bilobate phytolith from *E. coracana*.

E. coracana and E. indica are closely related and some of the phytoliths they create are similar in appearance. Jattisha and Sabu (2012) documented the phytoliths produced by *E. indica* which include bilobate (Fig. 4.7) as well as saddle phytoliths (Fig. 4.8). The saddle phytoliths created by *E. indica*, at frist glance, closely resemble those produced by *E.coracana*. There are, however, slight differences in the curvature of the anterior and posterior margins of the elongated saddle phytoliths. *E. coracana* saddles are more flattened at the margins. The bilobate phytoliths generated by the two grasses differ remekadly. While *E.coracana* creates variant one bilobates, *E. indica* bilobates fall into the variant two category because of their short shanks. *E.indica* bilobates also have concave outer margins unlike *E.coracana* bilobates (Jattisha & Sabu 2012:6).



Figure 4.7. Planar view of bilobate phytolith from *E.indica* (Jattisha & Sabu 2012:6).



Figure 4.8. Planar view of saddle phytolith from *E. indica* (Jattisha & Sabu 2012:6).

Pennisetum glaucum

P. glaucum belongs to the Panicoideae subfamily which produces cross and bilobate shaped phytoliths (Twiss *et al.* 1969:111), both of which were abundant in the sample analysed. *P. glaucum* phytoliths correspond to variant two bilobates described by Rossouw (2009:47).

In the planar view the length of the bilobate shank is smaller than a third of the total length of the phytolith body. The lobes can be symmetrical or asymmetrical to each other and have concave outer margins. In side view the phytolith appears trapezoidal. In terms of size, the bilobates measured to approximately 20µm (Fig. 4.9).

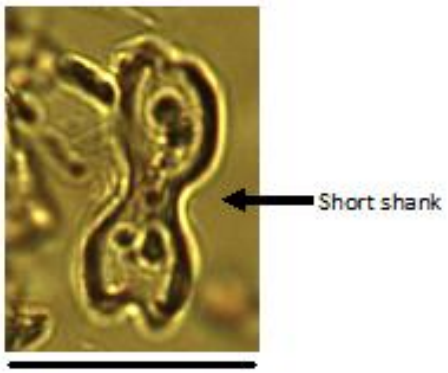


Figure 4.9. Planar view of bilobate variant 2 from *P. glaucum*.

Variant 5/6 cross phytoliths were present in similar numbers to the bilobate phytoliths. Variant 5/6 phytoliths are cross shaped in planar view with a square body visible within the cross (cf. Pearsall 2000:387-388). The lobes of the crosses observed in *P. glaucum* were asymmetrical in shape and the size of the phytolith varied (Fig. 4.10). Epidermal long cells and bulliform phytoliths were also present in the sample.

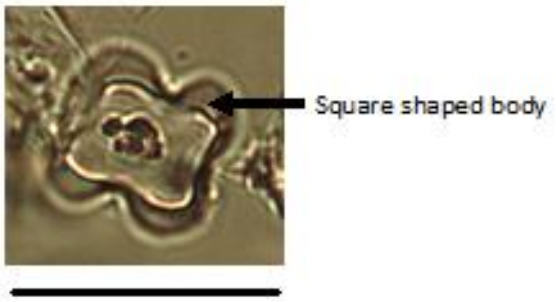


Figure 4.10. Planar view of variant 5/6 cross shaped phytolith from *P. glaucum*.

Cenchrus ciliaris (buffelgrass) is a grass closely related to *P. glaucum* and also creates bilobate phytoliths. While *C. ciliaris* bilobates fall into the variant two category they are markedly different from the bilobates observed in *P. glaucum*. *C. ciliaris* bilobates have convex outer margins (Fig. 4.11), unlike *P. glaucum* bilobates which are concave. *C.ciliaris* and *P. glaucum* phytoliths are similar in size (Rossouw 2009:157).

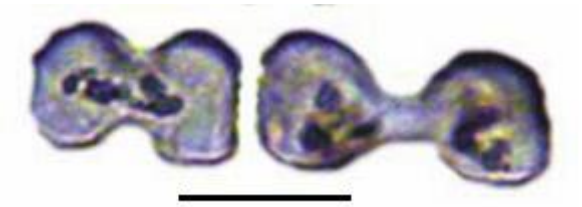


Figure 4.11. Phytoliths produced by *Cenchrus ciliaris* (Rossouw 2009:157).

Sorghum bicolor

Unlike *P. glaucum*, for which reference material was unavailable, *S. bicolor* phytoliths have been photographed and documented by Rossouw (2009). *S. bicolor* produces several types of bilobate phytoliths including variant two bilobates with relatively short central portions and ovate lobes with convex margins (Fig. 4.12). In some instances the outward edges have a bifid with acute protrusions (Fig. 4.13). In side view the phytoliths appear trapezoidal or tabular (Rossouw 2009:154). Ninety-seven percent of the phytoliths produced by *S. bicolor* are bilobates. The other three percent is composed of polylobates (Rossouw 2009:217), which are asymmetrical in the planar view with an extra lobe located on a relatively short, but well defined shank (Fig. 4.14). In side view the polylobate phytoliths also appear tabular. The phytoliths produced by *S. bicolor* are approximately 20µm in size (Rossouw 2009:154).



Figure 4.12. Planar view of a *S. bicolor* bilobate (after Rossouw 2009:154).

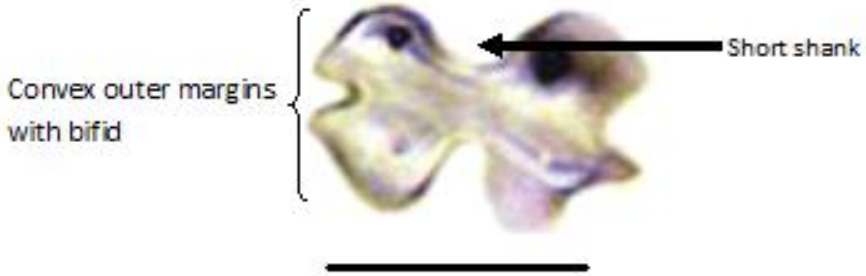


Figure 4.13. Planar view of variant 2 bilobate from *S. bicolor* (after Rossouw 2009:154).

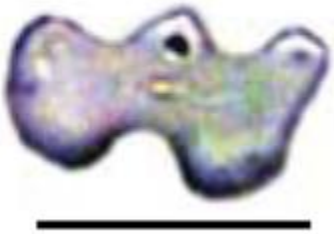


Figure 4.14. Planar view of variant 3 bilobate from *S. bicolor* (after Rossouw 2009:154).

Grasses closely related to *S. bicolor* include, among others, *S. versicolor* and *S. caffrorum* and these also produce bilobate phytoliths (Fig. 4.15-Fig. 4.16). *S. caffrorum* phytoliths, similar to *S. bicolor* bilobates are category two bilobates, but the shape and size of the lobes of *S. caffrorum* bilobates varies greatly from those created by *S.bicolor* and almost resembles cross phytoliths (Fig. 4.15). Another bilobate produced by *S. caffrorum* (Fig. 4.16) has convex outer margins with bifids, however it does not look similar to any of the phytoliths observed during analysis of *S. bicolor* phytoliths.



Figure 4. 15. Planar view of a *S. caffrorum* bilobate (after Rossouw 2009:154).

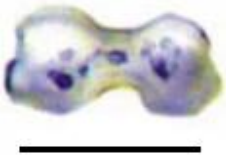


Figure 4.16. Planar view of a *S. caffrorum* bilobate (after Rossouw 2009:154).

S. versicolor creates an abundance of polylobate phytoliths as well as variant two bilobates which have concave outer margins (Fig.4.17). The bilobates produced by *S. vesicolor* do not resemble *S. bicolor* phytoliths.



Figure 4.17. Planar view of a *S. versicolor* bilobate (after Rossouw 2009:203).

Vigna unguiculata

In contrast to plants which belong to the Poaceae family, *V. unguiculata* (Fabaceae) does not create easily identifiable epidermal short cell phytoliths. It does, however, create a wide variety of other phytoliths including stomata, trichome bases, vascular cell phytoliths and epidermal phytoliths. These phytoliths were observed in the leaves, stems and roots.

The *V. unguiculata* stomata phytoliths produced in the leaves are irregular in shape. The size of the guard cells usually vary, but are most commonly articulated in such a way that the stoma are open (Fig. 4.18). The outer margins of the guard cells are sinute and epidermal cells may still be articulated to them. *V. unguiculata* stomata phytoliths are larger than 20μm in size.

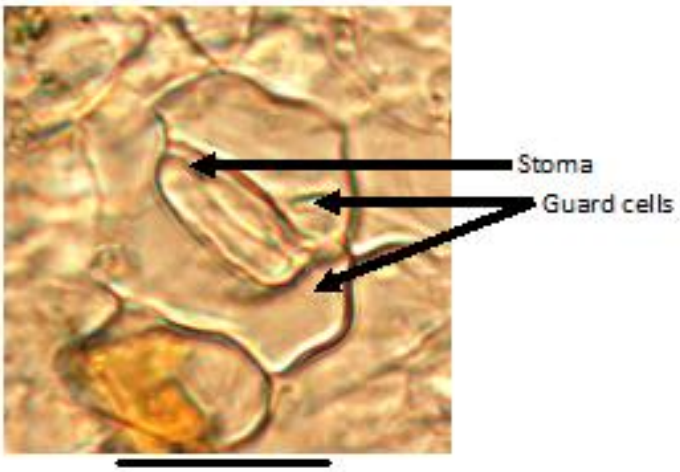


Figure 4.18. Stomata from *V. unguiculata* leaves.

The trichome bases observed in *V. unguiculata* leaves are, like the stomata, larger than 20µm. The centre of the trichome base is orbicular or ovate in shape, while the outer layer of the phytolith is segmented. Each segment is trapezoidal in shape with acute processes where the segments are articulated. Bulbous processes can also be found in the centre of the outer margins of the segments (Fig. 4.19).

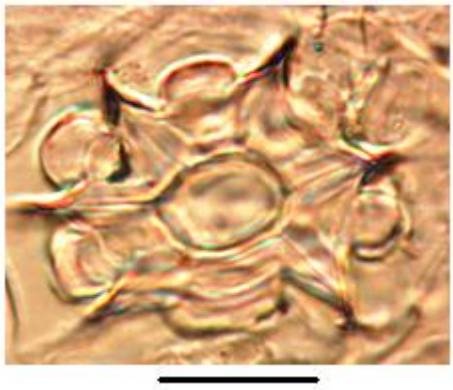


Figure 4.19. Trichome base from *V. unguiculata* leaves.

The remainder of the phytoliths found in the sample, namely vascular cell and epidermal phytoliths were irregular in shape and size and could not be used to identify *V. unguiculata* in the archaeological samples.

Zea mays

Identification systems have been established for *Z. mays* (cf. Pearsall 2000; Piperno 2006) and both morphological and size attributes are included in these systems. Cross shaped phytoliths are common in *Z. mays* leaves (Piperno 1984:362), but they are not the only phytoliths created. Rondel phytoliths are produced in *Z. mays* cobs and fruit cases and these, similar to the cross phytoliths, can be used to distinguish between *Z. mays* and other grass species (Piperno 2006:60-61).

Z. mays creates mostly variant one crosses. Cross shaped phytolith can be viewed from four different angles. In the two side views the cross phytolith appear trapezoidal or rectangular in shape. These views are rare, however, because cross phytoliths mostly lie with their dorsal or ventral sides facing upwards. In all cross shaped phytoliths, except variant one, the dorsal and ventral views of the phytolith differ remarkably. In variant one crosses the dorsal and ventral views are mirror images of each other (Piperno 1984:368), thus when the ventral surface is being observed, the dorsal surface is visible and in appearance resembles a smaller cross within a cross (Pearsall 2000: 387) (Fig. 4.20).

In terms of size Pearsall (1978) showed that there is a difference between *Z. mays* phytoliths and the phytoliths created by other Panicoid grasses. She divided cross phytoliths into four size categories, namely small (6.87-11.4μm), medium (11.45-15.98μm), large (16.03-20.56μm), and extra large (20.61-25.19μm) and determined that *Z. mays* creates a significant number of large and extra large phytolith, while wild Panicoid grasses rarely create phytoliths of those sizes.

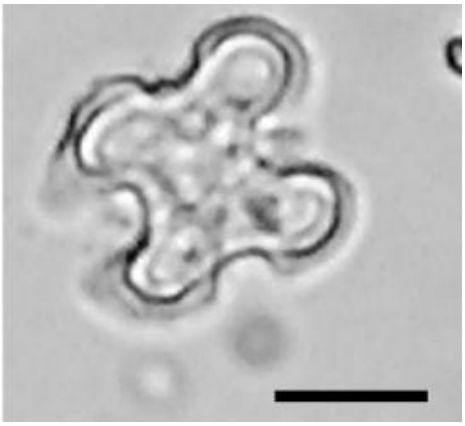


Figure 4.20. Large variant 1 cross shaped phytolith from *Z. Mays* (after Iriarte 2004:617).

The size of rondel phytoliths is less important than that of crosses, because morphological characteristics are usually enough to distinguish between the rondels produced by *Z. mays* and the rondels created by wild Panicoid grasses (Piperno 2006: 64).

Z. mays rondels have two orbicular or ovate faces which are connected by a shank that can be seen in the side view. This shank may vary in length and width (Piperno 2006: 64). *Z. mays* rondels are often referred to as "wavy-top rondels" (Pearsall *et al.* 2003:613), because the outer margins of the phytolith are sinute with three or four indentations (Fig. 4.21).

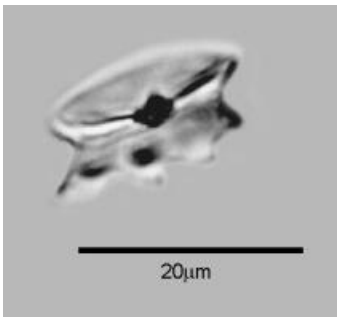


Figure 4.21. Ruffle-top rondel from *Z. Mays* (after Piperno 2006:204).

In addition to crosses and rondels, *Z. mays* also create a number of undiagnostic phytoliths including epidermal long cells, bulliform cells and vascular cells.

Phytoliths in Bokoni Soils

Phytoliths were extracted from each of the samples taken at KG1 and BFK1 and were mounted onto microscope slides. Two slides of processed surface material and two slides of subsurface material were analysed, while three slides of each archaeological sample were analysed. Because the weight of the sample was not taken after processing it was not possible to quantify the phytolith numbers. I did, however, calculate the average number of each phytolith type encountered in each sample. The calculated averages were used as the basis for the description of phytoliths encountered in each of the samples analysed. These findings are illustrated in diagrams showing each site's phytolith distribution.

In this part I present the results of the phytolith analysis of each soil sample by site, in the order that I analysed them. The control samples were analysed first in order to establish a modern baseline. This assisted in assessing whether the archaeological samples were

contaminated, and thus they are presented first.

Komati Gorge Homestead 1

Control samples: Sample A

Two control samples; a surface and subsurface sample were taken during the excavations at KG1. The surface sample was taken ten meters away from the excavated area, while the subsurface sample was taken five meters from the section that was sampled.

A veld fire that took place on the site prior to sampling resulted in the presence of burnt plant material, which can obscures or damage phytolith. It, thus, was not a surprise that burnt and disarticulated phytoliths were common, as were broken/damaged phytoliths. It is difficult to correctly identify damaged phytoliths, thus only intact phytoliths were identified and counted.

Bilobate short[2] cell phytoliths dominated the surface sample and comprised seventy percent (140 phytoliths) of the the total number of phytoliths. Variant one, two and three bilobates were all abundant. Other phytoliths such as saddle short cells were also present in the sample, but at lower percentages. Only 14% (28 phytoliths) of the phytoliths encountered were saddles, while 5.5% (11 phytoliths) were trapezoid shaped. Oblong, reniform and rondel phytoliths each contributed 2% (4 phytoliths) to the total phytolith count. Polylobate, cross, rectangle, hair and square epidermal short cells were rare and three (1.5%) or less phytoliths were encountered on average (Table 4.1; Fig. 4.22; Appendix A).

[2] See chapter 2 (background) for definitions of morphotypes, and an identification key.

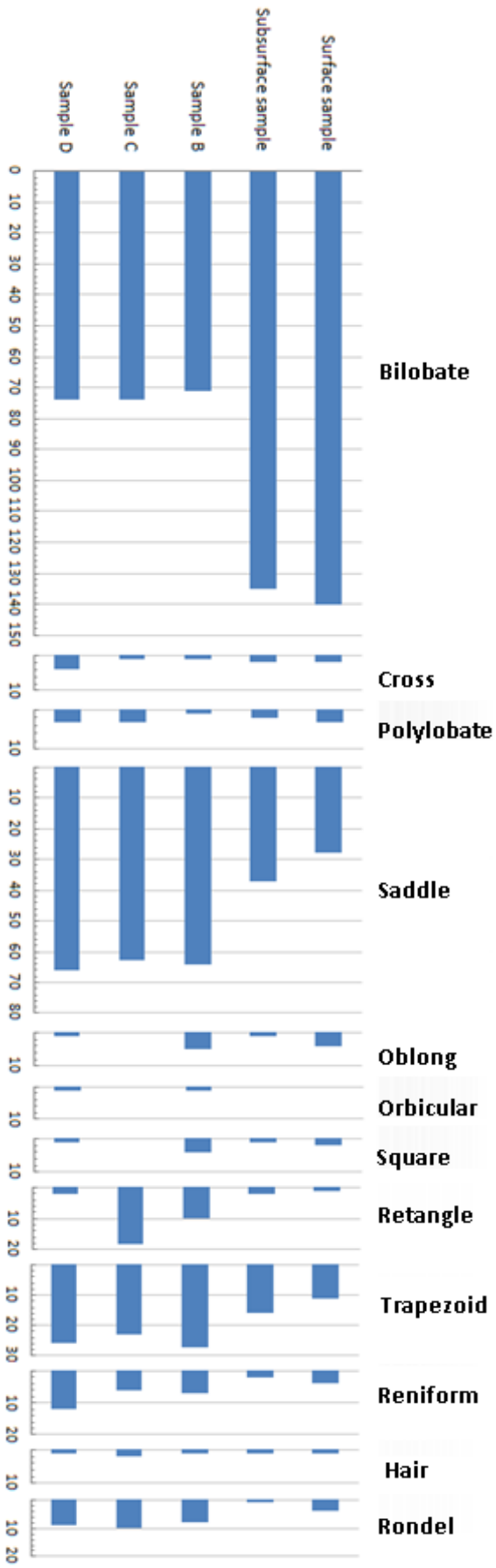


Figure 4.22. The phytolith count of the samples taken at the test pit excavated at KG1.

Table 4.1.Number of phytoliths counted in surface samples.

Phytolith morpohotypes	**A14.1**	**A14.2**	**Average**	**Percentage of sample**
Bilobate	138	141	140	70
Trapezoid	10	13	11	5.5
Square	2	3	2	1
Hair	2	0	1	0.5
Rondel	7	1	4	2
Saddle	26	30	28	14
Rectangle	1	1	1	0.5
Cross	1	4	2	1
Orbicular	0	0	0	0
Polylobate	2	4	3	1.5
Reniform	5	2	4	2
Oblong	6	1	4	2
	200	200	200	100

There was a smaller amount of burnt plant material in the subsurface control sample than in the surface sample, which made the identification of phytoliths easier. The subsurface sample showed similar phytolith distribution patterns to the control sample. Sixty-seven and a half percent (135 phytoliths) of the phytoliths encountered in the subsurface sample were bilobate short cells, while only 18.5% (37 phytoliths) were saddle shaped and 8% (16 phytoliths) were trapezoid phytoliths. Rectangle, cross, polylobate and reniform short cells each contributed one percent (2 phytoliths) of the total phytolith count. Square, hair, rondel and oblong shaped phytoliths were rare and one phytolith (0.5%) of each was encountered during analysis (Table 4.2; Fig. 4.22; Appendix A).

Table 4.2. Subsurface sample's phytolith count.

Phytolith morpohotypes	A15.1	A15.2	Average	Percentage of sample
Bilobate	142	127	135	67.5
Trapezoid	13	18	16	8
Square	2	0	1	0.5
Hair	1	1	1	0.5
Rondel	3	0	1	0.5
Saddle	25	48	37	18.5
Rectangle	3	2	2	1
Cross	3	2	2	1
Orbicular	0	0	0	0
Polylobate	5	0	2	1
Reniform	2	2	2	1
Oblong	1	0	1	0.5
	200	200	200	100

Archaeological soil samples: Sample B

Sample B, which was taken at 5 centimetres below the surface, was taken from the archaeological deposit on a terraced area at KG1. Three slides containing processed material were analysed and similar to the control samples, the bulk of the phytoliths encountered were bilobate short cells. The number of each phytolith morphotype encountered in the control samples and sample B varied greatly. It should be noted that fewer bilobates occurred in sample B than in the control samples, while a higher number of saddle and trapezoid shaped phytoliths were counted.

In sample B the two dominant phytolith types were saddle and bilobate phytoliths. Seventy one (35.5%) of the phytoliths were bilobates and 32% (64 phytoliths) of the total number were saddles. The number of trapezoid phytoliths in sample B increased to 13.5% (27 phytoliths). An increase in the quantity of rectangle, rondel and reniform phytoliths were also noted. Five percent (10 phytoliths) of the sample was rectangular phytoliths, 4% (8 phytoliths) were rondel shaped and 3.5% (7 phytoliths) were reniforms. Two and a half percent (5) of the phytoliths counted were oblong shaped and two percent (4 phytoliths)

were square. Similar to the control samples, hair, cross, orbicular and polylobate phytoliths were rare and only one (0.5%) of each were found (Table 4.3; Fig. 4.22; Appendix A).

Table 4.3. Sample B phytolith count.

Phytolith morpohotypes	**B13.1**	**B13.2**	**B13.3**	**Average**	**Percentage of sample**
Bilobate	65	71	75	71	35.5
Trapezoid	23	29	30	27	13.5
Square	0	5	6	4	2
Hair	1	1	0	1	0.5
Rondel	6	14	4	8	4
Saddle	78	59	56	64	32
Rectangle	7	4	19	10	5
Cross	2	1	1	1	0.5
Orbicular	0	3	1	1	0.5
Polylobate	2	1	1	1	0.5
Reniform	12	5	2	7	3.5
Oblong	4	7	5	5	2.5
	200	200	200	200	100

Archaeological soil samples: Sample C

Sample C was taken 15cm below the surface and ten centimetres below sample B. In sample C the number of phytoliths counted per phytolith shape was similar to those of sample B. Bilobate short cells were the most abundant, and 37% (74 phytoliths) of the sample consisted of them. Thirty-one and a half percent (63 phytoliths) of the phytoliths encountered were saddles, 11.5% (23 phytoliths) were trapezoid shaped and 9 percent (18 phytoliths) were rectangular. The rest of the sample contained 1% (2 phytoliths) hair phytoliths, 5% (10 phytoliths) rondels, 3% (6 phytoliths) reniform phytoliths and 1.5% (3 phytoliths) polylobate short cells. Cross shaped phytoliths were very rare and only 1 (0.5%) was encountered (Table 4.4; Fig. 4.22; Appendix A).

Table 4.4. Sample C phytolith count.

Phytolith morpohotypes	**C2.1**	**C2.2**	**C2.3**	**Average**	**Percentage of sample**
Bilobate	59	81	82	74	37
Trapezoid	28	16	25	23	11.5
Square	0	0	0	0	0
Hair	2	2	3	2	1
Rondel	13	15	2	10	5
Saddle	63	55	70	63	31.5
Rectangle	20	23	10	18	9
Cross	2	0	2	1	0.5
Orbicular	0	0	0	0	0
Polylobate	4	3	1	3	1.5
Reniform	9	5	5	6	3
Oblong	0	0	0	0	0
	200	200	200	200	100

Archaeological soil samples: Sample D

Sample D was taken ten centimetres below sample C, at 25cm below the surface and was the lowest sample taken from the test pit. The number of phytoliths found per phytolith shape was similar to samples B and C. Thirty seven percent (74 phytoliths) of the phytoliths encountered were bilobates and 33% (66 phytoliths) were saddles. The sample also contained 26 (13%) trapezoid phytoliths, 12 (6%) reniform short cells and 9 (4.5%) rondels. Oblong, polylobate, orbicular, cross, rectangle, hair and square shaped phytoliths were rare. Four (2%) crosses, three (1.5 %) polylobates and 2 (1%) rectangle phytoliths were counted. Square, hair, orbicular and oblong phytoliths each contributed one (0.5%) phytolith to sample D's overall phytolith assemblage (Table 4.5; Fig. 4.22; Appendix A).

Table 4.5. Sample D phytolith count.

Phytolith morpohotypes	D3.1	D3.2	D3.3	Average	Percentage of sample
Bilobate	73	69	78	74	37
Trapezoid	26	23	27	26	13
Square	0	0	4	1	0.5
Hair	1	1	2	1	0.5
Rondel	11	9	7	9	4.5
Saddle	65	65	68	66	33
Rectangle	0	4	2	2	1
Cross	3	7	2	4	2
Orbicular	0	1	3	1	0.5
Polylobate	5	2	4	3	1.5
Reniform	16	15	3	12	6
Oblong	0	4	0	1	0.5
	200	200	200	200	100

Buffelskloof Private Nature Reserve

Control samples: Sample 1

Two control samples were taken on a terrace at BFK1. The first control sample, a surface sample was taken ten meters away from the excavated area, and the subsurface control sample was taken five meters from the sampled area.

In the surface sample trapezoid and saddle shaped phytoliths were the most common phytoliths found. Twenty-five and a half percent (51 phytoliths) of the sample consisted of trapezoid phytoliths. The same number of saddle phytoliths was encountered. Eighteen and a half percent (37 phytoliths) of the phytoliths in the surface sample were bilobate short cells, 12% (24 phytoliths) were rondels and 5.5% (11 phytoliths) were oblong. Reniform, hair and square phytoliths were not common. Four and a half percent (9 phytoliths) of the sample consisted of squares, 3% (6 phytoliths) were hair phytoliths and 4% (8 phytoliths) were reniform. Polylobate, orbicular and cross shaped phytoliths were rare and only one (0.5%) of each were found (Table 4.6; Fig. 4.23; Appendix B).

Table 4.6. Surface sample phytolith count.

Phytolith morpohotypes	1.1.1	1.1.2	Average	Percentage of sample
Bilobate	37	37	37	18.5
Trapezoid	46	56	51	25.5
Square	10	8	9	4.5
Hair	6	6	6	3
Rondel	24	24	24	12
Saddle	51	50	51	25.5
Cross	2	0	1	0.5
Orbicular	2	1	1	0.5
Polylobate	3	0	1	0.5
Reniform	6	10	8	4
Oblong	13	8	11	5.5
	200	200	200	10

The subsurface sample contained more saddle phytoliths than the surface sample. Thirty-four percent (68 phytoliths) of the sample's phytoliths were saddles. The number of bilobate and trapezoid phytoliths found in the subsurface sample was similar to those in the surface sample. Sixteen percent (32 phytoliths) of the sample consisted of bilobate short cells and 27.5% (55 phytoliths) of the phytoliths found were trapezoid shaped. Seven percent (14) of the phytoliths encountered were oblong shaped, 6.5% (13 phytoliths) were rondel, 4% (8 phytoliths) were reniform and 2.5% (5 phytoliths) were square shaped. Polylobate, orbicular, cross and hair phytoliths were rare; one percent (2 phytoliths) of the sample consisted of polylobate phytoliths, while only one of each of the other shapes was found (Table 4.7; Fig. 4.23; Appendix B).

The control samples taken at BFK1 contained a substantial amount of organic matter, however, while the remains from trees, grasses and other plants were visible in the samples, only grass epidermal phytoliths were encountered during analysis.

Table 4.7. Phytolith count from the subsurface sample.

Phytolith morpohotypes	**1.2.1**	**1.2.2**	**Average**	**Percentage of sample**
Bilobate	30	35	32	16
Trapezoid	56	53	55	27.5
Square	6	4	5	2.5
Hair	2	0	1	0.5
Rondel	12	15	13	6.5
Saddle	70	66	68	34
Cross	1	0	1	0.5
Orbicular	0	3	1	0.5
Polylobate	2	2	2	1
Reniform	8	7	8	4
Oblong	13	15	14	7
	200	200	200	100

Archaeological soil samples: Sample 2

Sample two was collected from the test pit excavated in archaeological deposit on a terrace. The sample was taken ten centimetres below the surface. The number of phytoliths found per short cell shape differed markedly from those in the surface and subsurface samples.

While the number of saddle phytoliths identified in this sample was similar to those found in the control samples, the number of trapezoid phytoliths present was substantially lower and the bilobate quantities was more than those found in the control samples. Forty-three and a half percent (87 phytoliths) of the sample's phytoliths were bilobate short cells, 12% (24 phytoliths) were trapezoid shaped and 32% (64 phytoliths) were saddles. Reniform and rondel phytoliths were not abundant. Four percent (8) of the phytoliths encountered were reniform, 4.5% (9 phytoliths) were rondel shaped, 1.5% (3 phytoliths) was polylobate and 1% (2 phytoliths) was crosses. The sample contained one square, one hair and one oblong phytolith (less than one percent of the sample) (Table 4.8; Fig. 4.23; Appendix B).

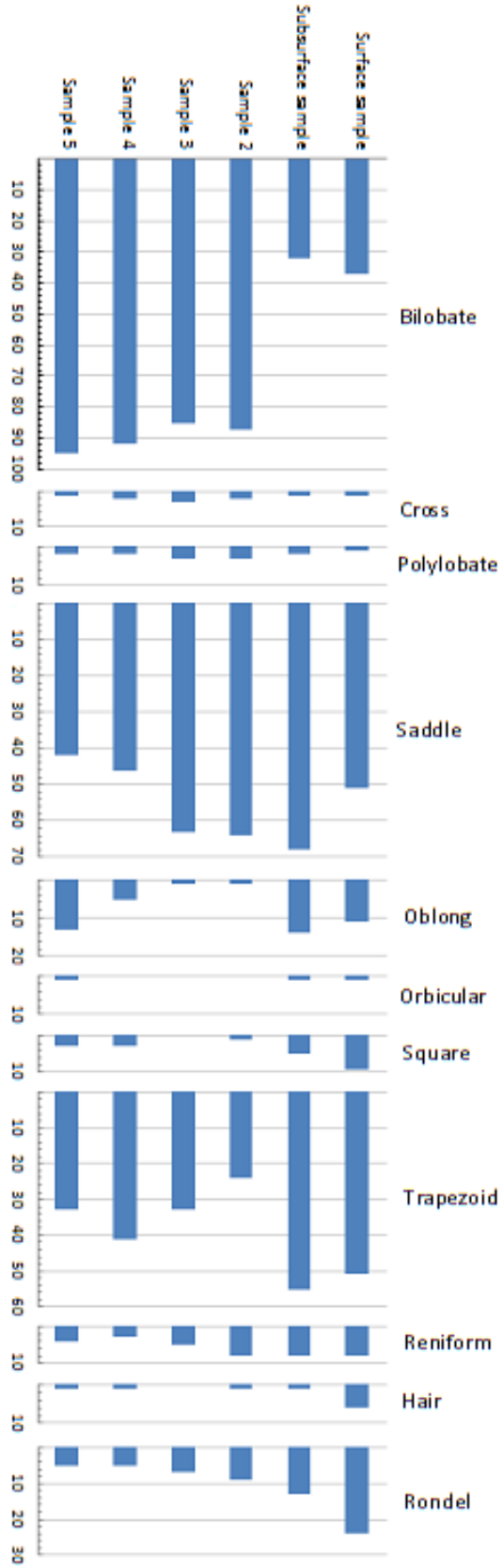


Figure 4.23. The phytolith count of the samples taken from the test pit at BFK1.

Table 4.8. Phytolith count from sample 2.

Phytolith morpohotypes	**2.2.1**	**2.2.2**	**2.2.3**	**Average**	**Percentage of sample**
Bilobate	83	81	97	87	43.5
Trapezoid	26	27	19	24	12
Square	1	0	1	1	0.5
Hair	1	0	1	1	0.5
Rondel	12	7	7	9	4.5
Saddle	69	68	54	64	32
Cross	1	2	3	2	1
Orbicular	0	0	0	0	0
Polylobate	1	5	5	3	1.5
Reniform	6	10	10	8	4
Oblong	0	0	3	1	0.5
	200	200	200	200	100

Archaeological soil samples: Sample 3

Sample three was taken at 20cm below the surface and similar to sample 2, bilobate short cells were abundant. Forty-two and a half percent (85 phytoliths) of the sample consisted of bilobates, 31.5% (63 phytoliths) were saddle phytoliths and 16.5% (33 phytoliths) were trapezoids. Rare phytolith shapes included rondels, crosses, polylobates, reniforms and oblongs. Three and a half percent (7 phytoliths) of the phytoliths encountered were rondels, 2.5% (5 phytoliths) were reniforms, 1.5% (3 phytoliths) was crosses, 1.5% (3 phytoliths) was polylobate, and 0.5% (1 phytolith) was oblong (Table 4.9; Fig. 4.23; Appendix B).

Table 4.9. Phytolith count from sample 3.

Phytolith morpohotypes	3.2.1	3.2.2	3.2.3	Average	Percentage of sample
Bilobate	97	81	78	85	42.5
Trapezoid	25	41	34	33	16.5
Square	0	0	0	0	0
Hair	0	0	0	0	0
Rondel	6	5	9	7	3.5
Saddle	58	66	65	63	31.5
Cross	3	1	4	3	1.5
Orbicular	0	0	0	0	0
Polylobate	5	1	3	3	1.5
Reniform	6	3	6	5	2.5
Oblong	0	2	1	1	0.5
	200	200	200	200	100

Archaeological soil samples: Sample 4

In sample 4, which was taken thirty centimetres below the surface, bilobates were abundant. Forty-six percent (92 phytoliths) of the phytoliths encountered were bilobates. Sample 4 contained slightly fewer saddle phytoliths than sample 3 and the number of trapezoids increased. Twenty-three percent (46 phytoliths) of the sample consisted of saddle shaped phytoliths, while 20.5% (41 phytoliths) were trapezoids.

Oblong and rondel phytoliths were present in low numbers in sample 4. Two and a half percent (5 phytoliths) of each type was encountered in the sample. Rare phytoliths included square, reniform, hair, cross and polylobate silica short cells. One and a half percent (3) of the phytoliths counted were square shaped, 0.5% (1 phytolith) was hair phytoliths, 1% (2 phytoliths) was cross shaped, 1% (2 phytoliths) was polylobate and 1.5% (3 phytoliths) was reniform (Table 4.10; Fig. 4.23; Appendix B).

Table 4.10. Phytolith count from sample 4.

Phytolith morpohotypes	4.2.1	4.2.2	4.2.3	Average	Percentage of sample
Bilobate	95	92	87	92	46
Trapezoid	32	42	50	41	20.5
Square	3	5	1	3	1.5
Hair	4	0	0	1	0.5
Rondel	5	7	4	5	2.5
Saddle	48	42	46	46	23
Cross	2	3	1	2	1
Orbicular	0	0	0	0	0
Polylobate	4	2	0	2	1
Reniform	4	3	3	3	1.5
Oblong	3	4	8	5	2.5
	200	200	200	200	100

Archaeological soil samples: Sample 5

Sample 5 was taken at forty centimetres below the surface and similar to sample four, bilobates were abundant. Forty-seven and a half percent (95 phytoliths) of the sample consisted of bilobate phytoliths. Trapezoid and saddle phytoliths were also abundant. Twenty-one percent (42 phytoliths) of the sample consisted of saddle phytoliths and 16.5% (33 phytoliths) of the phytoliths encountered were trapezoid shaped. Sample 5 contained more oblong shaped phytoliths than any of the other samples taken from archaeological deposits at BFK1. The number of oblong phytoliths was, however, similar to those found in the control samples. Six and a half percent (13 phytoliths) of the phytoliths counted were oblong shaped.

The rest of the sample comprised square, rondel, hair, cross, orbicular, polylobate and reniform phytoliths. Two and a half percent (5 phytoliths) of the phytoliths counted were rondel shaped, 2% (4 phytoliths) were reniform, 1.5% (3 phytoliths) was square and 1% (2 phytoliths) was polylobate. Hair, cross and orbicular silica short cells each contributed one phytolith (0.5%) to the total phytoliths counted for sample 5 (Table 4.11; Fig. 4.23; Appendix B).

Table 4.11. Phytolith count from sample 5.

Phytolith morpohotypes	5.1.1	5.1.2	5.1.3	Average	Percentage of sample
Bilobate	88	100	97	95	47.5
Trapezoid	39	30	31	33	16.5
Square	3	2	5	3	1.5
Hair	1	0	1	1	0.5
Rondel	2	5	9	5	2.5
Saddle	41	44	41	42	21
Cross	3	0	0	1	0.5
Orbicular	0	1	1	1	0.5
Polylobate	1	0	4	2	1
Reniform	5	6	0	4	2
Oblong	17	12	11	13	6.5
	200	200	200	200	100

Grass Subfamilies Represented by the Phytoliths

As discussed in chapter two, and in the earlier part of this chapter, certain phytolith morphotypes correspond to certain grass subfamilies (see Appendix B for a summary table). My phytolith analysis, discussed above, identified the phytoliths present at the two sites. I now discuss the phytolith data in terms of the grass subfamilies represented by the phytolith morphotypes identified. I start with KG1 and focus on the grass subfamilies present, with a specific emphasis on domesticates species.

Komati Gorge Homestead 1[3]

Panicoideae

Bilobate phytoliths dominated the control samples and were abundant in the three archaeological samples taken at KG1. Almost seventy percent of the two control samples comprised bilobates. There, however, were fewer bilobates in the archaeological soils, and less than fifty percent of each sample consisted of bilobate phytoliths. Both *P. glaucum* and *S. bicolor* produce bilobate phytoliths. Variant one, two and three bilobates were all present

[3] See Figure 4.16.

in the control and archaeological samples, but after careful examination, it was determined that neither *P. glaucum* nor *S. bicolor* phytoliths were among those found. *E. coracana* produces a small number of bilobates which were, also, not observed in any of the samples taken at KG1.

Cross and polylobate phytoliths were rare in all the samples that were analysed, which is not surprising since these are not as common in Panicoideae as bilobates. The cross phytoliths encountered were compared with the comparative collection and it was determined that none of them resembled the variant 5/6 crosses created by *P. glaucum* or variant one crosses produced by *Z. mays*. The 'wavy-top' rondels created in *Z. mays* cobs were not observed in the control or archaeological samples.

Pooideae, Danthonioideae and Ehrhartoideae

A number of phytolith morphotypes are created by Pooid grasses, including rondel phytoliths (Rossouw 2009:64). These were marginally more common in the archaeological and control samples than the other phytoliths generally produced by Pooideae namely oblong, orbicular and square phytoliths (Rossouw 2009:64; Twiss *et al.* 1969:111). Rectangular phytoliths were also rare in the control samples, but in the archaeological deposits approximately 5% of sample B and almost 10% of sample C consisted of them. Rectangles were rare in sample D.

Trapezoid phytoliths, while associated with Pooid grasses, are also commonly produced by plants belonging to the Danthonioideae and Ehrhartoideae subfamilies (Rossouw 2009:62). Trapezoid phytoliths were common in the archaeological samples, but the numbers were slightly lower in the control samples. In the control samples less than 10% of the phytoliths encountered were trapezoids, while in the archaeological samples approximately 12 percent of the phytoliths counted were trapezoid shaped.

Chloridoideae and Aristidoideae

While trapezoids were common in the KG1 archaeological samples, saddle shaped phytoliths, which are associated with the Chloridoideae and Aristidoideae subfamilies (Rossouw 2009:63), were present in all samples. The surface and subsurface samples comprised 14% and 18.5% saddles, while in sample B, C and D the number of saddles was almost equal to the number of bilobate phytoliths observed.

Squat and elongated saddles were both observed in *E. coracana*, and squat saddles with similar morphometric attributes to those observe in *E. coracana* were encountered in samples C and D. Alhough it is not possible to say with complete certainty that the saddles observed were produced by *E. coracana*, it is probable that they were, because these types of saddles were not recorded in *E.indica*. Further research is, however, required to determine if other Chloridoid grasses produce phytoliths with the same size and morphological attributes as *E. coracana* before all the saddle phytoliths from the archaeological sample can be positively attributed to *E. coracana*. Research on the morphometric differences between different variations of *E.coracana* should also be explore to establish whether all phytoliths created by *E. coracana* are similar.

Other phytoliths

Apart from the various phytoliths produced by Poaceae, the only other phytoliths that were observed in the samples were hair phytoliths. Hair cell and hair base phytoliths are commonly found in Eudicots, and are mostly produced in leaves (Piperno 2006:39-40). Unicellular hair phytoliths were found in low numbers in all of the samples, but since hair cell phytoliths are produced by numerous families including, Cucurbitaceae, Asteraceae and Moraceae (Piperno 2006:40), it is difficult to determine their exact origin without a comprehensive comparative collection.

The hair phytoliths were the only evidence of non Poaceae plants growing on or near the site. No phytoliths linked to *V. unguiculata* were found in any of the samples taken.

***Buffelskloof Private Nature Reserve*[4]**

Panicoideae

The number of bilobate phytoliths found in the BFK1 surface and subsurface samples were low in comparison to the control samples taken from KG1. Less than 20% of each sample consisted of bilobates. These numbers, however, increased to the extent where they were dominant in the archaeological samples. Cross and polylobate phytoliths, which are often observed in Panicoideae (Fredlund & Tieszen 1994:326), were rare in all the samples.

Close examination of the phytoliths encountered in the control samples revealed that *S.*

[4] See Figure 4.17.

bicolor, Z. mays and *P. glaucum* phytoliths were absent. In sample three and five of the archaeological deposit phytoliths resembling those produced by *P. glaucum* were, however, identified. No *P. glaucum* phytoliths were found in sample four. *S. bicolor* phytoliths, and the types of cross shaped phytoliths produced by *Z. mays* plants, as well as the characteristic "wavy-top" phytoliths which are produced in *Z. mays* cobs, were also absent from these archaeological samples.

Pooideae, Danthonioideae and Ehrhartoideae

Orbicular and square phytoliths, associated with Pooideae, Danthonioideae and Ehrhartoideae, were rare in all the BFK1 samples, and comprised less than five percent of each sample. Rondels were common in the surface sample and constituted twelve percent of the overall phytoliths. Rondel phytoliths decreased with depth, while oblong phytolith numbers fluctuated. Trapezoid phytoliths were abundant in the two control samples, and were common in the archaeological samples. In sample two moderate numbers of trapezoids were encountered. The number of trapezoids gradually increased with depth, before decreasing in sample five, the sample taken from the lowest level of the test pit. The number of reniform phytoliths encountered in all the samples was relatively low, and less than five percent of each sample consisted of them.

Chloridoideae and Aristidoideae

The number of variant one and two saddle phytoliths encountered during analysis fluctuated. The number of saddles found in the surface sample was almost equal to the number of trapezoids encountered in this level. In the subsurface, as well as samples two and three, saddle phytolith numbers were higher than in the surface sample. These numbers decreased, however, as the bilobates increased and levels four and five contained the lowest number of saddles of all the samples taken.

Bilobates similar in shape and size to those produced in *P. glaucum* were encountered in levels three and five, but it is likely that this was not the only crops cultivated at BFK1. Various saddle phytoliths with the same morphological characteristics as *E. coracana* were found in all the samples taken from archaeological soils. It therefore is possible that *E. coracana* was also cultivated at this site.

Other phytoliths

The only non-grass phytoliths encountered in the samples analysed, apart from hair cell phytoliths, were two unidentified phytoliths which were present in low numbers. Unknown 1 is oblong in shape with acute and tenuous protrusions which covers large sections of the phytolith body and gives it a 'root-like' appearance (Fig. 4.24). This phytolith was primarily observed in the surface sample.



Figure 4.24. Unknown 1 from the surface sample.

Unknown 2 resembles a hair base cell with a ruminate outer margin and an orbicular central portion. The outer section of the phytolith does not appear to be segmented (Fig. 4.25). These phytoliths were observed in sample three and similar to other hair phytoliths it could have been made by various Eudicots.

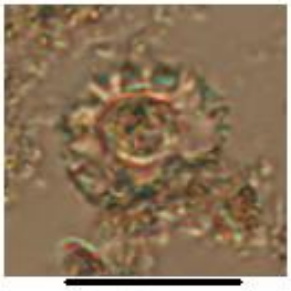


Figure 4.25. Unknown 2 from sample three.

The hair cell phytoliths encountered in both the control and the archaeological samples were unicellular. These phytoliths were similar to those found in the Komati Gorge Homestead 1 samples and could be from the same plant family. Also, as with the KG1 samples, *V. unguiculata* phytoliths were absent from the BFK1 samples.

Ic and Iph Index

I calculated the Ic and Iph indexes for the period during which the Komati Gorge village and Buffelskloof were occupied. I present the Ic and Iph values calculated for the KG1 and BFK1 samples in this section, and highlight the key trends observed in the values.

Komati Gorge Homestead 1

Ic values

The surface Ic value was low (11%), as was the value calculated for the subsurface samples (13%). The archaeological samples' Ic values were substantially higher than those calculated for the control samples. The values, however, decreased with depth. Accordingly, sample B had the highest value (31%). Sample C's value was 29%, and sample D had an Ic value of 26% (Fig. A.4; Fig. 4.26).

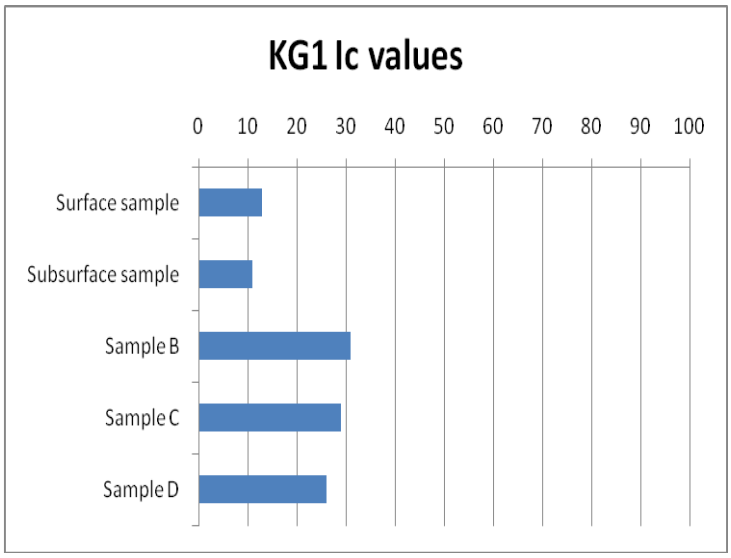


Figure 4.26. Graph indicating KG1 Ic values.

Iph values

The Iph values calculated for KG1's control samples were low, similar to the Ic values. The surface sample's Iph value was 16% and the subsurface samples' was 21%. The Iph value of the archaeological samples in comparison with the control samples suggests that during the period the site was occupied environmental moisture was higher than at present. Sample B had the highest value at 47%, while sample C and D's values were both calculated to be 45% (Fig. A.4; Fig 4.27).

A correlation between temperature and moisture was noted. When the Ic value decreases the Iph value decrease, and vica versa.

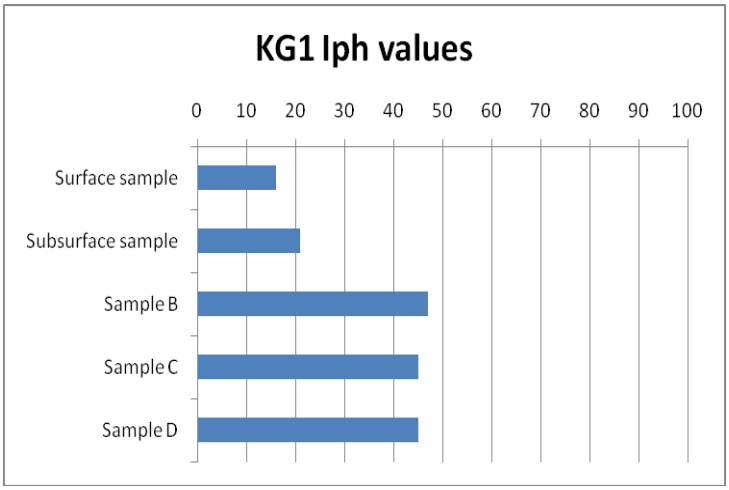


Figure 4.27. Graph indicating KG1 Iph values.

Buffelskloof Private Nature Reserve Homestead 1

Ic values

The Ic index calculated for the control samples yielded relatively high values. The results were in what is considered the the transitional zone between mesic and xeric conditions. The surface sample's Ic value was 54% and the subsurface value was 48%. The archaeological samples' values were considerably lower than those of the control samples. Sample 2 had an Ic value of 22% and the value for sample 3 was 23%. The Ic values of samples 4 and 5 were slightly higher than samples 2 and 3. Sample 4 had an Ic value of 29% and a value of 30% was determined for sample 5 (Fig. B.4; Fig. 4.28).

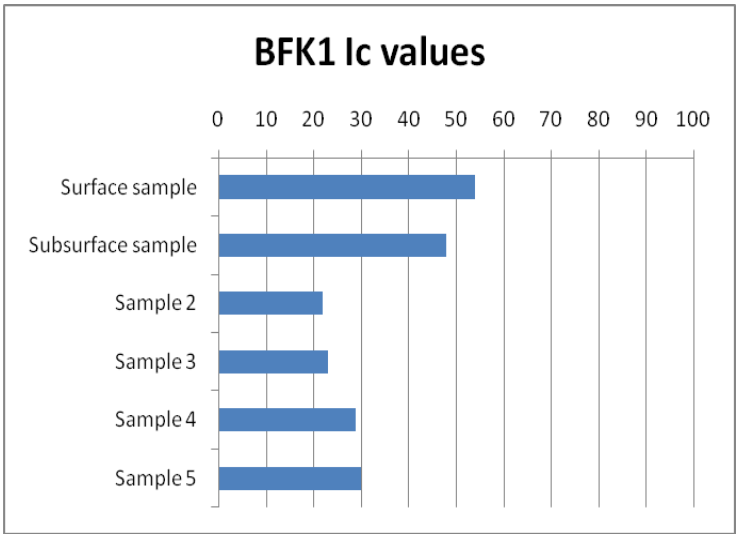


Figure 4.28. Graph indicating BFK1 Ic values.

Iph values

Similar to the Ic values calculated for BFK1, the Iph values were high for the control samples, and substantially lower for the archaeological samples. The surface sample's value was 53% and the subsurface sample had an Iph value of 66%. Samples 2 and 3 both had an Iph value of 41%, while sample 4's value was 32% and sample 5's value was 30% (Fig. B.4; Fig. 4.29).

A correlation between temperature and moisture was also noted for the BFK1 samples. The control samples had a high Ic value, as well as a high Iph value. It, however, was noted that samples 2 and 3 had the lowest Ic values of all the BFK1 samples, while their Iph values were much higher that those observed for samples 4 and 5, which had greater Ic values. This deviation from the observed trends could be due to a number of factors which will be discussed in the following chapter.

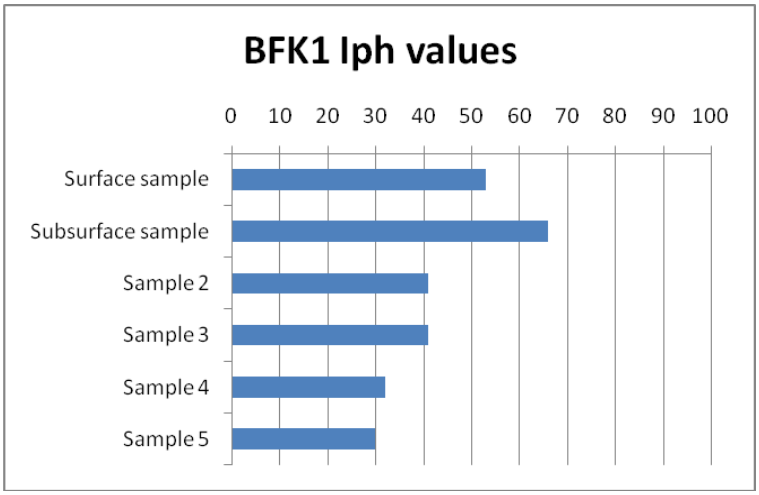


Figure 4.29. Graph indicating BFK1 Iph values.

Conclusion

Phytoliths linked to the Panicoideae, Pooideae, Danthonioideae, Ehrhartoideae, Chloridoideae and Aristidoideae subfamilies were identified during the phytolith analysis of archaeological and control samples taken from agricultural terraces at KG1 and BFK1. The number of phytoliths found per morphotype indicates that the plant growth at both sites have changed significantly from the time of the sites' occupation to the present, while the Ic and Iph values calculated for both sites indicate a change in the environmental conditions.

Phytoliths resembling the saddles created by *E. coracana* were observed in KG1's samples C and D and all the archaeological samples analysed from BFK1. Phytoliths similar to those created by *P. glaucum* were identified in samples 3 and 5 of BFK1. While the absence of *S. bicolour*, *V. unguiculata* and *Z. mays* phytoliths indicate that these domesticated plants were not cultivated on the areas chosen for sampling, it can not be conclusively stated that they were not present on site as it is possible that they were cultivated on other areas of the site. A thorough horizontal sampling study, which is beyond the scope of this dissertation, is required to conclusively rule out their presence.

CHAPTER 5 - DISCUSSION

Introduction

In chapter four I presented the results of my analysis of the phytoliths in the soil samples taken from KG1 and BFK1. The sites analysed represented the first and the last phases of the Bokoni sequence, with KG1 representing the earliest phase of Bokoni settlement with evidence of terraced agriculture and BFK1 the final defensive phase. The historical archaeological research on these sites focus on different aspects of Bokoni history, for example site layout and sequence. My study specifically focussed on identifying the types of domesticated plants cultivated by the people of Bokoni at these sites, in part to determine whether new crops were introduced at Bokoni sites. I also identified the indigenous plants growing on the terraces, to establish what types of vegetation were growing in the region the sites were built in. In this chapter I discuss the results of the phytolith analysis in the broader archaeological context of Bokoni agriculture, settlement patterns and occupation sequences. I also discuss the limitations of phytolith analysis with reference to the samples I collected and analysed.

Komati Gorge Homestead 1

Domesticated plant choices and constraints

The research currently being conducted by the team led by MH Schoeman at KG1 focusses on how and why terrace agriculture started in Bokoni. It has been proposed that terracing was introduced to manage soil moisture and/or to limit erosion (Schoeman 2013: pers. comm.). Others have suggested that the introduction of new crops, for example *Z. mays,* could be responsible for the introduction of terracing at Bokoni sites (Maggs 2008).

As discussed in chapter two, African cereal crops such as *E. coracana*, *P. glaucum*, *S. bicolor,* as well as legumes, for example *V. unguiculata,* were cultivated by pre-colonial farming communities in southern Africa (e.g. Davies 1975; Maggs 1980), and could have been grown by the people of Bokoni. Based on the data collected during my analysis of the soil samples taken from archaeological deposits on agricultural terraces at KG1, it was established that phytoliths resembling those produced by *E. coracana* were present in KG1's samples C and D. The phytolith morphotypes created by *Z. mays*, however, were not present in any of the samples analysed.

One factor that should be taken into account when interpreting these results is the variability of the phytoliths produced by *E. coracana, P. glaucum, S. bicolor* and *V. unguiculata*. Consequently, it is impossible to establish which variant of these crops were cultivated.The phytoliths produced by these African domesticated have not been studied in great detail. The few studies which have documented these phytoliths (see e.g. Jattisha & Sabu 2012; Rossouw 2009) have noted morphometric attributes, however, they have not investigated the differences between the phytoliths produced by different variants of these domesticates. Moreover, they have not established whether there are similarities between the phytoliths created by African domesticated plants and closely related grasses.

Since only phytoliths resembling those created by *E. coracana* were present in the archaeological samples, and phytoliths linked to the other domesticated plants were not observed, it is possible that *E. coracana* was the principle crop cultivated at KG1. This possibility, however, should be treated with caution due to the limited nature of the sampling. it is not possible to assert that only *E. coracana* was cultivated at the site.

While, it is possible that the absence of phytoliths linked to certain domesticates could have been the result of the limited scale of sampling, or of social choices made by the site occupants. The absence of *Z. mays* in the other Bokoni phytolith study (e.g. Sjöström 2013) supports the latter possibility. Consequently, I explore possible fators that might have informed crop selection.

The plants chosen for cultivation on the KG1 terrace would have been determined by a number of aspects. The first is that people used specific terraces for specific crops, for example, plants at higher risk of bird interference might have been planted closer to the homesteads in order to minimise yield losses.

The second is availability. Crops such as *Z. mays* might simply not have been available to the Komati Gorge community. Thirdly, environmental factors, for example climate, height above sea level and soil nature would have affected not only what crops were cultivated, but also which variants of these crops were cultivated. The soil on the terraces excavated at KG1, for example, comprised shallow clay sediments. *E. coracana* easily adapts to various soil types (Smith *et al.* 2007:123). *P. glaucum,* however, does not fare well in soils, such as clay, which are prone to waterlogging (National Research Council 1996: 91). Furthermore,

shallow soil deposits can stunt the growth of certain crops, for example *S. bicolor,* which has deep penetrating roots that can be adversely affected by soil depth (National Research Council 1996: 90). These crops, if cultivated, would have been planted in a more suitable location.

The clay soils at Komati Gorge are also particularly prone to erosion (Schoeman 2013 pers. comm.). This might be an additional factor mitigating against the extensive cultivation of *P. glaucum* in the Komati Gorge village. As discussed in Chapter two, the cultivation of *P. glaucum* can cause soil erosion (National Research Council 1996:51), and this in combination with the erosion prone soils at Komati Gorge would have impacted negatively on the long term sustainability of farming on the site.

On a societal scale, social and cultural choices also would have influenced crop preferences. As demonstrated by Boeyens (2003) not all southern African communities adopted *Z. mays* as soon as it reached South Africa. Similarly, the choice to produce *E. coracana* would also have had a social component. It is more palatable than other African cultigens, and it has small seeds are not prone to insect damage (National Research Council 1996: 40). Furthermore, the ability to store seeds with minimal grain loss due to insect and animal activities would have been important to pre-colonial communities such as the people of Bokoni.

Boeyens (2003) and Hall *et al.* (2008) suggested that the cultivation of substantial amounts of *Z. mays* only started in the late 18th century. It, however, has been suggested that *Z. mays* might have been introduced into southern Africa as early as the 16th century (Maggs 2008), and thus they have postulated that it could have been grown by the community that occupied KG1. Noting the limitations of the column sampling technique, the absence of *Z. mays* phytoliths, however, appears to corroborate Hall *et al.* (2008) and Boeyens' (2003) findings. This definitely casts doubt on the suggestion that the introduction of *Z. mays* was responsible for the introduction of terracing, because my research suggests that only African domesticated crops were cultivated on the terraces at KG1.

The reason for the stratigraphic distribution of *E. coracana* is equally opaque, and it is unclear why phytoliths similar to those produced by *E. coracana* could only be identified in samples C and D, instead of all the archaeological samples. Phytolith preservation is one of

the key factors which influence the distribution of phytoliths, however it is not the only possible explanation for the absence of *E. coracana* phytoliths in the upper levels. There are two other explanations relating to the occupation sequence at the site. The first of these is that the soils in Sample B accumulated after village was abandoned. The second relates to the superimposition of the two homesteads in the KG1 area.

The smaller downslope homestead overlies the domestic zone and upper terrace of the larger up slope homestead (Fig. 3.1). The occupations thus are not contemporaneous, and the smaller homestead was established on the larger, older one when it was abandoned. The phytoliths resembling *E. coracana* in the lower levels could be linked to the first occupation of KG1, because the agricultural terraces sampled formed part of the older homestead. It is possible that sample B did not contain evidence of domesticated plants, because the older homestead associated with the terraces was abandoned prior to the deposition of the sample B soil, and the use of this terrace had shifted during the occupation of the later homestead (Schoeman 2013 pers. comm.).

Regional vegetation and climate

While the phytolith analysis of the KG1 terraces provides important data on the climate and the nature of the vegetation at the site, it is important to note that several factors may have influenced the phytolith deposition. Animal activities, as well as agricultural methods, for example the fertilization of fields with manure may have introduced phytoliths onto the terraced areas (see e.g. Carrión *et al.* 2000:248; Ghosh 2008; Maggs 2008:179). While this could impact on the results of this study, I suggest that since domesticated animals would have grazed in the region close to the settlements, the phytoliths introduced onto the terraces would still reflect regional vegetation.

Phytolith preservation and transportation were also considered during the interpretation of the phytolith data. While it is possible that phytolith preservation could have played a role in the absence of non-Poaceae phytopliths. It is more likely, however, that the lack of phytolith evidence of non-Poaceae taxa is indicative of the rarity of these plants, particularly woodland species such as trees and ferns, in the sample area. Interviews conducted with farmers in the area surrounding Komati Gorge have established that there were very few trees in the region at the start of the twentieth century (Schoeman 2013 pers. comm.). This information supports

the phytolith evidence which suggests that KG1 was situated in a grassland area.

The oral and phytolith data challenges Acocks' (1988) vegetation model, which suggested that the area, in which Komati Gorge is located, was once bushveld or thornveld. The lack of trees and shrubs could have been the result of human action, due to, for example, a demand for firewood. Similar interpretations relating to the role of pre-colonial farming communities in the creation of grasslands have been made to explain the origins of the Transkei grassland. Feely's (1989) research, however, demonstrated that the Transkei grassland pre-dates the arrival of pre-colonial farmers. At this stage the phytolith data from the Komati Gorge village does not support Acocks' (1988) suggestion, but rather points to parallels with the Transkei grasslands.

The regional vegetation in the area where KG1 is located would have been dependent, to some degree, on the climate. The phytolith data were used in conjunction with research done by Norström *et al.* (2005; 2009), among others, to gain insights into regional vegetation and climate in the area at the time that the site was occupied. According to Holmgren *et al.* (2001) an Ice Age prevailed from the 1500s to the 1800s, and it had a profound effect on global climate. A cool, dry climate persisted in South Africa (Mayewski *et al.* 2004:251) which resulted in several severe droughts in the mid and late 1500s and early and late 1700s. While arid conditions were the norm, periods of high rainfall were noted between the 17th and 18th centuries as well as in the late 19th century (Norström *et al.* 2005:166-167). Mucina and Rutherford (2006) indicated that the area in which KG1 is located currently receives moderate amounts of rainfall and a high mean annual temperature was suggested for the area.

My phytolith data reflects current as well as past environmental conditions. As indicated in chapter two *E. coracana* fares well in temperate and tropical regions, because it is adapted to hot, dry climates, as well as cooler conditions. In addition to the phytoliths associated with *E. coracana*, phytoliths produced by the indigenous vegetation were identified in the archaeological samples. Furthermore, phytoliths linked to Aristidoid, Chloridoid and Panicoid grasses were abundant in the archaeological samples. Plants belonging to these subfamilies usually occur in tropical and subtropical regions (Gibson 2009:27-28). The majority of the Aristidoid and Chloridoid grasses follow the C4 photosynthetic pathway, which allows them to inhabit dry, hot climates (Gibson 2009:27-28; Glemin & Bataillon

2009:275). Panicoideae also comprises C4 grasses, however C3 and a number of C3/C4 intermediary grasses form part of this subfamily. Thus, Panicoideae, while common in the same regions as Aristidoideae and Chloridoideae, are not limited to open arid climates (Gibson 2009:27). The abundance of phytoliths related to these subfamilies suggests that relatively high temperatures prevailed at the site during the period that the site was inhabited. To determine whether this interpretation is correct, I calculated the Ic values for the KG1 control and archaeological samples. Ic and Iph values were calculated for the control samples in order to compare the results with the values calculated for the archaeological samples, and to determine if the values could accurately portray regional climate.

The control samples were dominated by Panicoid grasses. Moderate numbers of Aristidoid and Chloridoid grasses were also present. The number of phytoliths related to C4 grasses far outweighed the number of C3 phytoliths. The control samples' Ic values were extremely low which indicates high regional temperatures. The Iph values were also low, which suggests above average amounts of rainfall in the KG1 area. These results were in line with the type of climate identified by Mucina and Rutherford's (2006).

While C4 grasses dominated the archaeological samples B to D, plants following the C3 photosynthetic pathway were also common in the archaeological samples. Pooid grasses predominantly follow the C3 photosynthetic pathway and are adapted to high altitudes and cool climates (Gibson 2009:27; Glemin & Bataillon 2009:275). Danthonioideae and Ehrhartoideae also comprise C3 grasses and occur in open habitats, but they also are common in mesic and forest biomes. C3 grasses prefer cool, wet habitats (Gibson 2009:28), thus the presence of C3 grasses suggests high moisture levels at the site during its occupation. The Iph values calculated from the phytoliths observed in the archaeological samples indicated that the moisture levels were in the transitional zone, however, they were closer to arid than mesic conditions. This could indicate that the climate was shifting from mesic to xeric conditions during the period when the Bokoni people lived there. The Ic values of the archaeological samples, on the other hand, suggests that a warm climate prevailed at Komati Gorge during the time of the sites occupation. Temperatures, however, were decreasing as indicated by comparing the Ic value of the topmost sample (Ic value = 31%) with the lowest sample D (Ic value = 26%).

When the control samples' Ic (11% and 13% respectively) and Iph values (16% and 21% respectively) were compared to those calculated for the archaeological samples (Ic:B - 31%, C – 29%, D – 26% and Iph: B - 47% C - 45% D - 45% respectively) it was noted that the temperatures were lower during the period when the site was occupied than at present. Rainfall was also lower during that period than the current regional rainfall. Thus the climate at KG1 when the people of Bokoni lived there was in line with the cool and arid global climate suggested for the Little Ice Age by Holmgren *et al*. (2001) and Mayewski et al. (2004). This, however, differs from the findings by Sjöström (2013) who studied the phytoliths from a core taken from the Lydenburg fenn. Her data showed that moisture levels were higher than present in the period in question. These contrasting findings deserve further investigation.

Buffelskloof Private Nature Reserve Homestead 1

Domesticated plant choices and constraints

Current archaeological research at Buffelskloof Private Nature Reserve is focussed on understanding terminal phase occupations, and the types of agricultural practises used during periods of unrest and upheaval in the area. The types of crops cultivated by the Bokoni people during the terminal phase of occupation is important, because it informs on their livelihoods, and might shed light on why the site was abandoned.

As mentioned in chapter two, pre-colonial farming communities chose the places where they settled with care. Areas which had fertile soil, were close to water and had adequate grazing for livestock were usually chosen for settlement (e.g. Greenfield *et al.* 2005:308-309; Smith *et al.* 2007: 115). The people of Bokoni, however, did not choose to live in Buffelskloof for any of those reasons, instead they occupied the site because it was inaccessible and isolated, thus providing a safe refuge in a time of trouble. The kloof comprises steep slopes, and soil deposits in the parts of the kloof that is not terraced are shallow due to erosion associated with the steep slopes and water run off. Terracing was probably introduced at the site to make it possible to settle on the slopes and to limit erosion, thereby ensuring that there was enough fertile soil to cultivate crops in.

Phytoliths resembling those created by *E. coracana* were encountered in all of the archaeological samples, which could indicate that it was one of the crops grown at the site. It

is likely that the inhabitants brought seeds with them when they retreated into Buffelskloof, which could indicate it was cultivated at other Bokoni sites. The soil conditions at their previous settlement, probably a phase 2 open valley site located on a gentle rolling hill, would have been very different from the steep slopes of the kloof. Furthermore, the moisture levels in the kloof are relatively high. As discussed in chapter two, and earlier in this chapter, *E. coracana* is well adapted to a variety of soil and climatic conditions, which is why the people of Bokoni were able to continue cultivating it at BFK1 in spite of the stark topographic and environmental differences between Buffelskloof and earlier phase 2 sites.

It, however, is possible that *E. coracana* was not the only crop cultivated at BFK1. Phytoliths similar to those produced by *P. glaucum* were observed in samples 3 and 5. *P. glaucum*, similar to *E. coracana*, would have been grown for specific reasons. For example, the people of Bokoni could have grown it because it is versatile and because it is a robust crop which is less prone to damage brought on by insects and crop diseases (National Research Council 1996:81 & 97). There are various possible reasons why phytoliths linked to *P. glaucum* were only present in samples 3 and 5. It was noted that clay soils were present on terraced areas. *P. glaucum*, unlike *E. coracana*, cannot tolerate waterlogging and does not grow well in clay soils (National Research Council 1996:91).

Noting, that *P. glaucum* was not present throughout the sequence, it is possible that the occupants might have stopped cultivating *P. glaucum*, because it failed to produce the quantity of grain needed to sustain the people living at the site. Phytolith preservation could, also, explain the lack of *P.glaucum* phytoliths, however the presence of phytoliths resembling *E. coracana* suggests that preservation was not the reason for the absence of *P. glaucum* phytoliths. Though phytoliths resembling *P. glaucum* were absent from two of the archaeological samples, the limited nature of the samples taken makes it impossible to illiminate the possibility that it, and other crops were cultivated on other areas of the site where environmental conditions were more favourable for crop cultivation.

While *E. coracana* might have fared better in the clays soils of BFK1 than *P. glaucum*, both crops would have produced lower yields than at earlier phase 2 settlements. This would have been the result of the soil type as well as access to sunlight. Day-length would have affected the growth of the crops at BFK1. *E. coracana* and *P. glaucum* fare well in areas where the

day-length is long (National Research Council 1996:90), however, days are relatively short in Buffelskloof, because the steep kloof slopes limits the amount of sunlight that reaches the valley floor. This would have affected crop development which would have resulted in lower yields.

Furthermore, I noted that the Buffelskloof terraces were smaller than terraces I observed at phase one and two sites. Consequently, the amount of grain harvested would have been much less than at open valley settlements. This, combined with the likely lower yields, would have impacted negatively on the community's food security.

Regional vegetation and climate

Regional climate would also have affected crop choice and growth. Crops such as *E. coracana* and *P. glaucum* need specific climatic conditions to reach maturity and to yield substantial amounts of grain. *P. glaucum* fares well in habitats with low rainfall and high temperatures, but is sensitive to cold weather (National Research Council 1996:90). *E. coracana* can be cultivated in a wider variety of environments than *P. glaucum*, but is best adapted to regions with high temperatures and humidity. It is also drought tolerant which allows it to flourish in tropical areas (National Research Council 1996:40-41).

At present the area in which BFK1 is located forms part of the Northern Mistbelt Forest Biome (Mucina *et al.* 2006a:601-602). Trees, herbs, shrubs and grasses are all common in this habitat as opposed to the NaNgwane Montane Grassland biome. The types of Poaceae and other plants growing in Buffelskloof are largely determined by the climate. High rainfall, temperatures and altitudes as well as the day length and the amount of sunlight that reaches the bottom of the kloof could influence plant growth. Despite the rich diversity of plants observed during excavations at the site, during the analysis of the control samples only Poaceae phytoliths were observed.

The lack of phytoliths associated with trees, ferns and herbs could be due to a number of factors. Phytoliths, for example, are trapped in organic remains which have to decay in order for phytoliths to be released into soils and sediments (Piperno 2006:1). Most of the soils on the agricultural terraces were covered by fresh leaves and a thick layer of humus. Both the humus and the leaves were removed from the area where control samples were taken prior to sampling in order to reach the soil below. The majority of the phytoliths linked to non-

Poaceae taxa might therefore still have been trapped in organic plant remains and would not have been present in the control samples.

Phytolith preservation could also account for the lack of non-Poaceae phytoliths in the control samples. Piperno (2006:108-109) mentions that the phytoliths produced by certain plants, for example Poaceae, are more resistant to decay than for example epidermal and hair phytoliths created by trees and herbs. It is possible that phytoliths belonging to taxa other than Poaceae dissolved after phytolith deposition into soils, which resulted in their absence from the samples.

As with the samples collected from KG1 I considered that the phytoliths might have been introduced by human and animal activities and as with the KG1 samples I came to the conclusion that any phytoliths introduced onto the terraces would have been from local origin which would have no impact on the interpretations made about the regional climate and vegetation. In contrast to the KG1 phytolith assemblage, only moderate numbers of phytoliths associated with Panicoid grasses were encountered in the control samples. Less than twenty percent of each control sample consisted of Panicoideae; however, plants belonging to Aristidoideae, Chloridoideae, Danthonioideae, Ehrhartoideae and Pooideae were abundant.

The high number of C3 grasses in the BFK1 control samples could be attributed to day-length and altitude, but it could also be linked to high environmental moisture levels and cool temperatures. Studies by Mucina *et al.* (2006a) indicated that Buffelskloof currently receives high rainfall. These studies also estimated a high mean annual temperature for the region. The control samples' Ic values did not support Mucina *et al.*'s (2006a) temperature data, and were found to be in the transitional zone. I interpreted this as an indication of a milder micro climate in the kloof, with the site rarely experiencing extreme heat or cold temperatures, unlike the surrounding hills where temperature fluctuations would be more extreme. The Iph values of the surface sample were also in the transitional zone, however the subsurface's values were above 60%, indicating a drier climate. This data also differs from the Mucina and Rutherford (2006) model.

The vegetation currently growing at BFK1 differs remarkably from what was at the site during its occupation. During the period when the Bokoni people lived at the site, it was a

grassland, and similar to Komati Gorge it was dominated by Poaceae with small trees and schrubs growing in the area. The shift from grassveld to forest was directly caused by the settlement. After the site was abandoned the stonewalled settlements started to act as fire breaks, which protected plants from fires, thereby, allowing fire sensitive trees and other taxa to flourish at the site. The present day plant growth at BFK1 is, largely due to this process of reforestation (Burrows 2012: Pers. comm), but climate change also plays a role.

Analysis of the samples taken from archaeological soils from the terraces showed that C3 grasses were less common in the archaeological samples than in the control samples, while the number of Panicoid grasses increased with depth which could indicate that the site was located in an open habitat. The abundance of Chloridoid, Aristidoid and Panicoid grasses could be an indicator of arid conditions. Based on research done by Holmgren *et al*. (2001), it is known that between the 1500's and the 1800's cool, arid climate conditions prevailed. Furthermore, there were periods of high rainfall and temperatures in the 19th century (Norström *et al.* 2005:166-167). As discussed in the previous chapter, Ic and Iph values were calculated for the archaeological samples. These Ic values fluctuated, but were all below 40%, which indicated that temperatures were high during the period when Bokoni people used the site. On the other hand, Iph values suggest that environmental moisture was high. I, therefore, inferred that the site was not occupied during one of the major droughts which took place in the 19th century, but during one of the wetter periods.

Conclusion

This chapter grappled with the implications of the data collected during the analysis. I highlighted the possible continued cultivation of *E. coracana*, and later introduction of *P. glaucum*, as well as the absence of *Z. mays* from the samples from both sites. I also provided possible explanations for why phytoliths associated with certain types of vegetation were present or absent. Based on the data collected during this study I inferred that rainfall levels and temperatures were lower at the Komati Gorge village during its occupation than at present. Buffelskloof, however, experienced higher temperatures when BFK1 was occupied than at present. The rainfall levels were relatively high during the occupation, but were lower than current levels in the area.

CHAPTER 6 - GENERAL CONCLUSION

Summary

In spite of the extensive agricultural terracing relatively little is known about the agricultural practices of the people of Bokoni. In Chapter two I highlighted several factors that could have influenced the introduction of methods associated with terrace agriculture, for example the use of terracing. One of these factors was the introduction of a new crop, for example *Z. mays*. My analysis found no evidence for the presence of *Z. mays* in the KG1 and BFK1 samples. It, therefore, is unlikely that the introduction of *Z. mays* was the principle reason why the people of Bokoni started to build terraces.

My analysis of the KG1 and BFK1 phytoliths, however, did establish that *E. coracana* and *P. glaucum* were possibly grown on the terraces. The introduction of terracing, therefore, is more likely an attempt to create the ideal growth conditions for African domesticated plants, and could have been used to manage moisture or limit soil erosion.

The phytoliths of indigenous flora at each site provided the foundation for valuable insights into past environmental and vegetation conditions at each site. This data in conjunction with research done in the area provided me with an understanding of what might have shaped crop choices and constraints, and ultimately agricultural practices employed by the Bokoni people.

Challenges and future research

I faced several challenges during this project, the first being the limited amount of work done on the diagnostic features of phytoliths from African domesticated plants. Little research, for example, has been done on the diagnostic features of *E. coracana* phytoliths. My research, based on phytoliths obtained from plants I cultivated and sampled, showed that some of the saddles created by *E. coracana* were morphometrically different from the documented saddles produced by Chloridoid grasses. These differences, however, were small, and further research is required to determine whether any of the grasses belonging to Chloridoideae create phytoliths resembling those made by *E. coracana*. Furthermore, variability between phytoliths from different *E. coracana* cultivars should also be explored.

While preliminary studies indicated that there might be some morphological differences between African domesticated plants and closely related indigenous grasses, a complete comparative collection for African domesticated plants is required before phytoliths can become a routine part of archaeological crop identification.

In addition, further research is required on the impact of pre-colonial farming practices on phytolith presence and preservation. It is crucial, for example, to better understand terrace formation and maintenance in Bokoni, and the impact this might have on phytolith preservation.

The data collected during this study was a good starting point, but the samples taken were limited and it was imposible to identify anomalies in the phytolith record or positively elliminate the possibility that other crops were cultivated by the people of Bokoni. More research and extensive sampling should be done at Bokoni sites to investigate broader environmental changes as well as crop cultivation.

Another aspect that needs further investigation is the age of sites. Bokoni sites have not been dated directly, thus it is difficult to determine when they were occupied. This presents a problem when explaining environmental change, because the sites cannot be fitted into a detailed environmental record. Further research is also required to determine regional differences in temperatures and rainfall. There is a significant difference between my research data regarding rainfall levels, and those of Jenny Sjöström which warrents indepth investigation.

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APPENDIX A: KG1 PHYTOLITH DATA

Table A.1. Komati Gorge Homestead 1: Control and Archaeological sample's phytolith counts.

	Surface Sample		Subsurface Sample		Archaeological Samples								
Phytolith morpohotypes	A14.1	A14.2	A15.1	A15.2	B13.1	B13.2	B13.3	C2.1	C2.2	C2.3	D3.1	D3.2	D3.3
Polylobate (*Panicoideae*)	2	4	5	0	2	1	1	4	3	1	5	2	4
Bilobate (*Panicoideae*)	138	141	142	127	65	71	75	59	81	82	73	69	78
Cross (*Panicoideae*)	1	4	3	2	2	1	1	2	0	2	3	7	2
Saddle (*Chloridoideae and Aristidoideae*)	26	30	25	48	78	59	56	63	55	70	65	65	68
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	10	13	13	18	23	29	30	28	16	25	26	23	27
Square (*Pooideae*)	2	3	2	0	0	5	6	0	0	0	0	0	4
Rondel (*Pooideae*)	7	1	3	0	6	14	4	13	15	2	11	9	7
Retangle (*Pooideae*)	1	1	3	2	7	4	19	20	23	10	0	4	2
Orbicular (*Pooideae*)	0	0	0	0	0	3	1	0	0	0	0	1	3
Reniform (*Danthonioideae and Ehrhartoideae*)	5	2	2	2	12	5	2	9	5	5	16	15	3
Oblong (*Pooideae*)	6	1	1	0	4	7	5	0	0	0	0	4	0
Hair	2	0	1	1	1	1	0	2	2	3	1	1	2
	200	200	200	200	200	200	200	200	200	200	200	200	200

Table A.2. Komati Gorge Homestead 1: Average phytolith counts for Control and Archaeological samples.

	Control Samples		Archaeological Samples		
Phytolith morpohotypes	Surface Sample	Subsurface Sample	Sample B	Sample C	Sample D
Polylobate (*Panicoideae*)	3	2	1	3	3
Bilobate (*Panicoideae*)	140	135	71	74	74
Cross (*Panicoideae*)	2	2	1	1	4
Saddle (*Chloridoideae and Aristidoideae*)	28	37	64	63	66
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	11	16	27	23	26
Square (*Pooideae*)	2	1	4	0	1
Rondel (*Pooideae*)	4	1	8	10	9
Retangle (*Pooideae*)	1	2	10	18	2
Orbicular (*Pooideae*)	0	0	1	0	1
Reniform (*Pooideae, Danthonioideae and Ehrhartoideae*)	4	2	7	6	12
Oblong (*Pooideae*)	4	1	5	0	1
Hair	1	1	1	2	1
	200	200	200	200	200

Table A.3. Komati Gorge Homestead 1: Percentage of each phytolith morphotype observed in Control and Archaeological samples.

	Control Samples		Archaeological Samples		
Phytolith morpohotypes	Surface Sample	Subsurface Sample	Sample B	Sample C	Sample D
Polylobate (*Panicoideae*)	1.5	1	0.5	1.5	1.5
Bilobate (*Panicoideae*)	70	67.5	35.5	37	37
Cross (*Panicoideae*)	1	1	0.5	0.5	2
Saddle (*Chloridoideae and Aristidoideae*)	14	18.5	32	31.5	33
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	5.5	8	13.5	11.5	13
Square (*Pooideae*)	1	0.5	2	0	0.5
Rondel (*Pooideae*)	2	0.5	4	5	4.5
Retangle (*Pooideae*)	0.5	1	5	9	1
Orbicular (*Pooideae*)	0	0	0.5	0	0.5
Reniform (*Danthonioideae and Ehrhartoideae*)	2	1	3.5	3	6
Oblong (*Pooideae*)	2	0.5	2.5	0	0.5
Hair	0.5	0.5	0.5	1	0.5
	100	100	100	100	100

Table A.4. Komati Gorge Homestead 1: Ic and Iph values calculated for Control and Archaeological samples.

Komati Gorge Homestead 1		
	Ic Value (%)	**Iph value (%)**
Surface sample	11	16
Subsurface sample	13	21
Sample B	31	47
Sample C	29	45
Sample D	26	45

APPENDIX B: BFK1 PHYTOLITH DATA

Table B.1. Buffelskloof Private Nature Reserve Homestead 1: Control and Archaeological sample's phytolith counts.

	Control Samples				**Archaeological Samples**											
Phytolith morpohotypes	**1.1.1**	**1.1.2**	**1.2.1**	**1.2.2**	**2.2.1**	**2.2.2**	**2.2.3**	**3.2.1**	**3.2.2**	**3.2.3**	**4.2.1**	**4.2.2**	**4.2.3**	**5.1.1**	**5.1.2**	**5.1.3**
Bilobate (*Panicoideae*)	37	37	30	35	83	81	97	97	81	78	95	92	87	88	100	97
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	46	56	56	53	26	27	19	25	41	34	32	42	50	39	30	31
Square (*Pooideae*)	10	8	6	4	1	0	1	0	0	0	3	5	1	3	2	5
Hair	6	6	2	0	1	0	1	0	0	0	4	0	0	1	0	1
Rondel (*Pooideae*)	24	24	12	15	12	7	7	6	5	9	5	7	4	2	5	9
Saddle (*Chloridoideae and Aristidoideae*)	51	50	70	66	69	68	54	58	66	65	48	42	46	41	44	41
Cross (*Panicoideae*)	2	0	1	0	1	2	3	3	1	4	2	3	1	3	0	0
Orbicular (*Pooideae*)	2	1	0	3	0	0	0	0	0	0	0	0	0	0	1	1
Polylobate (*Panicoideae*)	3	0	2	2	1	5	5	5	1	3	4	2	0	1	0	4
Reniform (*Pooideae, Danthonioideae and Ehrhartoideae*)	6	10	8	7	6	10	10	6	3	6	4	3	3	5	6	0
Oblong (*Pooideae*)	13	8	13	15	0	0	3	0	2	1	3	4	8	17	12	11
	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200

Table B.2. Buffelskloof Private Nature Reserve Homestead 1: Average phytolith counts for Control and Archaeological samples.

	Control Samples		Archaeological Samples			
Phytolith morpohotypes	Surface Sample	Subsurface Sample	Sample 2	Sample 3	Sample 4	Sample 5
Bilobate (*Panicoideae*)	37	32	87	85	92	95
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	51	55	24	33	41	33
Square (*Pooideae*)	9	5	1	0	3	3
Hair	6	1	1	0	1	1
Rondel (*Pooideae*)	24	13	9	7	5	5
Saddle (*Chloridoideae and Aristidoideae*)	51	68	64	63	46	42
Cross (*Panicoideae*)	1	1	2	3	2	1
Orbicular (*Pooideae*)	1	1	0	0	0	1
Polylobate (*Panicoideae*)	1	2	3	3	2	2
Reniform (*Pooideae, Danthonioideae and Ehrhartoideae*)	8	8	8	5	3	4
Oblong (*Pooideae*)	11	14	1	1	5	13
	200	200	200	200	200	200

Table B.3. Buffelskloof Private Nature Reserve Homestead 1: Percentage of each phytolith morphotype observed in Control and Archaeological samples.

	Control Samples		Archaeological Samples			
Phytolith morpohotypes	Surface Sample	Subsurface Sample	Sample 2	Sample 3	Sample 4	Sample 5
Bilobate (*Panicoideae*)	18.5	16	43.5	42.5	46	47.5
Trapezoid (*Pooideae, Danthonioideae and Ehrhartoideae*)	25.5	27.5	12	16.5	20.5	16.5
Square (*Pooideae*)	4.5	2.5	0.5	0	1.5	1.5
Hair	3	0.5	0.5	0	0.5	0.5
Rondel (*Pooideae*)	12	6.5	4.5	3.5	2.5	2.5
Saddle (*Chloridoideae and Aristidoideae*)	25.5	34	32	31.5	23	21
Cross (*Panicoideae*)	0.5	0.5	1	1.5	1	0.5
Orbicular (*Pooideae*)	0.5	0.5	0	0	0	0.5
Polylobate (*Panicoideae*)	0.5	1	1.5	1.5	1	1
Reniform (*Pooideae, Danthonioideae and Ehrhartoideae*)	4	4	4	2.5	1.5	2
Oblong (*Pooideae*)	5.5	7	0.5	0.5	2.5	6.5
	100	100	100	100	100	100

Table B.4. Buffelskloof Private Nature Reserve Homestead 1: Ic and Iph values calculated for Control and Archaeological samples.

Buffelskloof Private Nature Reserve Homestead 1		
	Ic Value (%)	**Iph Value (%)**
Surface sample	54	53
Subsurface sample	48	66
Sample 2	22	41
Sample 3	23	41
Sample 4	29	32
Sample 5	30	30

APPENDIX C: PLANT SPECIES COMMON IN THE KANGWANE MONTANE GRASSLAND BIOME (ADAPTED FROM MUCINA *ET AL.* 2006b)

Graminoids

Alloteropsis semialata subsp. Eckloniana
Andropogon schirensis
Bewsia biflora
Brachiaria serrata
Bulbostylis burchellii
Ctenium concinnum
Cymbopogon caesius
Cyperus obtusiflorus var. obtusiflorus
Cyperus obtusiflorus
Digitaria diagonalis
Digitaria tricholaenoides
Diheteropogon amplectens
Diheteropogon filifolius
Eragrotis chloromelas
Eragrotis plana
Eragrostis racemosa
Eulalia villosa
Heteropogon contortus
Hyparrhenia hirta
Loudetia simplex
Monocymbium ceresiiforme
Panicum ecklonii
Panicum natalense
Paspalum scrobiculatum
Rendlia altera
Themeda triandra
Trachypogon spicatus
Tristachya leucothrix
Schizachyrium sanguineum
Setaria nigrirostris
Setaria sphacelata

Herbs

Acalypha peduncularis
Acalypha villicaulis
Alepidea setifera
Argyrolobium speciosum
Aster harveyanus
Berkheya setifera
Corchorus confuses

Cyathula cylindrical
Dicoma zeyheri
Dimorphotheca jucunda
Eriosema cordatum
Euryops laxus
Euryops transvaalensis subsp. setilobus
Helichrysum adenocarpum
Helichrysum cephaloideum
Helichrysum nudifolium var. nudifolium
Hemizygia modesta
Hemizygia thorncroftii
Impomoea oblongata
Lotononis difformis
Lotononis spicata
Mohria caffrorum
Pentanisia angustiflia
Pentanisia prunelliodes subsp. latifolia
Ruellia patula
Schistostephium crataegifolium
Selago stewartii
Senecio panduriformis
Sonchus wilmsii
Streptocarpus occultis
Thunbergia atriplicifolia
Vernonia natalensis
Vernonia oligocephala

Geophyic Herbs

Agapanthus inapertus subsp. inapertus
Boophone disticha
Cheilanthes deltoidea
Cheilanthes hirta
Eucomis Montana
Gladiolus ecklonii
Habenaria dregeana
Hypoxis iridifolia
Hypoxis rigidula var. pilosissima
Moraea pubiflora
Pteridium aquilinum
Watsonia latifolia
Watsonia watsonioides
Zantedeschia albomaculata subsp. Macrocarpa

Succulent Herbs

Aloe integra
Aloe kniphofioides
Kleinia galpinii

Small Trees

Acacia caffra
Faurea rochetiana
Pachystigma macrocalyx

Tree Ferns

Cyathea dregei

Tall Shrubs

Calpurnia glabrata
Cephalanthus natalensis
Diospyros lyciodes subsp. guekei
Vernonia tigna

Low Shrubs

Anthospermum rigidum subsp. rigidum
Asparagus cooperi
Asparagus virgatus
Athrixia phylicoides
Diospyros scabrida var. cordata
Gymnosporia heterophylla
Hemizygia albiflora
Heteromorpha involucrate
Indigofera comosa
Myrsine Africana
Rhus discolour
Schistostephium rotundifolium
Syncolostemon comptonii

APPENDIX D: PLANTS COMMON IN KOMATI GORGE AREA (ADAPTED FROM MULLER. 2013)

Grasses

Elionurus muticus
Heteropogon contortus
Setaria nigrirostris
Setaria sphacelata
Trachypogon spicatus
Aristida congesta
Aristida junciformis
Aristida meridionalis
Aristida scabrivalvis
Aristida bipartita
Digitaria monodactyla
Digitaria diagonalis
Microchloa caffra
Andropogon schirensis
Diheteropogon amplectens
Alloteropsis semialata subsp. Semialata
Cynodon dactylon
Bewsia biflora
Brachiaria serrata
Eragrostis capensis
Eragrostis gummiflua
Eragrostis plana
Eragrostis racemosa
Eragrostis chloromelas
Eragrostis curvula
Loudetia simplex
Melinis nerviglumis
Tristachya leucothrix
Tristachya rehmanii
Panicum natalense
Cymbopogon excavatus
Cymbopogon plurinodis
Hyparrhenia hirta
Themeda triandra
Monocymbium ceresiiforme
Sporobolus sp.
Rendlia altera
Trichoneura grandiglumis
Helictotrichon turgidulum
Paspalum dilatatum
Miscanthus junceus

Other vegetation

Kniphofia porphyrantha
Eulophia ovalis bainessii
Anematheca grandiflora
Crinum bulbispermum
Erythrina zeyheri
Papaver aculeatum
Pentanisia angustifolia
Striga elegans
Zantedeschia albumaculata
Scabiosa columbaria
Thunbergia atriplicifolia
Trachyandra sp.
Verbena tenuisecta
Wahlenbergia sp.
Ranuncullus multifidus
Oenothera tetraptera
Nerine angustifolia
Leonotis sp.
Ipoemoea crassipes
Hypoxis rigidula
Hypoxis obtusa
Helichrysum sp.
Habernaria sp.
Gladiolus grassifolius
Dianthus mooiensis
Aloe greatheadii
Agapanthus inapertus
Becium obuvatum
Chironia palustris subsp. Transvaalensis
Cleome sp.
Clerodendrum triphyllum var. triphyllum
Diospyros lycioides
Diospyros austro africana
Stoebe vulgaris
Pycreus rehmannianus
Cyperus difformis
Eliocharis limosa
Aponogeton sp.
Limosella maior
Arundinela nepalensis
Salix babylonica
Acacia dealbata
Acacia mearnsii
Populus x canescens
Eucalyptus sp.

Crataegus pubescens

APPENDIX E: PLANTS COMMON IN THE NORTHERN MISTBELT FOREST BIOME (ADAPTED FROM Mucina *ET AL.* 2006a)

Tall Trees

Anthocleista grandiflora
Aphloia theiformis
Brachylaena transvaalensis
Chionanthus battiscombei
Chionanthus foveolatus subsp. major
Combretum kraussii
Cryptocarya transvaalenis
Curtisia dentata
Drypetes gerrardii
Faurea galpinii
Kiggelaria africana
Maytenus acuminate
Ochna gamostigmata
Ocotea kenyensis
Olea capensis subsp. macrocarpa
Podocarpus latifolius
Psydrax obovata subsp. elliptica
Pterocelastrus galpinii
Rapanea melanophloeos
Rothmannia capensis
Rhus chrindensis
Schefflera umbrellifera
Syzygium gerrardii
Trichilia dregeana
Xymalos monospora

Small Trees

Cassipourea malosana
Dombeya pulchra
Englerophytum magalismontanum
Gymnosporia harveyana
Heteropyxis canescens
Mackaya bella
Oxyanthus speciosus subsp. gerrardii
Ochna arborea var. oconnorii
Peddiea africana
Rinorea angustifolia

Woody Climbers

Acacia ataxacantha

Bauhinia galpinii
Dalbergia armata
Keetia gueinzii
Rhoicissus rhombiodea

Climbing Graminiods

Prosphytochloa prehensilis

Tall Shrubs

Coptosperma rhodesiacum
Canthium kuntzeanum
Carissa bispinosa subsp. zambesiensis
Pavetta barbertonensis
Pavetta kotze
Psychotria capensis
Psychotria zombamontana
Sclerochiton harveyanus

Soft Shrubs

Duvernoia adhatodoides
Galopina circaeoides
Hypoestes triflora

Mega Herbs

Ensete ventricosum
Strelitzia caudata

Herbs

Begonia sonderiana
Plectranthus rubropunctatus
Plectranthus swynnertonii
Plectranthus tetragonus
Sphaerocionium capillare
Streptocapus davyi
Streptocarpus fenestra-dei
Streptocarpus meyeri
Streptocarpus micranthus
Streptocarpus parviflora

Streptocarpus pentherianus
Streptocarpus roseo-albus
Streptocarpus wilmsii

Epiphytic Herbs

Asplenium aethiopicus
Asplenium boltonii
Asplenium splendens
Clivia caulescens
Crocosmia aurea
Dryopteris inaequalis
Dietes iridioides
Mystacidium brayboniae

Geophytic Herbs

Elaphoglossum acrostichoides
Polypodium polypodioides subsp. ecklonii
Polystichum macleae
Pteris catoptera

Graminoids

Carex spicato-paniculata
Cyperus albostriatus
Oplismenus hirtellus

APPENDIX F: PLANTS COMMON IN THE BUFFELSKLOOF PRIVATE NATURE RESERVE (ADAPTED FROM BURROWS 2002)[1]

Mosses

Dumortiera hirsuta
Lunularia cruciata
Radula lindenbergiana
Frullania ericoides
Dicranolejeunea chrysophylla
Lopholejeunea fragilis
Ptychanthus striatus

Ferns

Lycopodium carolinianum var. grandifolium
L. cernuum
L. clavatum
L. gnidioides
L. verticillatum
Selaginella caffrorum
S. dregei
S. mittenii
Equisetum ramosissimum
Ophioglossum lusoafricanum
O. polyphyllum
O. reticulatum
O. vulgatum subsp. africanum
Marattia fraxinea var. salicifolia
Osmunda regalis
Todea barbara
Anemia dregeana
Mohria vestita
M. marginalis
Schizaea pectinata
Dicranopteris linearis
Gleichenia polypodioides
G. umbraculifera
Hymenophyllum tunbrigense
Trichomanes borbonicum
T. melanotrichum
T. rigidum
Cyathea dregei
Pteridium aquilinum subsp. aquilinum

[1] The Buffelskloof Private Nature Reserve contains thousands of plant species. This is a selection of the common taxa observed.

Adiantum capillus-veneris
A. poiretii
Cheilanthes eckloniana
C. hirta var. nemorosa
C. inaequalis var. buchananii
C. viridis var. viridis
Doryopteris concolor
Pityrogramma argentea
Pteris catoptera var. catoptera
P. cretica
P. dentata
P. vittata
Pellaea calomelanos var. calomelanos
P. dura
P. pectiniformis
Loxogramme lanceolata
Pleopeltis macrocarpa
P. schraderi
Pleopodium simianum
Polypodium polypodioides subsp. ecklonii
Asplenium adiantum-nigrum var. adiantum-nigrum
A. aethiopicum
A. boltonii
A. gemmiferum
A. erectum var. erectum
A. lobatum var. lobatum
A. monanthes
A. protensum
A. rutifolium
A. splendens
A. theciferum var. concinnum
A. varians subsp.fimbriatum
Ceterach cordatum
Thelypteris bergiana
T. confluens
T. dentata var. dentata
T. gueinziana
T. pozoi
Athyrium scandicinum
Cystopteris fragilis
Elaphoglossum acrostichoides
E. spathulatum
Cyrtomium caryotideum var. micropterum
Dryopteris athamantica
D. inaequalis
D. squamiseta
Polystichum transvaalense

P. luctuosum
Blechnum attenuatum var. giganteum
B. australe
B. capense
B. punctulatum var.atherstonei
B. tabulare

Cycads and conifers

Pinus patula
Widdringtonia schwarzii

Grasses

Agrostis lachnantha var. lachnantha
Alloteropsis semialata subsp. eckloniana
Andropogon appendiculatus
A. eucomus
A. schirensis
A.Rich.
Aristida recta
Brachiaria brizantha
B. serrata
Brachypodium flexum
Briza maxima
Bromus catharticus
B. speciosa
Chloris diluta
Cymbopogon nardus
Danthoniopsis pruinosa
Digitaria debilis
D. tricholaenoides
Diheteropogon filifolius
Ehrharta erecta var. erecta
E. erecta var. natalensis
Eragrostis capensis
E. chloromelas
E. curvula
E. racemosa
Festuca caprina var caprina
F. costata
Helictotrichon turgidulum
Heteropogon contortus
Hyparrhenia cymbaria
Ischaemum fasciculatum
Koeleria capensis
Loudetia camerunensis

Melicia racemosa
Melinis nerviglumis
M. repens subsp. repens
Merxmuellera macowanii
Monocymbium ceresiiforme
Oplismenus hirtellus
Panicum deustum
P. natalense
P. maximum
Paspalum urvillei
Pennisetum natalense
Phragmites australis
Poa annua
Prosphytochloa prehensilis
Rendlia altera
Rottboellia cochinchinensis
Schizachryium sanguineum
Setaria lindenbergiana
S. megaphylla
S. pumila
S. sphacelata var. sphacelata
S. sphacelata
Schumach. var. sericea
Sporobolus centrifugus
S. pectinatus
Sporobolus sanguineus
Stiburus alopecuroides
Themeda triandra
Trachypogon spicatus
Trichopteryx dregeana
Tristachya biseriata
T. leucothris

Sedges

Ascolepis capensis
Bulbostylis burchellii
B. humilis
B. scabricaulis
B. schoenoides
Carex austro-africana
C. cognate var. cognata
C. spicato-paniculata
Costularia natalensis .
Tetraria natalensis
Cyperus albostriatus
C. cyperoides

C. keniensis .
C. leptocladus
C. obtusiflorus var.flavissimus
C. pseudoleptocladus
C. schlechteri
Ficinia gracilis
F. stolonifera
Fuirena pubescens
F. stricta
Fimbristylis dichotoma
F. stricta
Isolepis costata var. macra
I. fluitans
Kyllinga alba
K. melanosperma
K. odorata
Mariscus dregeanus
M. uitenhagensis
Pycreus mundii
P. muricatus
Schoenoplectus corymbosus
Schoenoxiphium lehmannii
S. madagascariense
S. sparteum
Scleria nutans
S. woodii

Trees and shrubs (also includes vines)

Salix babylonica
S. mucronata
Morella brevifolia
M. microbracteata
M. pilulifera
M. serrata
Celtis africana
Trema orientalis
Chaetacme aristata
Ficus craterostoma
F. glumosa
F. ingens var. ingens
F. salicifolia
F. sur
F. burkei
F. thonningii
Osyridocarpus schimperianus
Osyris lanceolata

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Thesium racemosum
Annona senegalensis
Pittosporum viridiflorum
Myrothamnus flabellifolia
Parinari capensis subsp. capensis
Cassine piragua subsp. peragua
Gymnosporia buxifolia
G. grandifolia
G. heterophylla
G. harveyana
G. mossambicensis var. mossambicensis
Maytenus acuminata
M. albata
M. peduncularis
M. undata
Pleurostylia capensis
Pterocelastrus echinatus
Pterocelastrus rostratus
Robsonodendron eucleiforme
Cassine eucleiformis A
podytes dimidiata subsp. dimidiata
Cassinopsis ilicifolia
Pyrenacantha grandiflora
Berchemia zeyheri
Helinus integrifolius
Phylica paniculata
Rhamnus prinoides
Scutia myrtina
Ziziphus mucronata subsp. mucronata
Ochna confusa
O. holstii
O. natalitia
Adenia gummifera var. gummifera
Basananthe sandersonii
Passiflora edulis Cassipourea gerrardii
Englerophytum magalismontanum
E. natalense
Mimusops obovata
M. obtusifolia
Diospyros galpinii
D. lycioides subsp. guerkei
D. lycioides subsp. sericea
D. whyteana
Euclea crispa subsp. crispa
E. natalensis subsp.natalensis
Chionanthus foveolata subsp. foveolata
Jasminum breviflorum

J. quinatum
J. streptopus. var. transvaalensis
Olea europaea subsp. africana
Schrebera alata
Cynoglossum lanceolatum
Ehretia rigida
Trichodesma physaloides

Legumes

Aeschynomene rehmannii var. eptobotrya
Argyrolobium harveyanum
A. pseudotuberosum
A. tomentosum
Calpurnia aurea
Crotolaria capensis
C. recta
Dalbergia armata
Desmodium repandum
D. setigerum
Dolichos pratensis
Dumasia villosa var. villosa
Eriosema angustifolia
E. kraussiana
E. psoraleoides
Erythrina lysistemon
Flemingia grahamiana
Indigofera frondosa
I. hedyantha
I. lydenburgensis
I. masonae
I. melanadenia
I. oxalidea
I. sanguinea
I. swaziensis subsp. perplexa
I. tristoides
Lotononis laxa
Lotus discolor ssp. discolor
Neonotonia wightii

Herbs

Acalypha caperonioides
A. glabrata
A. schinzii
Adenocline acuta
Clutia affinis

C. laxa
C. monticola
C. pulchella
Euphorbia clavarioides var. clavarioides
E. cooperi
E. ingens
E. kraussiana
E. peplus
Jatropha latifolia var. latifolia
Phyllanthus burchellii
Alectra orobanchoides
A. parvifolia
A. sessiliflora
Bowkeria cymosa
Buchnera dura
Craterostigma wilmsii
Cycnium adonense
C. racemosum
Diclis reptans
Graderia subintegra
Halleria lucida
Harveya huttonii
Jamesbrittenia grandiflora
Nemesia fruticans
N. strumosa
Sopubia mannii var. tenuifolia
Striga elegans
Sutera caerulea
S. neglecta
S. paucifolia

Gourds

Coccinia adoensis