Reconstruction of environments and plant use in Holocene Southern Africa : study of macrobotanical remains from Late Stone Age sites of Toteng (Botswana), Leopard Cave and Geduld (Namibia)

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RECONSTRUCTION OF ENVIRONMENTS AND PLANT USE IN HOLOCENE SOUTHERN AFRICA

STUDY OF MACROBOTANICAL REMAINS FROM LATE STONE AGE SITES OF TOTENG (BOTSWANA), LEOPARD CAVE AND GEDULD (NAMIBIA)

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To all the mothers I acquired along the way

ABSTRACT / RÉSUMÉ

Through macrobotanical (wood charcoal and seeds/fruit) analysis from three major Later Stone Age (LSA) sites located in the Kgalagadi Basin in southern Africa, this study is interested in reconstructing the environmental conditions during the Holocene in the region, in particular in the last two to three millennia. Initially this work couples archaeological macrobotanical analysis with the construction of modern reference material in an effort to trace the environmental/vegetal evolution as well as to comprehend socio-ecological and socio-environmental dynamics in Southern Africa during the late Holocene. The scope of this study covers the period spanning the last 3000-2000 years, with the main objective of understanding what relationships humans had with their environment at a time linked with the arrival or the appearance of the first herding practices in that part of Africa. These herding practices are believed to be accompanied by significant human movement from eastern or central Africa southwards. Favourable environmental conditions may have influenced their routes as well as settlement choices, and these are aspects that this archaeobotanical study aims to address. This study also employed an ethnographic approach, working with local communities in the Erongo region of Namibia, so as to make inferences to past vegetation utilisation practices while at the same time discerning and reconstituting past human activities.

Keywords: macrobotany, archaeobotany, wood charcoal analysis, seed analysis, Holocene, Southern Africa, Later Stone Age, ethnography, environmental reconstruction

A travers l'analyse de matériel macrobotanique (charbon et graines /fruits) issus de trois sites majeurs du *Later Stone Age* (LSA) d'Afrique australe, cette étude s'intéresse à reconstituer les conditions environnementales durant l'Holocène dans la région, en particulier au cours des deux à trois derniers millénaires. L'étude de ce matériel, accompagné de la constitution d'une collection moderne de références de la végétation du bassin Kgalagadi, vise à mieux cerner l'impact que l'environnement a pu avoir sur les sociétés humaines (subsistance, peuplements, etc.) à une période-clé du *(LSA)*, qui marque l'émergence des pratiques pastorales dans la région. L'étude des environnements est ici primordiale pour interpréter les conditions qui ont pu favoriser l'arrivée de ces premiers éleveurs et leurs lieux d'installation. En complément, une approche ethnographique a été menée, en travaillant avec les communautés locales dans la région de l'Erongo en Namibie, qui peuvent aider à comprendre et reconstituer les pratiques passées d'utilisation de la végétation.

Mots –clés: macrobotanique, archèobotanique, anthracologie, carpologie, Holocène, Afrique austral, Later Stone Age, ethnographie, reconstruction environnementale

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Introduction

Southern Africa[1] is an important part of the scene in the narrative of human evolutionary history. The subcontinent has produced several early hominin taxa, from the Australopithecines and the early representatives of the genus Homo (Pickering et al. 2011) to the first anatomically Modern Humans.

Today the region is home to several ethnicities among them the autochthonous San community whose members are considered to be the descendants of the first people of southern Africa. Upon their early interactions with other groups, notably the proto-Khoekhoe, until recent times, their territory remained mainly restricted to the dry Kgalagadi basin, with a population essentially shared between modern Namibia, Botswana, South Africa and Zimbabwe. Their ancestors existed in the region for thousands of years before the arrival of proto-Khoekhoe herders around 2000 years ago and then Bantu-speaking agro-pastoralists from East and Central Africa (Pleurdeau et al. 2012, Mitchell 2002) followed by European colonisers from the 17th century on.

The lifestyle and particular adaptations of one of the last remaining hunter and gatherer populations of Southern Africa, evolving in an environment that is strongly marked by aridity, has attracted the attention of scholars and travellers since the 18th century and the San communities, even though they have now largely (been) converted into sedentary herders, are often cited as an example in anthropological research. In contrast, our knowledge of the interactions between the ancestors of the San and their environment is still limited due to a lack of systematic studies of well-preserved remains from prehistoric sites.

In this work we aim at investigating the relationship between the Late Stone Age populations in Southern Africa and one element of this environment: the plant world. Our work is based on the study of archaeobotanical macroremains (charcoal and charred, desiccated and mineralised seed/fruit remains) from three sites: Leopard Cave and Geduld in present-day Namibia and

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[1] The southernmost region of the African continent, comprising the countries of Botswana, Angola, Lesotho, Malawi, Mozambique, Namibia, South Africa Swaziland, Zambia and Zimbabwe is referred to in this work as Southern Africa or as the African subcontinent.

Toteng in Botswana (Figure 1). Together they span a chronological period of more or less 2900 years, from ca. 3700 cal BP to ca. 800 cal BP.

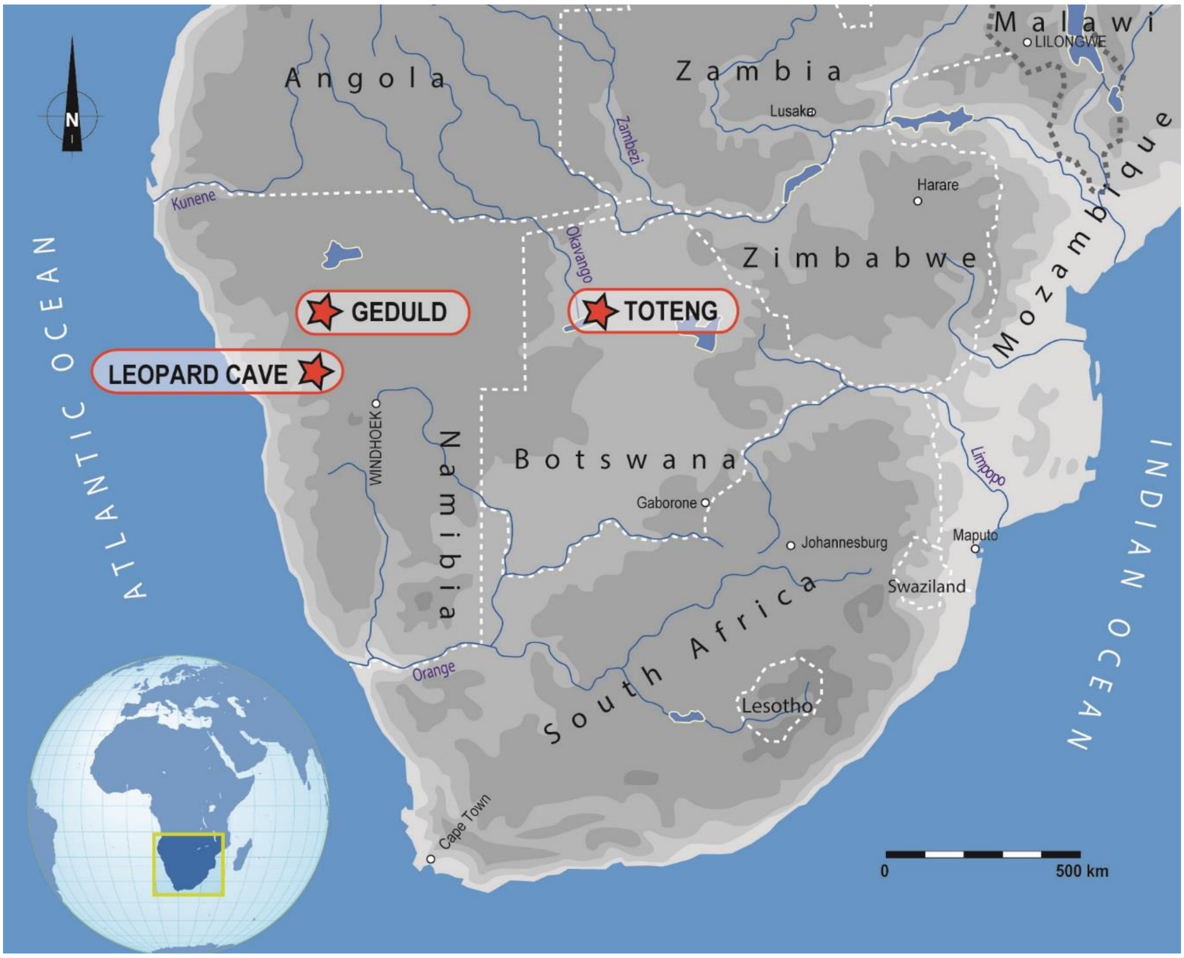

Figure 1: Map of Southern Africa with the localisation of the study sites

The three sites are situated within the vast Kgalagadi basin covering a territory of approximately 2.5 million km^2 in Southern Africa and hosting a large diversity of landforms including rocky outcrops, extensive sand flats and major paleolake basins. New and advanced research methods have in the past few decades brought to light the diversity of the Southern African Quaternary paleoclimates and environments, predominantly by using multi-proxy approaches (Eitel et al. 2006). Close links exist between climate, topography, soil types, vegetation, flooding patterns and the temporal and spatial evolution of the environment. Major environmental changes, though sometimes controversial, are widely viewed as a significant driver of human evolution in Southern Africa and in Africa as a whole (Scott and Woodborne 2007).

One source of information on past plant formations and their evolution through time is provided by pollen studies. The survival of pollen is dependent though on the nature of deposits and the dry environments that prevail in Southern Africa are usually unfavourable to the preservation of this type of organic markers (Wadley 2006). Despite the rarity of adequate "preservation containers" (Scott and Neumann 2018) several studies have been conducted in the region since the 1950s allowing for reconstructions of the Pleistocene and Holocene vegetation cover in different areas. A recent work summarised these results allowing a closer view of pollen sequences over a wide region and providing clues to a better comprehension of paleoclimatic conditions (Scott el al. 2012). At the same time this study has revealed the heterogeneous and fragmentary nature of the available data suggesting that supplementary, high-resolution pollen information in association with other palaeoenvironmental proxies is still much needed. The scarcity of sites, non-standardised methods of interpretation and low taxonomical resolution are among the factors that make it difficult to come up with a consistent and continuous regional palaeoenvironmental reconstruction. In order to compensate for bad preservation, alternative pollen sources notably from marine cores and hyrax[2] dung are also considered (for example Gil-Romera et al. 2006, 2007, Scott and Woodborne 2007b, Lim et al. 2016, Scott, Marais and Brook 2004). While these can be very rich in information on the past vegetation their depositional history, and thus geographical and floral representativeness, is quite different from that of terrestrial and fluvial/lacustrine deposits.

Another source of information on past plant formations, especially those that grew near settlement sites and with which past populations interacted, is provided by the study of charred wood remains from archaeological contexts. The archaeobotanical discipline dealing with this material - anthracology (from the Greek word *anthrax* - charcoal) - is developed, together with the study of seed and fruit remains, in our work.

The analysis of charred wood from archaeological settlements, camp fires and graves brings to light the human use of fuel and timber wood, thus addressing different aspects the wood economy of past populations (Ludemann and Nelle 2017). Moreover, when certain

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[2] The hyraxes are small herbivorous mammals belonging to the order of *Hyracoidea*. Four of these live in Africa, a fifth can also be found in the Middle East.

methodological procedures are respected, charcoal remains stemming from domestic fires (used for cooking, heating, etc.) are likely to provide a representative image of the ligneous vegetation that was exploited for fuel over a longer period of time and thus indirectly of the local landscape dynamics (Ludemann and Nelle 2017). In some instances, charcoal can even be used as a proxy for reconstructing past climates (Thornton-Barnett 2013). Indeed the expression “timber does not fly” (Leroi-Gourhan in Neumann 1992) applies here as wood charcoal is usually found in situ and provides an idea of the environment within which it is found (Dotte-Sarout et al. 2015).

Charcoal studies are still rare in Southern Africa and one major reason for this is without doubt the lack of covered and/or stratified deposits, notably in rock shelters and caves, where organic remains are better preserved than they are in shallow open-air sites (Eichhorn and Jürgens 2003). South Africa, including Lesotho and Swaziland, concentrates the highest number of studies and this is also the region where rock shelters are more numerous (Prior 1983, Prior and Williams 1985, Lennox and Bamford 2016, 2017, Esterhuysen 1996, Esterhuysen and Mitchell 1996, Thornton-Barnett 2013, Allsop 1998, Sievers 2006, 2016, Wadley et al. 2011, Shackleton and Prins 1992). Few anthracological studies have so far been undertaken In Namibia and none in Botswana (Vogelsang et al. 2002 and 2010) (Table 1).

Despite the development of anthracology during the last decades our vision of Man-plant interactions remains patchy in this part of the world. Antonites and Antonites (2013) deplore for example the lack of studies concerning Early Farming Bantu communities in South Africa and their regret could unfortunately apply to their geographical regions and periods of the Southern African Prehistory. Many of the above-mentioned studies concern for example mainly Pleistocene occupations and Holocene settlements have for various reasons been less in focus.

At many sites from this period systematic collecting of archaeobotanical remains was not part of excavation priorities. Even when plant remains were collected and analysed, for example at Big Elephant and Geduld, and providing interesting results on fruit collection and seasonality, a lack of a systematic sampling of charcoal remains prevented more detailed anatomical and statistical approaches analysis (Wadley, 1979, 2016, Smith et al. 2010, Kinahan 1995, Jacobson 1987). Questions pertaining to past practices of management and exploitation of wood resources as well as the anthropogenic impact on the vegetation are thus difficult to address adequately. For the same reasons, little is known on the distribution of plant species during the Late Pleistocene and the Holocene.

Table 1: Summary of general published charcoal studies in Africa from both the Pleistocene and Holocene periods

Country/region	Site	Period	References
South Africa	Elands Cave Bay	Pleistocene	Allsop 1998
South Africa	Free State	Holocene/Pleistocene	Thornton-Barnett 2013
South Africa	Rose Cottage, Sibudu	Pleistocene	Wadley 1991, 2006, Wadley et al. 2011
South Africa	Sibudu	Pleistocene	Lennox & Bamford 2015, 2016, 2017, Sievers 2006, 2016
South Africa		Holocene: farming communities	Antonites and Antonites 2013
South Africa			Robbertse et al. 1980
South Africa, Lesotho	Caledon River	Holocene/Pleistocene	Esterhuysen 1996
Lesotho	Western Lesotho	Holocene/Pleistocene	Esterhuysen & Mitchell 1996
Swaziland	Lubombo Mountains	Holocene	Prior & Williams 1985
Namibia	Kaokoland	Holocene/Pleistocene	Eichhorn 2002, Vogelsang et al. 2002, 2010
Mozambique	Chibuene	Holocene: farming communities	Ekblom et al.2014
Cameroon	Dibamba	Holocene: Iron Age	Höhn & Neumann 2017
Central Africa	Muyambe Forest	Holocene	Hubau et al. 2011
Togo	Bassar area	Holocene: Iron Age	Eichhorn & Robion-Brunner 2017
Namibia	Kunene region	Holocene/Pleistocene	In Vogelsang and Eichhorn
Namibia	Northern Namibia	Holocene	Ritcher and Eichhorn 2002
West Africa		?	Rolando 1997

Besides charcoal remains, our work is based on seed/fruit assemblages collected during the excavations at Leopard Cave and Geduld. This type of plant remains can more often be identified to the species level than charcoal and thus provide a higher taxonomic resolution. Moreover seed and fruit remains bear witness to other activities than fuel collection notably to foraging for food, fodder and medicinal uses (Thornton-Barnett 2013). In Southern Africa most fruit/seed studies concern Middle Stone Age sites like Sibudu (Sievers 2015, Sievers 2017, Wadley 2004, 2006) and much less can be said about Holocene/LSA settlements (Symes 2008, Symes, 2012). From some hunter-gatherer sites in Lesotho there is for example only a mention of the presence of seed deposits but without further precisions (Plug 1997).

The objective of our work is thus to produce new data on Late Stone Age environments and plant economies. The botanical identification of charcoal remains from the three sites mentioned above will allow us to reconstruct the vegetation communities present in the surroundings of the sites between during the second half of the Holocene. Our perspective is comparative both across space and time. Thus, did the populations inhabiting Leopard Cave, Geduld and Toteng benefit from similar environments or did the composition of the flora vary from one site to another? Did the vegetation communities change over time, for example due to overexploitation and/or climatic change? Can we detect changes in the vegetation that might be linked to changes in the subsistence system such as the introduction of domestic livestock, a question that has been much debated in the context of Southern African Holocene Late Stone Age communities? Have some species disappeared between this period and today?

Through the anthracological analysis we are also interested on how past populations organised the acquisition of wood for fuel and other uses. Did they visit different habitats for colleting wood? Do they seem to have operated a choice of species? Were some species avoided as it can sometimes be the case among populations inhabiting these regions today?

The seed/fruit analysis allows us to approach several other aspects of past plant economies such as the collecting of plants for food. Through the presence of different species we can also gain supplementary information on the composition of the vegetation cover. Did communities collect fruits and seeds from the same species as those they used for fuel or are there discrepancies between the two datasets? Where were seeds and fruits collected (catchment areas) and when (seasonality)? How were they prepared and consumed?

The present thesis follows a classical plan with two introductory chapters (I and II) describing the environmental and archaeological context of our study. A third chapter is dedicated to the material and methods comprising a section dealing specifically with the constitution of a reference collection, an indispensable tool for the identification of archaeological charcoal samples. The anatomy of the wood species making up the comparative collection is presented in detail as an appendice, in the form of anatomical plates and descriptions. During fieldwork in Namibia we had the opportunity to conduct among present-day local Damara and San communities and the results of our enquiries on the present plant exploitation and use are exposed in chapter IV.

In chapter V we present the results of our identifications of wood charcoal and seed/fruit remains from Leopard Cave, Geduld and Toteng. The taxa identified are described in detail, followed by a presentation of the quantitative results from each site.

The discussion in terms of paleoenvironment and plant uses constitutes the chapter VI followed by a conclusion and future perspectives.

CHAPTER I - ENVIRONMENTAL BACKGROUND OF SOUTHERN AFRICA

1. Environmental context

1.1. Delimitation of the study area

The three sites concerned by our study are located in the west/central parts of Southern Africa, slightly north of the Tropic of Capricorn (or Southern Tropic) and south of the vast alluvial fan created by the endorheic delta of the Okavango River in northern Botswana (Figure 2). The study zone is comprised within the semi-arid Kgalagadi[3] basin that extends over 2.5 million km^2 in Southern Africa mainly in present-day Namibia, Botswana and South Africa with minor encroachments also into Angola, Zambia and Zimbabwe in its northern parts.

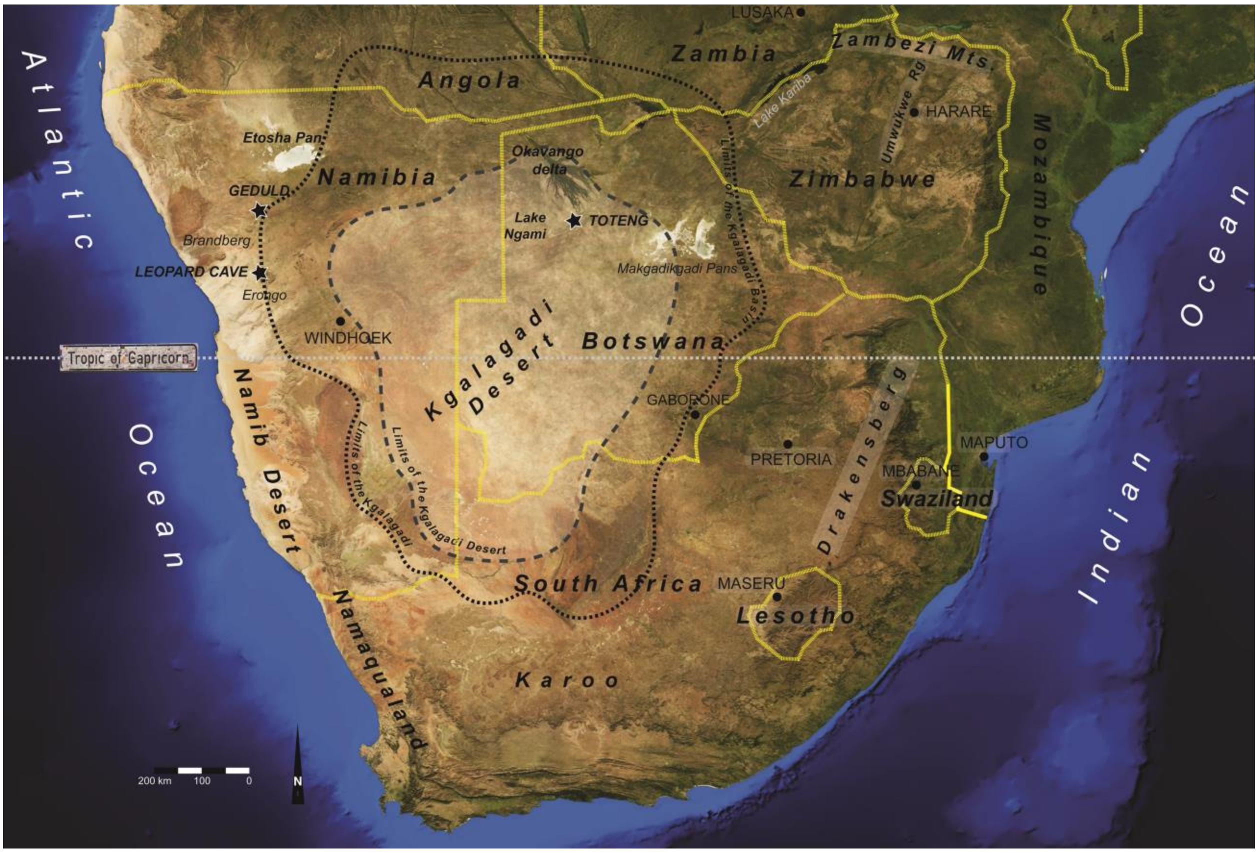


Figure 2: Map of Southern Africa with the localisation of the study sites and geographical features mentioned in the text

[3] Kalahari was derived from the word Kgalagadi which refers to "the land that has dried up" or "the land of thirst". The name stems from the Setswana verb "*go kgala*" meaning to "dry up". The name Makgadikgadi (saltpans) also has the same connotations. The words Kalahari & Kgalagadi have been used interchangeably in literature over the years.

The Kgalagadi (or Kalahari) desert, covering a surface of approximately 900,000 km^2 constitutes the heart of the homonymous basin. The present day Kgalagadi basin is characterised by a diversity of open landscapes comprising savannahs, shrublands, grasslands and sand deserts (Van Wyk and Van Wyk 2007).

1.2. Geomorphology and soils

During the late Jurassic and early Cretaceous, Southern Africa underwent a number of significant epirogenic[4] movements (Tooth 2002).

Recent investigations of proxy evidence for climatic and environmental changes (Table 2) suggest that a temporally and spatially complex succession of events characterised the evolution of Southern Africa during the late Quaternary period (Shaw 2003; Thomas and Shaw 2002). Multi-proxy data including lacustrine carbonates, diatoms, shoreline sediments, pollen records etc. has allowed the reconstruction of landforms, climate and biodiversity over a long period covering the late Pleistocene and the Holocene periods. Aeolian records reflect an arid phase that occurred during the Last Glacial Maximum while the beginning of the Holocene presents warmer and more humid conditions due to sea surface temperature movements (SST) (Humphries et al. 2017). Such variations in climate of course had considerable influence on the flora and fauna of the region. Palaeoenvironmental research is still going on in Southern Africa with the quest to further elucidate the longstanding history of past climatic changes as well as to comprehend the prospective changes.

[4] Vertical tectonic movement that compresses the earth's crust in slow displacements usually showing long wavelengths but exhibiting little folding, rather tending to lift whole land masses evenly.

Table 2: Summary of current geomorphological literature bearing on Southern Africa

Proxy used	Region concerned	Period	References
Palaeoclimatic data	Africa	Late Pleistocene	Blome et al. 2012
Dune deposits	SW Kgalagadi	Holocene	Blumel et al. 1998
Lacustrine and fluvial features	Middle Kgalagadi	Late Quaternary	Burrough et al., 2009
Lake beach ridges	Northern Botswana	Pleistocene-Holocene	Burrough et al., 2007
Pollen from cow dung	Botswana, Zimbabwe,	Holocene	Carrión et al. 2000
Temperature, rainfall	South Africa	Late Quaternary	Chevalier& Chase, 2016
Archaeology	Kgalagadi	Holocene	Denbow, 1986
Fluvial deposits, soil sediments	NW Namibia	Holocene	Eitel et al.2002;2005;2006
Pollen from hyrax middens	NW Namibia	Holocene	Gil-Romera et al 2007a,
Dunes, marine and fluvial	Namibia	Holocene	Heine, 2004;2005
Stalagmites	NE South Africa	Holocene	Holmgren et al., 1999
Aeolian sediments	E coast Southern Africa	Holocene	Humphries et al. 2017
Lacustrine sediments, diatoms	Lake Ngami basin, NW	Holocene	Huntsman-Mapila et al.
Palaeoclimatic data	Namib desert	Late Pleistocene	Lancaster, 2002
Carbon isotopes from bovid teeth	N Cape province, South	Pleistocene-Holocene	Lee-Thorp & Beaumont, 1995
Sedimentary cycles	Kgalagadi basin	Early Pleistocene	Matmon et al., 2015
Pollen from hyrax middens	South Africa	Late Quarternary	Gil-Romera et al., 2006
Pollen	South Africa	Late Pleistocene	Meadows et al.,1996
Rainfall and temperature	S and W Africa	Present (1961-2000)	New et al., 2006
Meteorology, sea surface	SW coast of Africa	Present (1948-72)	Nicholson&Entekhabi1987
Silt deposits	Central Namib desert	Terminal Pleistocene-	Srivastava et al., 2006
Plant biomarkers, pollen records	N Angola and central South	Holocene	Rommerskirchen et al.,
Pollen from hyrax dung	SW Cape, South Africa	Late Pleistocene	(E. M. Scott, 1994)
Pollen from hyrax dung	W Cape, South Africa	Western Cape	Scott and Woodborne 2007
Pollen	Southern Africa	Middle and Late	Scott and Neumann 2018
Pollen from hyrax dung	NW Namibia	Pleistocene-Holocene	Scott et al. 2004
Lacustrine formations.	NW Botswana	Terminal Pleistocene-	Shaw, 1985; 1988
Calcrete, fossil wood	Middle Kgalagadi	Pleistocene-Holocene	Shaw & Cooke., 1986)
Diatoms, sand ridges, lake	NW Kgalagadi	Late Pleistocene	Shaw et al., 2003)
Stalagmites	N Namibia,	Holocene	Sletten et al., 2013
Sediments, paleosoils, in situ	Karoo, South Africa	Permian-Triassic	Smith et al.,1995
Meteorological records	W coast Southern Africa	Late Pleistocene	Stuut & Lamy, 2004
Deep sea sediments	NW Africa	Late Pleistocene	Stuut, et al., 2004)
Cave speleothems	Cape Province, South Africa	Late Pleistocene	Talma & Vogel, 1992
Diatoms, aeolian deposits,	Northwestern Kgalagadi	Pleistocene	Thomas et al.2002
Wetlands, wetland deposits	Eastern Free State, South	Pleistocene	Tooth and McCathy 2007
Alluvial ridges	Eastern Free State, South		Tooth et al. 2002
Palaeoclimatic data	Southern Africa	Holocene	Tyson & Lindesay, 1992
Stalagmites	NE South Africa	Holocene	Tyson et al. 2002
Stalagmites	NE Namibia	Holocene	Voarintsoa et al. 2016
Calcretes/Carbonates	Kgalagadi	Pliocene-Holocene	Watts, 1980)
Lacustrine archives	S Cape	Holocene	Wündish et al 2016

Geomorphological data provide a comprehension of the Kgalagadi basin's geological past and its evolution during the Quaternary period (Burrough et al. 2009, Matmon et al. 2015, Shaw 1988). The basin is mostly flat and comprises one of the largest sand bodies in the world. The middle Kgalagadi, in northern Botswana, includes three paleolake basins: Makgadikgadi, Ngami and Mababe. They constitute a vast area of internal drainage where ancient aeolian, fluvial and lacustrine sediments can be traced (Burrough and Thomas 2008). The paleolakes are associated with the still existing Okavango Delta and together they cover a total area of more than 60 000 km2. The abundance of ancient fluvial and lacustrine shorelines has rendered this area highly interesting for paleolacustrine research for more than four decades (Shaw 1985). Thomas et al. (2003) have documented the geomorphological setup of the Middle Kgalagadi especially the Lake Ngami, establishing a network of relic and current inflows substantiated by remnants of ancient shorelines. The dating of deposits by using diatom records and luminescence dating has revealed Holocene modifications of older landforms as well as fluctuations of the lakes' surfaces and levels during the Holocene period. Similar studies carried out in the Tsodilo hills used lacustrine sediments and carbonates, molluscs and diatoms as well as AMS, OSL and C14 dating (Thomas et al. 2003). Thanks to a multi-proxy approach this study has allowed to determine the timing of fluctuations between wetter and drier Quaternary periods in the Kgalagadi Basin. However, the approach is limited to certain areas of the basin as aeolian and lacustrine formations in stratigraphic formations are not found everywhere.

The northwestern part of the Kgalagadi basin is made up of remnants of aeolian dunes and ephemeral springs and drainage ways (Burrough and Thomas 2008).

Most of Southern Africa consists of plateaus covered by soils that can be as old as a million years (Dewitte et al. 2010). The determinants of the soil patterns are differences in age, parent material, physiography and past and present climatic conditions. The majority of soils found in the region are sandy arenosols composed mainy of quartz particles and with a poor waterholding capacity as well as poor nutrient contents (Figure 3). Wind-blown sands cover large tracts of the south-central and southeastern parts of the subcontinent and are for example predominant in present-day Botswana. These loose sandy deposits result from the drying up of the Kgalagadi group of paleolakes (see above) as well as other fluvio-lacustrine formations.

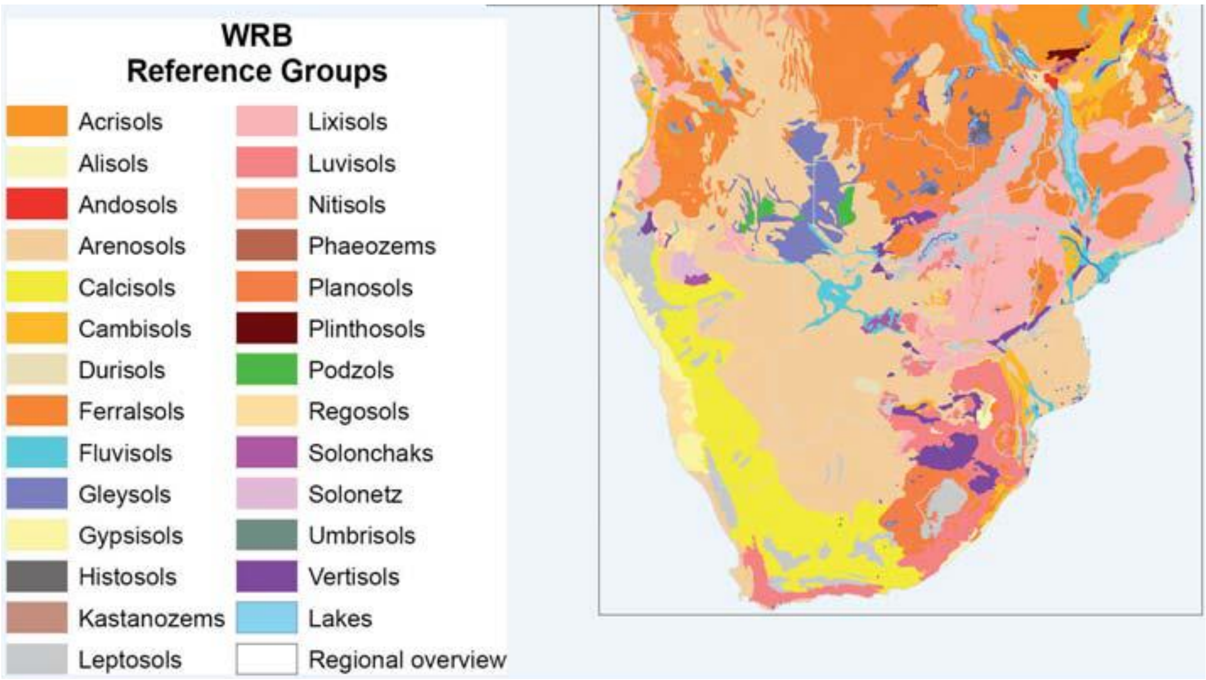


Figure 3: Major soil types of Southern Africa (Dewitte et al. 2010)

To the southwest and further south, the region is made up of xerosols, regosols and yermosols which are all aridisols and in conformity with the arid and desertic coastline area of western Namibia. Fluvisols are present in areas that have been flooded by surface waters or rising groundwater, from rivers or delta formations. In the north / central parts of the region, in southern Zambia, the soils are mostly of ferralsol type, with low occurences of arenosols. Ferralsols are old soils that have developed on geologically old parent material. A more diversified situation is visible in the interior of the Mozambican coast to the east and towards the eastern parts of the subcontinent in the South Africa's eastern Cape. Here a mixture of luvisols, vertisols and arenosols and planosols are present. The diverse landforms of this area with mountains, lowlands and wetlands contribute to a higher diversity of soil types. In the west (Namib Desert), the dominant soils are arenosols, gypsisols and leptosols together with sand dunes, gravel and rock outcrops (Heine 2005).

1.3. Past and present climatic conditions

Our study region belongs to the Semi-Arid and Arid Zones of the African continent, as defined by Bationo et al. (2012). The Semi-Arid Zone is characterised by average annual rainfalls of 200-

800 mm and is located between the sub-humid wooded savannah zone and the Arid Zone, at latitudes ranging between 15°-20°N and 15°-25°S (Figure 4). The Arid Zone extends north of latitude 20°N and south of latitude 20°S with annual rainfalls not exceeding 200 mm. The immense Saharan Desert in North Africa and the Namib and Kgalagadi deserts in Southern Africa are part of this arid zone.

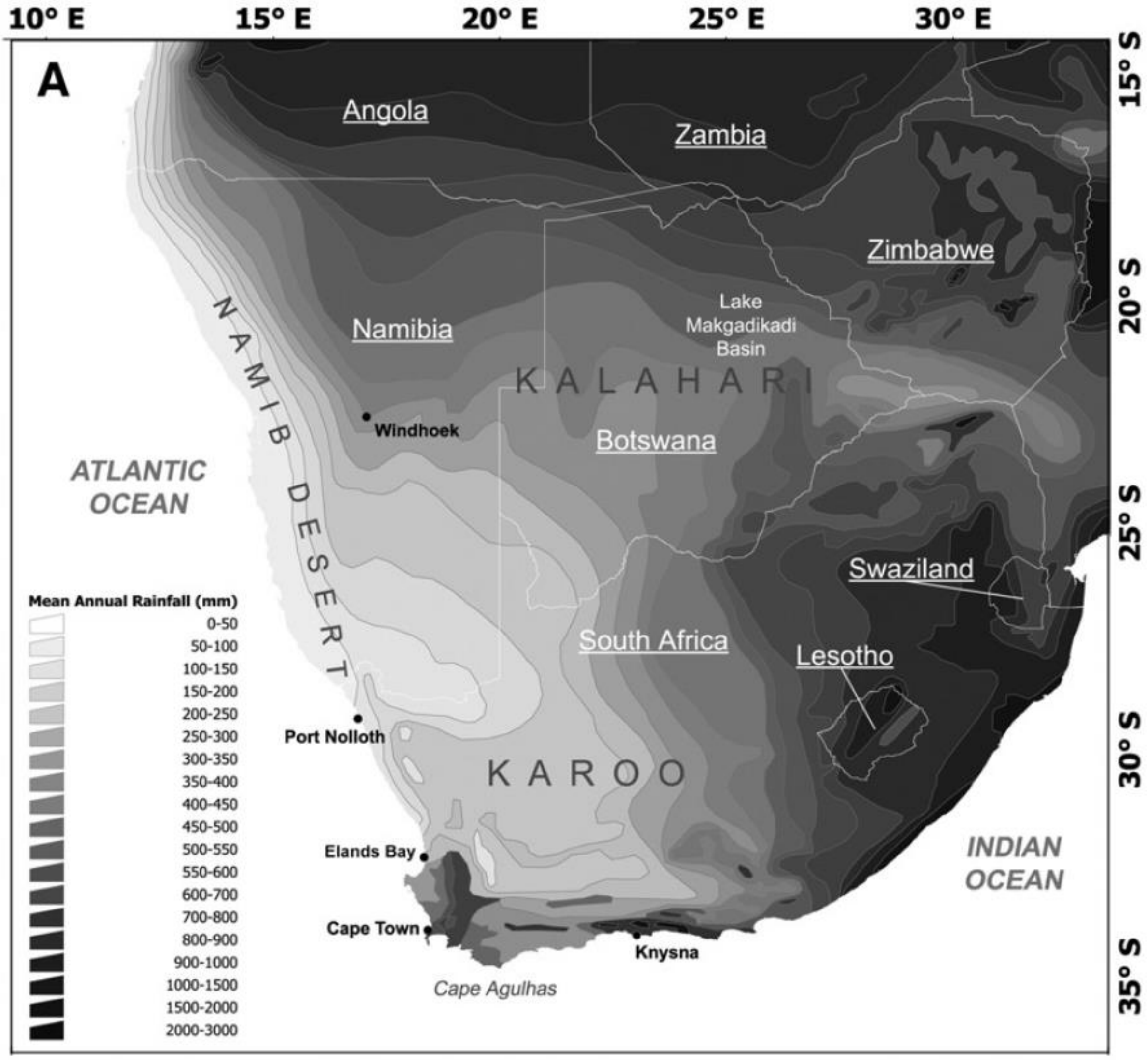


Figure 4: Modern annual precipitation over southern Africa (Chase and Meadows 2007)

The interior landmass of Southern Africa is influenced by several major rain-bearing systems principally relating to the limit of the Inter Tropical Convergence Zone (ITCZ) that migrates south during the southern hemisphere summer. This migration divides the ridge of high pressure responsible for the stable winter drought conditions (April-October) and allows the penetration of the Indian Ocean easterly low pressure bringing rainfall into the southern summer rainfall zone

(Burrough et al. 2009). The Atlantic is a secondary source of moisture for Southern Africa also strongly associated with the ITCZ and supplying moisture via the tropical westerlies (recurved equatorial trade winds) principally to the region northwest of the Middle Kalahari at approximately 12°S. Angola, the source region of the Middle Kalahari's principal river systems, marks the southernmost limit of the rain-bearing systems associated with the West African Monsoon.

As a result the Southern African climate is diverse, ranging from warm and wet condition in the eastern part to semi- to hyper-arid climates in the central and western areas. Mediterranean climate conditions even prevail in the southwest. The neighbouring ocean currents play a major role for shifts in atmospheric circulation and changes in sea surface temperatures interact to influence regional climate dynamics (Humphries et al. 2017, Wündsch et al. 2016). The two main currents are the warm Algulhas in the Indian Ocean, influencing the southern and eastern parts of the mainland, and the cold Benguela current of the Atlantic Ocean to the west (Voarintsoa et al. 2017). Wündsch et al. (2016) point out that Southern Africa is characterised by three major rainfall zones, namely the summer rainfall zones due to the movements of the ITCZ leading to the tropical easterlies trade winds. Likewise, the winter rainfall zone lies along the west coast whose chief source of precipitation is the westerlies trade winds. And finally, the Year-round Rainfall zone which is a representation of the transition between the two latter zones and enjoying both summer and winter rains.

Today, only a small part of Southern Africa is humid e.g. the humid zone around the southern and eastern extremities. The interior and the western margins are mostly dry with annual potential evaporation greatly exceeding precipitation. The arid conditions in Namibia and Angola are a result of the cold winds on the west coast as opposed to the moisture rich air to the southeastern and eastern coasts, resulting in precipitation over the mountainous areas of the Drakensbug where mean annual rainfall may attain 2000 mm. Mean temperatures vary according to the season and the region and range from 18° in the mountains to around 40° in the summer. The degree of aridity generally decreases along an east-west gradient, from sub-humid and semi-arid in the eastern interior to arid and hyper-arid in the west (Tooth and McCarthy 2007).

Like other continents, the African landmass has undergone important climatic fluctuations during the Quaternary period. Still, as most of the continent lies in the tropics it has been less affected by glacial activities during the Pleistocene than the northern hemisphere. Instead the pivotal influences of climate change have been due to variations in precipitation, evaporation and runoff patterns, induced by the recurrent latitudinal movement of the ITCZ[5] as well as oceanic current, thermohaline circulation and current air masses (Nicholson 2000).

During the Last Glacial Maximum (LGM) ice sheets covered much of North America and northern Eurasia, affecting climates worldwide by initiating drought, desertification and a dramatic drop in sea levels and temperatures. Most records show that generally dry conditions associated with lower tropical land and sea surface temperatures were common in both hemispheres (Chase 2000).

In Africa and the Middle East smaller mountain glaciers formed as sandy deserts expanded (Thornton-Barnett 2013). In equatorial and North Africa, two drastic humid/arid transitions believed to match the major Greenland warming events associated with the switching of the oceanic thermohaline circulation to the modern mode that occurred circa 1514.5 and 11.511 BP (Chase 2000). In southern Africa a period of fluctuations between wet and dry conditions was observed with patterns of drier conditions in the eastern and some western sides of Southern Africa and wetter conditions in the southwest (Stone 2014). Nkoana et al. (2015) report that during the LGM winters in most of Southern Africa were significantly wetter than they are today.

The compilation of pollen data from Southern Africa indicates that colder temperatures prevailed during the LGM (Scott et al. 2012). In the northern Namib desert, pollen data covering the last 21 000 years also shows that this region was characterised by colder and more arid conditions than at present with a vegetation cover formed by lower elements from the Asteroideae, Ericaceae, and Restionaceae groups. The Late Glacial to early Holocene transition saw two arid periods, between 14.4-12.5 and 10.9-9.3 ka cal. BP, a period that can be linked to

[5] The strong seasonality with summer monsoonal rainfall characterised the climate of a large part of Africa influenced by the recurrent movement from North to South of the ITCZ during the year.

the Younger Dryas. Marine pollen taxa from the Mozambique Channel (Elmoutaki, 1994) similarly indicates that the climate was drier than today in eastern southern Africa during the late Pleistocene (Younger Dryas).

In the early Holocene rainfall increased along the coasts due to the warming of the Indian Ocean while the central interior remained dry until circa 7 ka. The middle Holocene remained generally wet but variable according to the regions. The warmest and most humid period in the Holocene was registered between 6.3 and 4.8 ka cal. BP and was then followed by a first dry spell. Cooler conditions occur around 3 ka and more uniform dry conditions are recorded across the subcontinent from around 2 ka (Scott and Neumann 2018).

Inferred warmer and more humid conditions at the start of the Holocene correspond to an extended phase of increased SST around southern Africa. This interpretation is consistent with southern African temperature records, which generally show that interglacial temperatures were established by 11–10 kcal yr BP, with maximum warming reached during the Holocene Altithermal at 8–6 kcal yr BP. The Mfabeni pollen record show forest growth and expansion (Finch and Hill, 2008) indicating warm and relatively moist conditions during the early Holocene (Humphries et al. 2017). More favourable conditions in the early Holocene followed by a drier Middle Holocene is also purported by the investigations conducted by Scott and Woodborne (2007a).

However, the past southern African climates and their driving factors, especially in the Holocene are still incompletely understood. This is much due to the absence of proxy records, or their rarity is mostly in connection with preservation as mostly arid conditions provoke the erosion of certain deposits. Despite these rare occurrences, significant environmental changes in the late Holocene could still be traced. In the southern Cape for example, the changes are very remarkable concerning the past 4200 years. Data from geo-archives show fluctuating lake levels suggesting a drier environment than now, with wetter conditions because of heavy rainfall that occurred between 3760-3690 cal BP (Wündsch et al. 2016). Similarly the period between 2710 and 700 cal BP until the past 140 years the climate was wetter in comparison to today.

Voarintsoa et al. (2017) state that climate changes in northeastern Namibia depend on solar action and that changes in global temperatures probably resulted in longer lasting summer rainfall seasons. In the same region, cooler conditions were recorded during the periods between 1660–

1710 and 1790–1830 and wetter periods comprising of longer summer seasons were linked to the progress of ITCZ towards the southwest. A slight advance of the Angola–Benguela Front (ABF) to the south was frequent at the time, bringing more rainfall inland. On the other hand, drier and warmer periods in northeastern Namibia, inferred from stalagmite post AD 1715, correspond to globally warmer climatic conditions, suggesting a migration of the ITCZ northeastwards, specifically with more warming of the Northern Hemisphere. This is concomitant with decreasing rainfall in the summer rainfall zone of southern Africa since ca. 1900.

Pollen records from Tswaing show both climate and vegetation fluctuations in the south central parts of South Africa in the early to late Holocene (Metwally 2014). Drier and warmer climatic conditions were recorded from the early to the mid Holocene while warmer and wetter conditions occurred in the mid Holocene in the periods around 7000-1800 cal BP, with a dry hiatus between 3800-3600 cal years BP.

The highest rates of aeolian sedimentation are coincident with the Late Glacial Maximum, a period of increased aridity across a great area of southern Africa 10,000-7000 B.P. (Truc et al. 2013; Chevalier and Chase 2016). The faunal and charcoal assemblages from Elands Bay Cave suggest that conditions remained relatively moist in the southwestern Cape throughout the Pleistocene/Holocene transition, 7000-4500 B.P. This period was the warmest of the last 10,000 years at several sites across the subcontinent (Mitchell 1997, JWP, Holocene LSA Limpopo river 10-2ka n.d.). Pollen sequences in the Mpumalanga bushveld suggest a greater prominence of broad-leaved savannah species (and thus wetter conditions) by 6500 B.P.

Stalagmites can store multiple climatic proxies in the form of stable isotopes, petrographic and mineral indications varying according to environmental factors such as solar activity and temperature changes (Voarintsoa et al. 2017). A stalagmite record from the Dante Cave in northeastern Namibia shows a gradual transition from wetter to drier conditions from 4.6 to 3.3 ka BP followed by a return to wetter conditions at around 1.8ka. A period from which further wet/dry conditions prevailed with the most recent wet period having been recorded at around 230-100 BP. Apparently the north of Kgalagadi desert was equally wet around the same time with the Makgadikgadi paleolake a crucial source of water. (Sletten et al. 2013, Pleurdeau et al. 2012).

1.4. Past and present vegetation

Most of the Holocene period presents the availability of water and an increase in temperatures, and the expansion of the Desert biome in some areas (Lim et al. 2016). There is an increase over time in the ratio of pollen from the Poaceae family compared to that of the Asteraceae family from around 16 000 to 10 000 cal BP which may be interpreted as an increase in moisture in the open, low-lying Nama-Karoo biomes found in Southern Namibia and South Africa. This increased precipitation may have led to the Nama-Karoo on the southern African side to expand into the comparatively grassier Grassland biome towards central and southeastern South Africa.

Despite being dominated by semi-arid to arid conditions the flora of present-day Southern Africa comprises more than 24 000 known plant taxa (Gibbs Russell 1987). Vegetation markers show a generally dry early and middle Holocene in Southern Africa. The results from the western Cape's Pakhuis Pass pollen sequence suggest that the early and middle Holocene periods were much drier than today (Scott and Woodborne 2007a). The dry spell is in part incited by the ITCZ system that encouraged dry air zones that are currently in the Karoo biome. At around 8 ka, C4 adapted grasses are found supporting this attestation. The period between 5 and 2 ka shows the prevalence of more succulent vegetation types suggesting a cooler period. This idea was supported by Gil-Romera et al. (2007) through pollen records depicting vegetation conditions and changes in the north-western margin of Southern Africa from 6 ka to the present and major changes towards the later Holocene where the vegetation shifted to an increase in the tree/grass proportions circa 4.2 ka and 1.6 ka resulting in arid savannahs. Prolonged periods of rain encouraged the expansion of savannah woodlands, mostly *Colophospermum mopane* and Combretaceae species (Eitel, Eberle, and Kuhn 2002). A vast area of the southern African highland plateau consists of at least some woodland savannah with *Brachystegia* and *Julbernadia* species that often coincides with granitic basement rock. Mid-Holocene sediments and pedological studies revealing vertisols, kastanozems and calcisols on the surface suggest they were formed under open grassland conditions in the northern parts of Namibia. Arid conditions were also recorded in southwestern Africa in northern Kgalagadi and the northern Namib desert towards 10k BP (Shp et al. 1998). The warmest and most humid conditions prevailed around 6-4 ka BP. The last 2000 years of the Holocene has experienced an increasing anthropogenic impact on the vegetation cover..

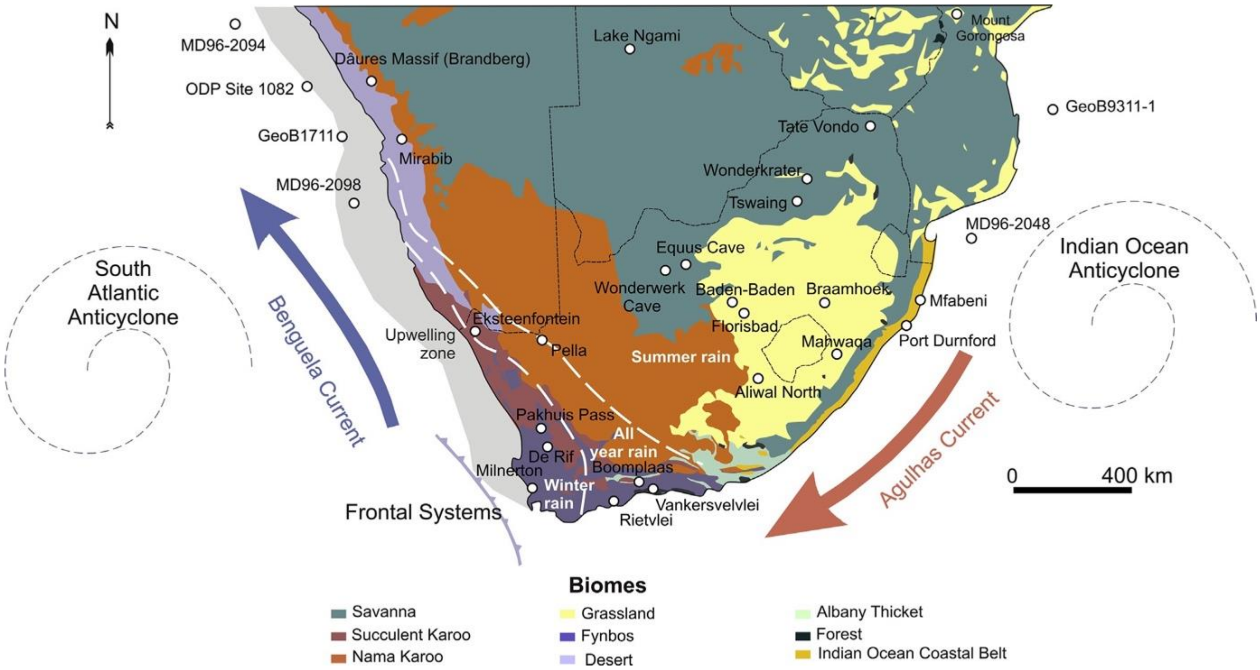


Figure 5: Biomes of Southern Africa (Rutherford et al. 2006)

Today different models are used to contextualise biomes (Figure 5) (Rutherford et al. 2006). First described biomes are viewed as a community of vegetation displaying similar vegetation characteristics or as a land community at a given geographical scale, whether continental and sub-continental level but also incorporating the faunal components among other various life forms present. But depending on the question at hand different authors do define and treat the definition of biomes as including the taphonomic characteristics they are interested in, for example considered biomes solely by considering botanical characteristics. Thus, Rutherford et al. (2006) describe biomes as "*a high-level hierarchical (hence simplified) unit having a similar vegetation structure exposed to similar macroclimatic patterns, often linked to characteristic levels of disturbance such as grazing and fire.*". Southern African biomes consist of a large variety of rich biomes and this chapter this will be used to take into consideration the initial description of the term.

Table 3: Physiognomy and main taxa of Southern African biomes

Biomes (Russel 1987, Carrión, 2000)	**Biomes** (Rutherford et al 2006)	**Vegetal cover dominance**	**Characteristic taxa**
Summer rainfall biomes			
Desert	Desert	Mostly ephermeral and annual plants	Poaceae Curcubitaceae Asteraceae
Nama Karoo	Nama-Karoo	Short, open low lying shrublands	Poaceae Opuntia aurantia Prosopis glandulosa(invasive species)
Savannah	Savannah	Woody C4 grasslands	Poaceae
Grassland	Grassland	Grasscover with little or no trees	Poaceae
Winter rainfall biomes			
Fynbos	Fynbos	Renosterveld and heathland	Restionaceae, Ericaceae, Asteraceae, Bruniaceae, Fabaceae, Rhamnaceae, Thymelaeaceae
Succulent Karoo	Succulent Karoo	Dwarf succulent dwarfs with rare C3 grasses	Crassulaceae
			Mesembryanthemaceae
	Indian Ocean Coastal Belt	Forest cover, grassland, dense savanna	
	Albany Thicket	Dense spiny and succulent vegetation	

The southern African biomes are currently recognised as composed of (Table 3):

- the mesic Forests Fynbos with poor soils,
- Grassland and Savanna with average rainfall ranging from 200-3000mm,
- and the more arid Indian Ocean Coastal Belt Nama-Karoo, Succulent Karoo and Albany Thicket Desert with rainfall levels ranging from 10-520 mm at least in the case of the Nama-Karoo (Truc et al., 2013) . These are divided into summer rainfall or winter rainfall biomes. The two biomes, namely Albany Thicket Biome which Rutherford & Westfall

(1994)[6] were omitted from earlier literature, while later works and recent classifications include them (Rutherford 2006; Scott and Neumann 2018).

The wetter winter-rainfall regions, that include the Fynbos biome to the west, the Succulent Karoo Biome of the Namaqualand together with the Little Karoo, the most species-rich semi-desert on earth, offer the highest assortment of succulent plants in the world. The Savannah biome to the north and east areas of summer-rainfall calibre and it is the largest biome in Southern Africa. The Grassland biome that is also of summer-rainfall type is rather rich in species (Rutherford et al 2006).

Some areas of Southern Africa covering shallow water wetlands are commonly associated with a specialised range of freshwater and flood tolerant woody species like *Syzygium* species and palms. Wetlands are distributed from the top of the catchment to the deltas at the bottom, indicating clearly the networked interdependence of water resources. Wetlands are often indicators of substantive groundwater resources and fluvial buffering, in particular, important in sediment and nutrient trapping (Scott & Neumann, 2018 in press).

The Mozambican coastal area is made up of mangrove forests while herbaceous swamps with papyrus and reeds are also widespread and common. There are relatively small areas of high altitude swamps, bogs and mires, which are characterised by Afro-alpine vegetation which is specialised and often endemic. Open water may have potamogetons and is often colonised by floating *Pistia* while *Echinochloa scabra* is common in the shallow waters. Clear water rivers downstream of wetlands such as the Okavango Delta, contain much submerged vegetation, including water lilies *(Nymphaea* sp.), the tubers of which are often harvested for food. Most wetland plant species have some economic value, for example as food or more usually as thatching, screen or carpet making material basement rock(Taylor et al., 1995).

The south-western corner of Namibia on the other hand, is at present a semi-desert environment, with mean annual precipitation of less than 100 mm (Vogelsang et al. 2010). The

[6] Previously referred to as unmappable 'dwarf forest' of the Eastern Cape and the Indian Ocean Coastal Belt off to the Eastern coastal cape bordering the Savannah biome in the mainland between the border of South Africa and Mozambique

low precipitation rates strongly influence the vegetation, which is a Dwarf Shrub Savannah, characterised by low shrubs and grassland that are drought resistant.

1.5. Fauna

Elsewhere in the world, the Pleistocene is marked by the extinction of mega-fauna with the exception of Africa. On the contrary, in Africa and especially in sub-Saharan Africa a diverse fauna persisted into current times probably because the overkill hypothesis does not apply here but rather a number of ecological modifications during the Pleistocene. The faunal diversity is more developed in certain environments than others for example the Southern Cape with a more sclerophyllous vegetation and quasi-no grassland adapted for grazers hosts a comparatively lower number of species and less animals (Deacon, 2017). Faunal species distribution, spread, as well as extinctions could be due to a number of factors and most importantly as a response to climate change. The major climatic and environmental changes southern Africa underwent during the Tertiary and the Pleistocene periods that provoked vegetation changes could also have possibly influenced the distribution of fauna with species diversity expected to be high. Archaeologically, research has been able to trace the evolution and distribution of southern African fauna especially during the Pleistocene through to the Holocene. (Erasmus et al. 2002). Since certain species conform only to specific environmental conditions, faunal data can be used to deduce the environmental changes and vice-versa.

CHAPTER II – THE LATE STONE AGE WITH A SPECIAL FOCUS ON THE STUDIED SITES

1. The Late Stone Age (LSA) in Southern Africa

1.1. The Late Pleistocene and the onset of the LSA

The transition between the Pleistocene period and the onset of the Holocene is accepted to have taken place around 10 000 years ago (Stynder et al. 2007). The Younger Dryas is the longest and coldest of several very abrupt climatic changes that occurred at the end of the Late Pleistocene (Easterbrook 2012) into the present interglacial Holocene. It is a very important period to climatologists and geologists when it comes to understanding climatic changes and global warming. The Younger Dryas stadial was a brief geological period characterised by extreme cold climatic conditions and drought, which occurred between approximately 12,800 and 11,500 BP (Harrison and Glasser 2011, Currant and Jacobi 2011). The changes preceding the Younger Dryas include sudden global warming 14 500 years ago that caused the immense Pleistocene ice sheets to retreat, followed by fluctuating cool and warm conditions between 14 000 and 12 000 BP. At the end of the Younger Dryas, from around 11 500 years ago the rise of temperatures and humidity resumed and the early Holocene warming period is believed to have caused the melting of the North American and European ice sheets sending a surge of fresh water into the North Atlantic. Thermally fractionated nitrogen and argon isotope data from Greenland ice core GISP2 indicate that the summit of Greenland was approximately 15 °C colder during the Younger Dryas than today (Alley 2000; Thornton Barnett, 2013).

Even though a few Middle Stone Age industries infiltrate into the Holocene period, in Southern Africa, the Late Stone Age (LSA) also known as the Later Stone Age is the most dominant. The term Late Stone Age was first coined by Goodwin in the 1920s (Goodwin, 1926; 1929)) to designate the Early LSA industries that started around 45 cal. ka BP and lasted until the Last Glacial Maximum, originating in the eastern parts of Southern Africa and spreading westward (Scott and Neumann 2018). The material culture relating to broadly this time range has been used to distinguish it from other periods.

The transition between the Middle and the Late Stone Ages is thought to be related to the introduction of the southern and eastern African Magosian industries that took place between the beginning of the Holocene to ca. 6000 BC (Deacon 2017; Clark 1959, Mcbrearty and Brooks 2000). The appearance of blade and complex stone tool techniques were perceived as a reference point for the evolution of the microlithic LSA industries going as far back as 40 000 years ago (Table 4) with incipient techniques such as the bipolar technique as evidenced from the Border cave (Villa et al. 2016). This definition was an impediment as the LSA was not fully exclusively microlithic. Therefore instead of trying to see the LSA in the light of lithic industries, it is better to view it as an industry that is built within a framework of adaptation (Clark 1959; Deacon 2017).

The proponents of the MSA created the first art and symbolic culture, they created arrows, they worked hide and had working tools hafted with unique gluing techniques. The lithic technology included Levallois prepared cores blades and composite microliths. MSA traditional cultural industries include pre-Still Bay, Still Bay, Howiesons Poort,and post-Howiesons Poort.

The Pre-Still Bay lithic industry is the earliest of the MSA characterised by Levallois cores, unifacial points and large blades and flakes assemblages. The Still Bay (SB) is another of the MSA lithic industries named after the Stillbay Site where it was first described (Goodwin, datings to between 71,900 and 71,000 BP) (Jacobs et al. 2008). The Still Bay style of lithic manufacture is distinctive for its association with bifacial points. Finally, the Howiesons Poort (HP) lithic industry was named after the Howieson's Poort Shelter near Grahamstown (Goodwin and van Riet Lowe 1929). The HP industry lasted for a period of about 5000 years, from 65,800 to 59,500 BP (Jacobs et al. 2008) and is distinctive for including both modern and pre-modern lithic assemblages.

Table 4: Summary of current chronological frame of MSA and LSA in Southern Africa

MIS dates	Chronozone	Cultural period	Industry/Culture	Beginning
	Holocene	Later Stone Age	Smithfield	860
			Wilton	~7,8ka
MIS 1 - 11 ka			Oakhurst	
	Late Pleistocene		Oakhurst	~13ka
MIS 2 - 24ka			Robberg	
			Robberg	~26ka
MIS 3 - 58ka			Early LSA	~48ka
		Middle Stone Age	Post HP MSA	59 500
			Howieson's Poort	~65ka
			Still Bay	~71ka
MIS 4 - 73ka			Pre-Still Bay MSA	
MIS 5 - 129ka			MSA	From ~280

In its initial stages, the LSA was interpreted as a technological (Goodwin & van Riet Lowe, 1929) phase representing a natural unit that included the two significant cultures of the Wilton and the Smithfield. During this period a sophisticated microlithic industry appeared circa 12 000 BP, but was later switched to a macrolithic one only to be re-shifted to a microlithic one accompanied by the hunting of small mammals circa 8000 BP. Nowadays, many archaeological sites document the heterogeneity of the LSA material culture in Southern Africa (Figure 6).

The period was also then later linked to the appearance of the modern hunter-gatherer San communities of southern Africa. The problem however lay in that they were interpreted using the contacts with the Mesolithic to the Neolithic cultures of north Africa (Deacon 2017) therefore they are not easy to compare with other regional cultures that occurred contemporarily.

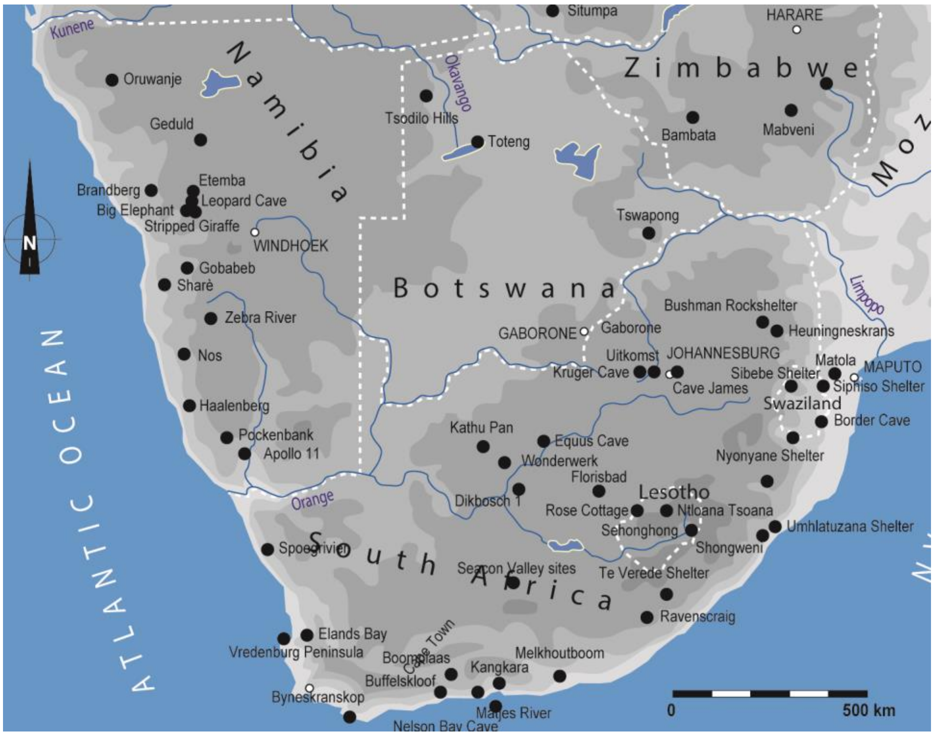


Figure 6: Map showing the density of main LSA sites in Southern Africa

1.2. Technical changes during the LSA

The LSA period sees a shift in lithic technology, raw material uses and subsistence approaches. A large number of sites (both shelter and cave sites) exist in Southern Africa but very few have been able to give a clear chronology dating back to the Late Terminal Pleistocene. Numerous Late Stone Age traditions in Africa appeared in the Late Pleistocene (Plug 1997) approximately between 40 000 and 12 000 BP, and are known to be linked to local adaptations (Figure 7). Their technical distinction is mainly based on their degree of microlithization and on their bladelet components.

When the concept of Later Stone Age was first coined in the 1920s (Goodwin 1928; Goodwin and van Riet Lowe 1929) the Smithfield and the Wilton industries were oftentimes selected as stratigraphically uncontrolled contexts (Mitchell 1997; Mitchell 2002). The Wilton industry was named after the two rock shelters in the Albany district of the Eastern Cape where it was first identified. The Smithfield, then, was suggested to be an autochthonous development determined by raw materials and unspecified ecological factors (Deacon 2017). Then the bigger challenge is fitting in human populations and their vast cultural contexts including subsistence strategies, settlement patterns in order to follow and understand these strategies during the different epochs through Pleistocene-Holocene, given that the Middle Stone Age (MSA) did not end abruptly but continued for at least 25 000 years after the appearance of the LSA. The Smithfield conforms to open-air sites while the latter was found in rock shelters in the Cape and around the Limpopo. The differences between the two were initially explained in terms of geographical location and access to raw materials before a conception of functionality and temporal differences were later added. But of recent, with a much clearer picture on Southern African palaeoenvironments, LSA studies have seen the interpretation of Late Stone Age period independent of site and material culture alone but rather taking into consideration changes and significant regional or local variations.

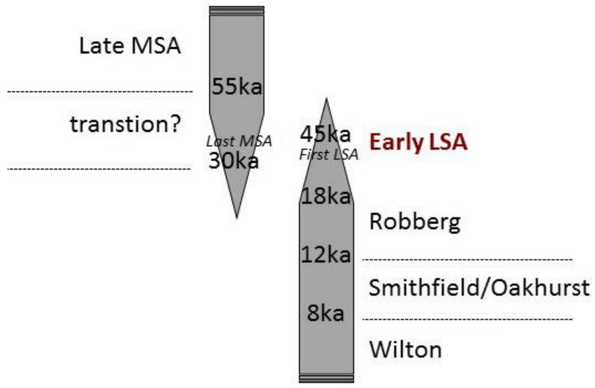


Figure 7: Synthetic cultural chronology of Late MSA and LSA traditions in Southern Africa

The Robberg industry was the last Pleistocene technological expression of the LSA and dates to 22,000/21,000 to 12,000 BP. The lithic assemblages are distinct for their abundant microlithic backed tools, bladelets, single platform bladelet cores, unifacial scrapers industries, bipolar cores, backed microliths and other formal tools (Deacon 1984, Mitchell 1988, Deacon1984, Thornton Barnett 2013). Also found in association with these lithics are ostrich eggshell beads, bone points, bored stones and worked tortoise shells. Most if not all of the assemblages come solely from caves or rock shelters (Mitchell 1998). The identification and inclusion of surface sites is indispensable for understanding late Pleistocene settlement-subsistence systems, but is complicated by the fact that in the LSA it is the variation in artefact and raw material frequencies and artefact size, rather than the presence/absence of specific type-fossils, which distinguishes one assemblage from another (Mitchell 1998). This industry corresponds to MIS2.

The Holocene Classic Wilton Industry on the other hand is a fully-fledged microlithic industry ranging between ca. 8000 and 3200 BP. It is dominated by apt tools like backed microliths and small convex scrapers (Figure 8), occurring in association with bone tools and wood and shell artefacts. This period is followed by the post-Classic Wilton emerging in the Late Holocene age dating to between *c*. 2700 and 100 BP. The post-Classic Wilton can be divided into a pre-pottery stage predating *c*. 1800 BP and a pottery phase that dates from *c*. 200 BP onwards. The post-Classic Wilton industry has regional variations and is more diverse than the Classic Wilton. In various areas, it is still an industry largely dominated by a microlithic industry. However, in some other regions it is associated with long end scrapers rather than with microliths (Deacon 1984). Post-Classic Wilton assemblages have among others been identified from the sites of Rose Cottage Cave and Tloutle in Lesotho.

The Oakhurst Complex dates to between 12,000–8000 cal. BP in most of Southern Africa and corresponds to the end of MIS2 and the early portion of MIS1 (Deacon 1984, Deacon and Deacon 1999, Mitchell 1997, 2002). The lithic assemblage is distinguishable by the presence of large scraping tools, plus the absence of microliths (Deacon 1978, 1984, Mitchell 2002, Sampson 1974, Figure 8). Several regional variants exist including Lockshoek in the Eastern Karoo near Blydefontein, Kuruman industry in the Northwest Cape (Humphreys and Thackery 1983) and Coastal Oakhurst (Deacon 1976). The assemblages of the latter two variants contain abundant bone tools, possibly used as projectile tips (Wadley 1989).

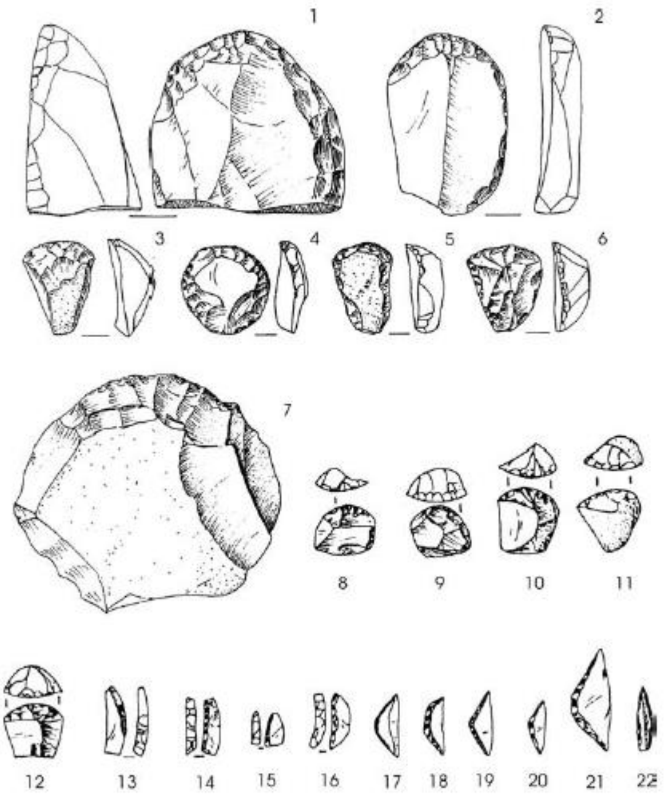


Figure 8: Oakhurst and Wilton artefacts from southern Africa. 1–7. Oakhurst scrapers; 8–12. Wilton scrapers; 13–22. Wilton backed microliths. (Barham and Mitchell 2008)

Even though in the past few decades, the definition of the Late Stone Age period has seen a shift from just emphasis on ecological adaptations, population mobility and systematic palaeoenvironmental change to a more socially dynamic concept including social organisation and ideologies that go beyond just tool crafting and use, the transition between the MSA and the LSA technologies of Southern Africa still remain relatively sketchy (Mitchell 2002). A curious example is the seemingly present link of Holocene hunter-gatherer LSA assemblages to the historical practices of the San communities of the Kgalagadi.

1.3. The Holocene LSA and its place among the history of the peopling structure of Southern Africa

From around 4000 BP a demographic rise is reflected in certain areas by the increase of the number of sites, the production of ceramics and the presence of domestic animals from ca. 2000 BP.

Some exceptionally preserved organic items that characterise more recent LSA as well as the San material cultures, including bone points and digging sticks, were already in use at Border Cave around 44 000 BP (d'Errico and Backwell 2016).

Theories that can confidently piece together the early development and evolution that constitute the Late Stone Age cultural and transitional dimensions and besides add people to them are still sketchy. At the beginning of the 1990s, this could be attributed to the lack of extensive ethnographic work as well as rock art research. Today the LSA is still built on materialistic based projects in different parts of Southern Africa. To date, research going as far back as the 1980s has not yet managed to arrive at a mutual conclusion or approach in understanding and contextualizing the so called "herders"; a fact that makes it a subject worth of curiosity. During the course of the LSA research, scholars have devised a number of models around migration and exchange or assimilation of livestock, goods and ideas.

The migration model accentuates that proto-Khoekhoe communities who are the possible ancestors of the Khoe-speaking herders were responsible for the introduction of new cultural and economic subsistence strategies in territories occupied by Khoisan hunter-gatherers (Pleurdeau et al. 2012, Sadr 2008).

Significant climatic and environmental changes took place during the terminal and post-Pleistocene periods concerning numerous cultural developments in several parts of Africa and the world inciting more sedentary organised lifestyles and developments in food productions but in southern Africa such practices arrived quite late. The absence of food production traditions including the adoption of new cultivated crops and the rearing of domestic animals raise questions on the occupants of the southern part of Africa and their socio-cultural and socio-ecological practices during the late Pleistocene and (Deacon 2017).

The current debate on the early peopling and evolution of Southern Africa including during the Pleistocene and the beginning of the Holocene is marred by many aspects, the most noticeable of them being the absence of domestic stock and anatomically modern human fossils in these earlier periods (Pleurdeau et al. 2012). Meanwhile in Southern Africa, the onset of the Holocene brought better climatic conditions and the diversity of plant and animal species increased (Plug 1997). The Pleistocene/Holocene sites around the Drakensburg and Lesotho show an increase in faunal species abundance which is attributed to the improved climatic conditions that follow the period after the Late Pleistocene. Topography of some of the sites could have played a major role in species distribution. For example, from the results from the eastern highlands of South Africa and Lesotho, it could be hypothesized that the sites at an altitude (Plug 1997) could have been unsupportive for certain species because the cold climate could have shortened the summer hence shortening the grazing areas. This pattern which might have been ubiquitous in the Late Pleistocene can still be observed today with some animals such as eland species being forced out of their territory during the winter.

1.4. The LSA during the Holocene and the advent of a Southern African 'Neolithic'

1.4.1. Chronology and the place of herding practices

The last 2000 years suggest a coexistence of different subsistence strategies; based on the introduction of herding practices and/or the continuation of hunting and gathering practices. Even though by now there is an agreement between different disciplines (linguists, anthropologists, archaeologists) that the sheep reached southern Africa around 2000 years ago (Sadr et al. 2017; Pleurdeau et al. 2012; Robbins et al. 2008)(Figure 9) what is still unclear is the origin of these animals as well as a consensus on the identity of the "herders" who kept them.

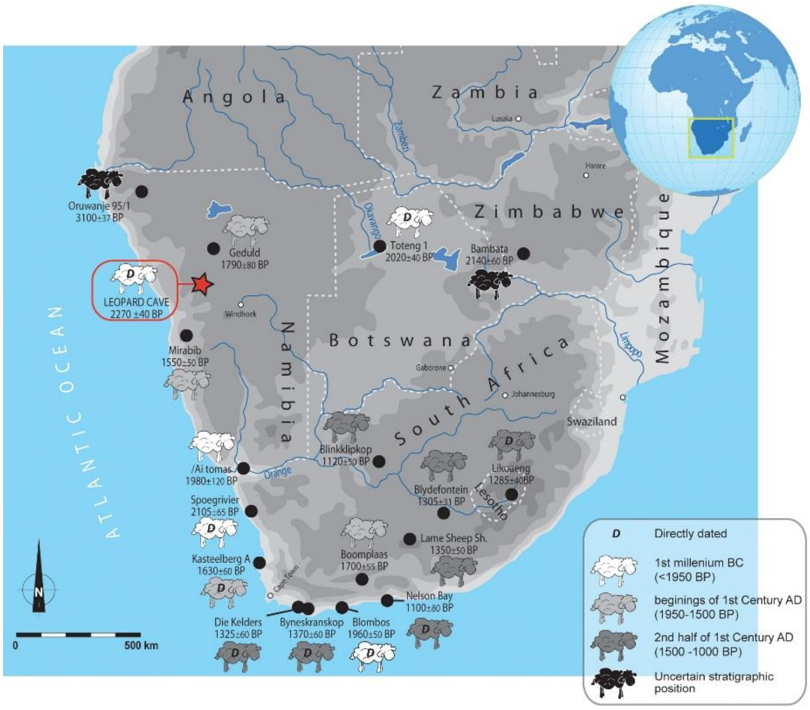


Figure 9: Later Stone Age sites of southern Africa with early evidence of caprines (Pleurdeau et al., 2012)

In southern Africa, as is the case in other parts of Africa, archaeological sites occupied by pastoralists are determined by a prevalence of stock and other mammalian bones (Sadr, 2013) and the earliest from north-western Botswana that put them two to three centuries before the well documented iron-using Bantu-speakers' villages, thus coming to a conclusion that the Bantu-speakers are not responsible for the introduction of cattle in LSA southern Africa and its economies at the time.

In 1979, sheep remains from Die Kelders in the Western Cape dating back to c. 2000 years ago accompanied by pottery were discovered, suggesting the possible contemporary nature of the earliest sheep and ceramics (Smith 2013) . Since then many more sites on the west and south coasts have produced dates for sheep between 2100 and 1860 BP. Thus the most significant aspect of the LSA period is the presence of archaeological sites with evidence of domestic stock and other mammalian bones (Sadr, 2008; Sadr et al., 2003; Sadr, 2013).

Ultimately in the I980s, "pastoralists" sites with an abundance of sheep bones, stone kraals and ceramics believed to belong to the Khoekhoe were found at Kasteelberg in the Western Cape and in the Karoo region of South Africa. The absence of domesticated livestock prior to this period suggests possible migrations and introduction of animals southwards probably accompanied by human migration (Orton et al., 2013; Pleurdeau et al., 2012; Sadr, 2008; Sadr 2013). But at the same time their presence in the region does not necessarily mean that they were accompanied by a vague of human migrations as that cannot be justifiable. Interestingly a turning point is the fact that while sheep does not appear where it is "expected" i.e in open air animal enclosures, inhabited by the Khoekhoe, the early sheep were being found in rock shelter sites with material culture that correlate with San hunter-gatherers.

Some theories attribute the origins of herding to the influx of genetically distinct herders into the subcontinent (Figure 10) while other schools hold the notion that herding stemmed from the acculturation of the local hunter-gatherer communities through small clusters of migrant herders who were genetically absorbed into the gene pool of the already established populations (Sadr 1998; Stynder 2009; Pleurdeau et al. 2012). Nonetheless, a number of factors can play a role in these migrations; the underlying driving factors being social and environmental (B. Heine and König, 2008;Mitchell, 2010) for both animals and herders more plausible (Pleurdeau et al. 2012).

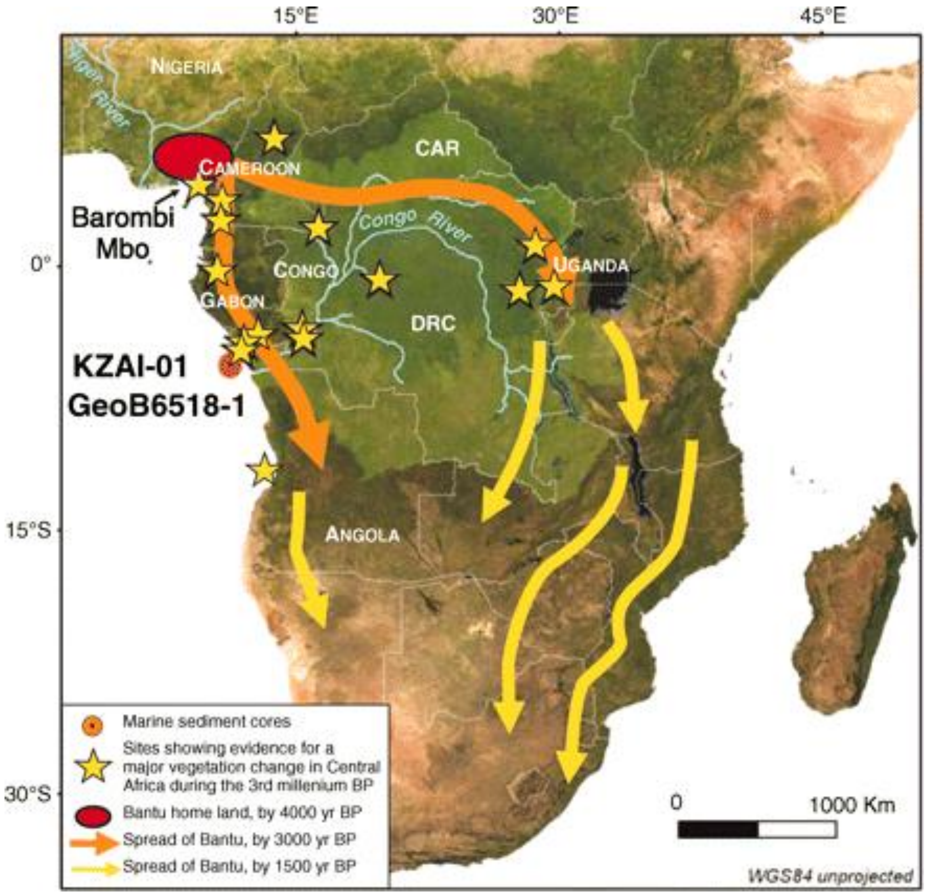


Figure 10: One of the proposed migration models showing routes from the west into Southern Africa possibly with livestock (Abagond 2018).

This therefore puts into question the idea of the Khoekhoe speakers as the introducers of the livestock through a migration in the Cape and raises another question of maybe the researchers should stop searching for what is absent as the absence of evidence might mean the evidence of absence, and to consider that "pastoralists" sites might never materialise because logically nomadic pastoralists leave little behind in the San rock shelters and that the little sheep found is possibly acquired from the nearby Khoekhoe pastoralists through theft or as wages or perhaps the locals may have simply later become herders (Sadr, 2008; Sadr 2013). Hypothetical Proto-khoe populations of the "pastoralists" (Khoe speaking) encountered by the first Europeans who arrived on the southernmost coast of Africa from the end of 15th century onwards is often thought to be the potential herders. Several recent genetic and linguistic studies support this hypothesis, although the place of origin of these early herders and/or stock is still widely debated.

However, the evidence of domesticated animals (mostly of sheep and very few cattle) with reliable AMS radiocarbon dates are very rare prior to 1500 BP. Currently, the most secured occurrences of domesticated animal presences with direct dates are from Spoegrivier (2105±65 BP) Blombos (1960±50 BP), and Kasteelberg (1630±60 BP) in South Africa and the site of Toteng in north-western Botswana (2020±40 and 2070±40 BP) which is the oldest in Southern Africa by far. The remainder of the sites provides morphologically identified caprines with dates assigned from stratigraphic associations, supposedly from LSA contexts but without direct dates as is the case at Geduld and Mirabib in Namibia dating to between 1950 and 1500 BP, Boomplaas, in South Africa and other later sites such as Lame sheep and Blinkklipkop in South Africa falling between (1500-1000BP) (Pleurdeau et al. 2012, Smith et al. 1995).

By applying biochemical proteomic analysis to faunal remains from Leopard Cave Le Meillour et al. (2007) have been able to show that bone remains first thought to have belonged to domesticated caprines (sheep/goat) in reality correspond to wild antelopes (see below : Leopard Cave). This discovery, made possible through to the use of innovative techniques, raises the question of the identification of caprine remains on other sites and thus of the herder versus hunter model.

Questions still stand about:

a) What actually constitutes the Holocene Late Stone Age period the Holocene LSA, in terms of subsistence and hunting strategies, networks or material culture, particularly in the context of the arrival of possible herding practices.
b) is the apparent scarcity of early/middle Holocene LSA occupation a reflection of reality, or a preference for hard-to-find-and-date open-air sites (the not so preserved type of sites) or rather an absence of herding practices at this time.

If recent research projects have indeed been successful in merging different disciplines (archaeology, linguistics, genetics) with the theoretical framework and thus answer certain questions, the global picture of the LSA is still to be understood (Smith 1993). Thus the research doors on this subject will remained open for a substantial amount of time.

There are a few hypotheses trying to explain the first occurrence herders and herding practices in the Southern Africa:

a) A migration from East Africa by pastoralists who arrived with livestock and either mixed with the original populations of southern Africa (genetic mix) or settled in the region without interacting with local hunter-gatherer groups.

b) The introduction of livestock by exchange with herders or by the spontaneous wandering of cattle from other regions (Henn et al. 2008, Mitchel et al. 2010, Sadr 2013).

If the question were “did the Bantu speaking agro-pastoralists introduce sheep and cattle from southern Africa?” then the second hypothesis would prove insufficient to answer the question. Firstly, there is no archaeological evidence to support this assertion and secondly livestock without guidance could not have wandered that far. In any case, the debate that is still at its peak even though archaeological, linguistic and genetic data rather support the former hypothesis (demic diffusion e.g. the arrival of new populations introducing their livestock and herding practices).

The low quantities of faunal remains corresponding to domesticated animals at sites dating to around 1000 AD is somewhat problematic when defining these sites as pastoralist. Sadr (2013) even suggests that certain practices resulted in the elimination of animal bones from the sites. Another possibility is the only a very limited number of cattle were kept. The consumption of livestock became elevated 2000 years ago but the lack of both faunal representation and human remains for isotope studies makes it difficult to prove this hypothesis.

1.4.2. Subsistence strategies

Food security during the LSA was heavily dependent on the environment. With the Karoo and Cape biomes rich in carbohydrates-rich geophytes, and fruit trees prevailing in the Savannah biomes, melons and tubers are prevalent in the Kgalagadi area. These geographical differences of biomes might account for the presence of certain remains of vegetal or faunal markers in some areas but not in others. Plant remains are more prevalent in the Mid-Holocene rock shelters dominated by the family Iridaceae in the Cape area. Even though the Holocene lacks a detailed record on the use of marine and littoral resources, MSA sites like Klassies River and Eland Cave show the use of these resources during the Pleistocene until the Terminal Pleistocene possibly with a Pleistocene/Holocene transition. Holocene site distribution for subsistence information derivation is a very important aspect to take into consideration. The period between the around 6000 BP has a very low number of sites, in the Lesotho and Transvaal areas certainly corresponding to the Mid-Holocene aridity which might have stood on the way of the installation of human settlements at the time.

Given that the amount of faunal remains in the Pleistocene surpasses that of the Holocene, Mitchell (2002) suggests that they consumed more meat than their Holocene counterparts who were less reliant on meat-based diets. Even though evidence shows that they were equally foraging, the late Pleistocene populations mostly hunted large mammals like equines and eland. On the other hand, the Holocene populations showed to be less reliant on foraging than previously thought with the discovery of large grazer remains such as wildebeest and hartebeest in their assemblages. Domestic cattle is also present in the Namaqualand in South Africa suggesting that cattle and sheep may have arrived together in the Cape region more or less 2000 years ago. Deacon (2017) speculates that wider investigations further to the south might show that cattle were also kept on contemporary Namibian sites.

2. Description of the sites

2.1. Leopard Cave (Erongo, Namibia)

Leopard Cave (S 21°34'22'', E15°33'18'') is located on the farm of Omandumba West, in the Omaruru region in the northwestern of the Erongo Mountain, ~200 km northwest of Windhoek (Figure 11). The site is located ~ 5 km SSW from the farm, and 1.7 km south of the Fackelträger site, excavated by Dr. Wendt in the 1960s (Wendt, 1972). The site is a rockshelter measuring c. 60 square meters (about 8 meters side) (Figure 12) and opens at an altitude of 1256 meters in a Cretaceous granite formation. The shelter opens to the south, facing the high peaks of the Erongo.

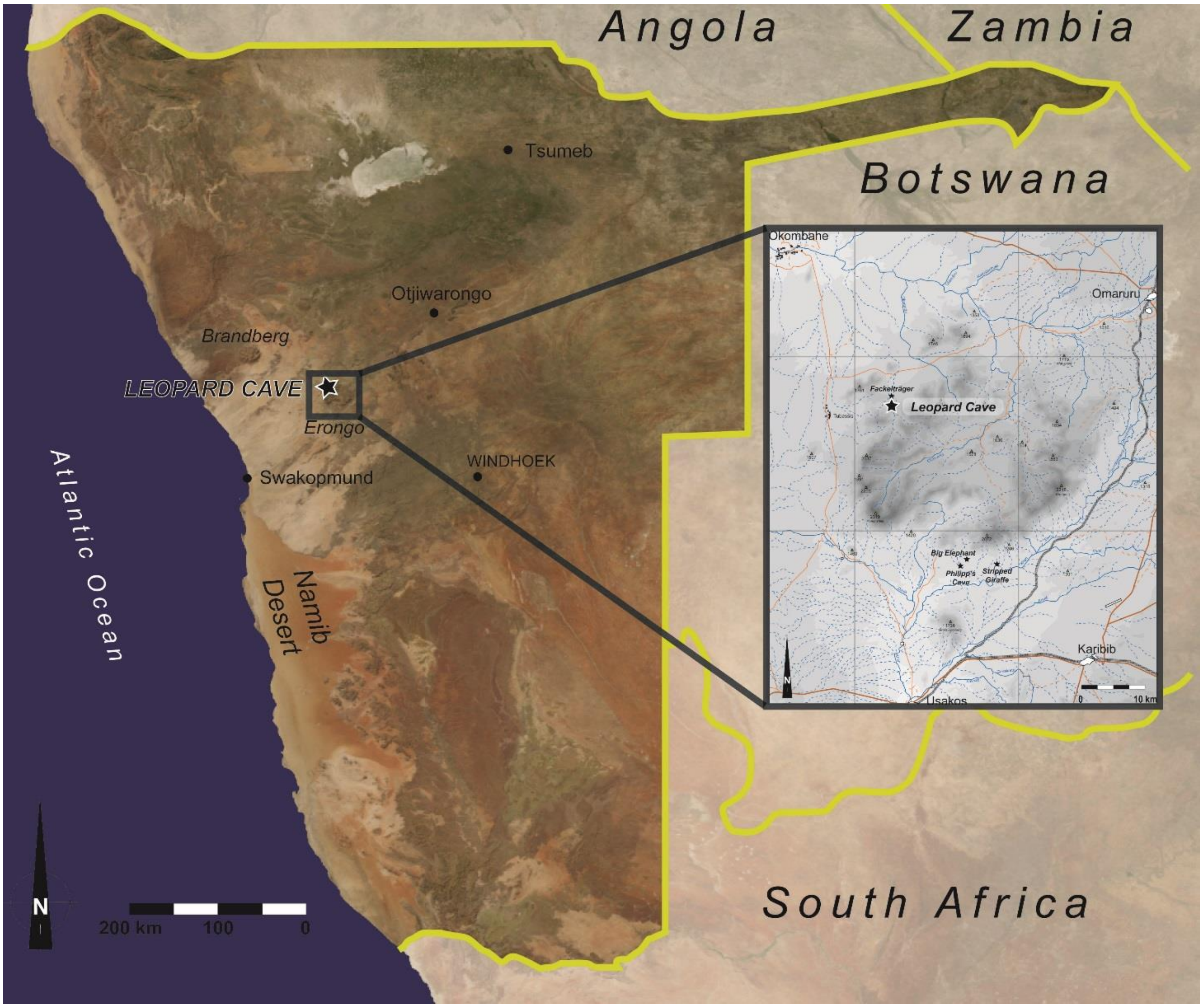


Figure 11: Location of site of Leopard Cave (Namibia)

The site was discovered in 2006 in the framework of a Franco-Namibian cooperation. From 2007, several campaigns have allowed the excavation of a surface of more than 8 m^2 within the shelter (Figure 12) and almost 4 m^2 outside the shelter. The unearthing of a 2 m deep archaeological sequence has allowed the discovery of a succession of Holocene human occupational levels (Figure 13).

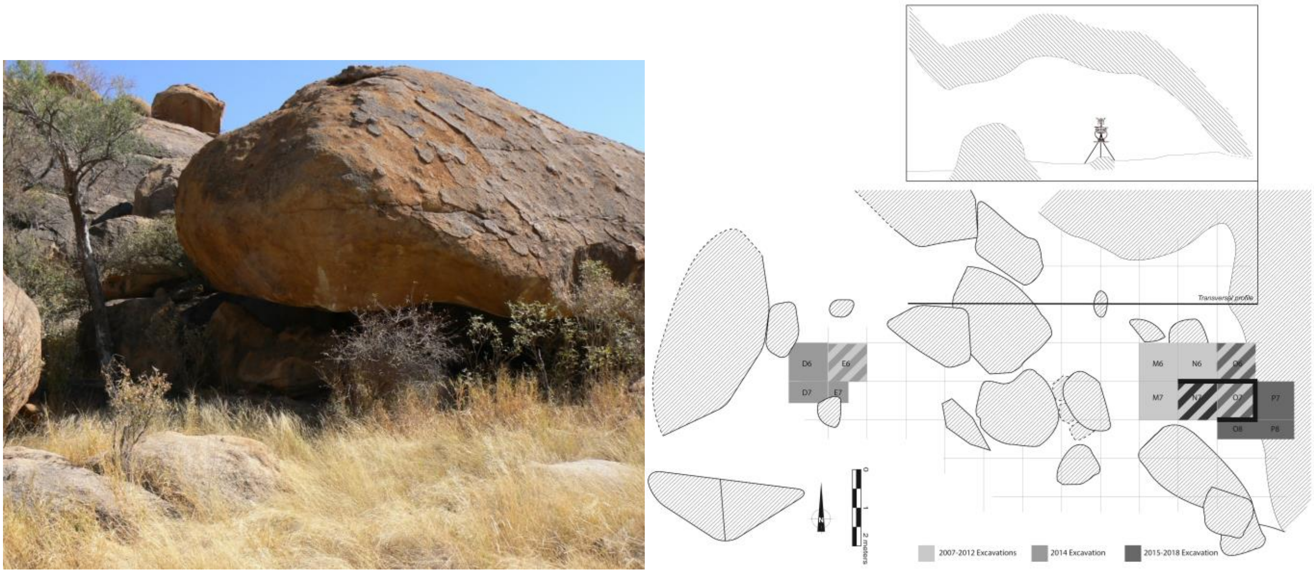


Figure 12: View of Leopard cave in 2012 (l) and location of the excavations areas (r)

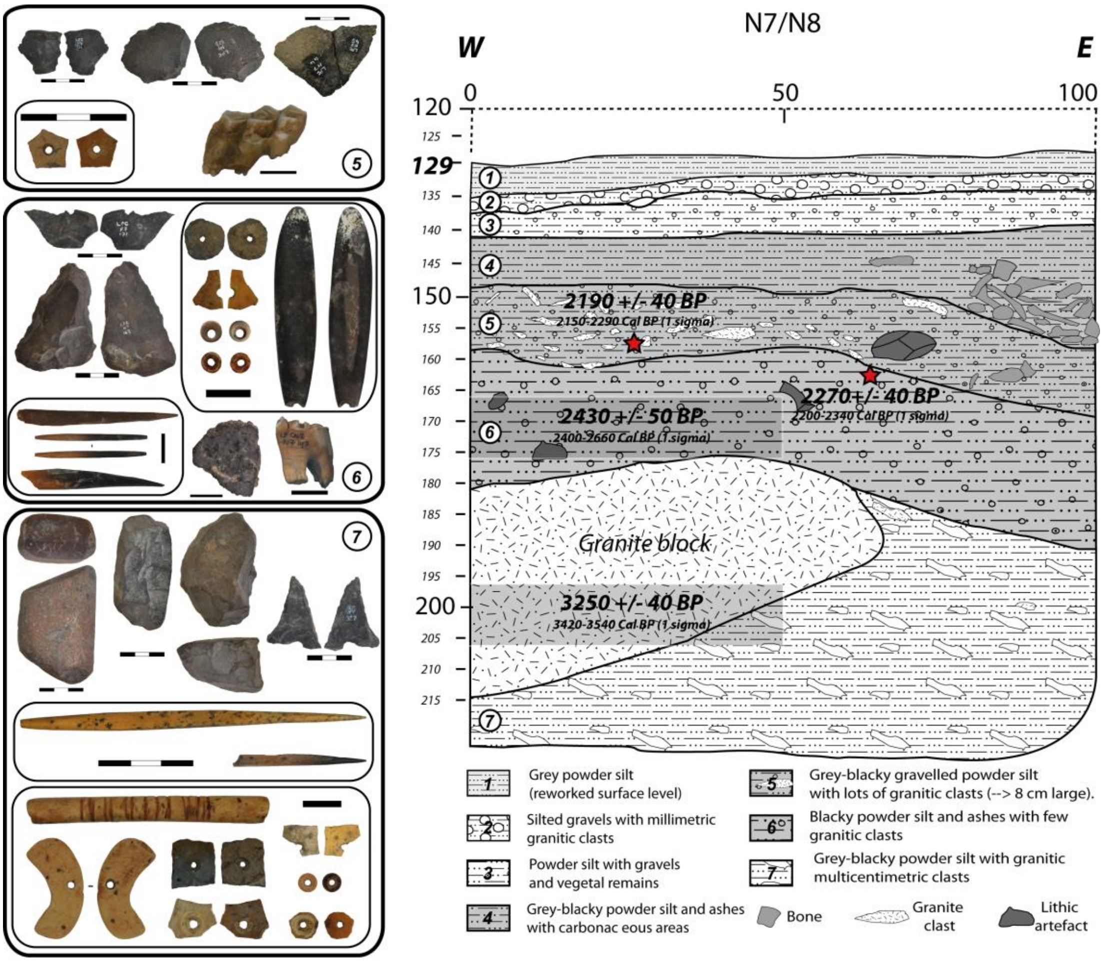


Figure 13: Synthetic EW transversal section and example of recovered material from Leopard cave. (Pleurdeau et al. 2012)

To a large extent, this sequence is dated to 5000-2000 BP. It allows for the documentation of hunter-gatherer occupations from the Later Stone Age, particularly based on an opportunistic production of stone tools, bone weapon, and of non-lithic and non-utilitarian productions such as beads or pendants. The excavations also provided numerous artefacts linked to pigment processing, like crushing and grinding tools as well as concentrations of pigments blocks. Physico-chemical studies, including pXRF analysis (Mauran et al. 2018), are underway in order to assess the link between the pigment used for parietal representations on the East and North walls of the shelter and the residues on archaeological tools (Mauran 2019, PhD).

2.1.1. Stratigraphy and dating

The latest excavation seasons (from 2014 onwards) have allowed for a broader comprehension of the chrono-stratigraphic sequence of Leopard Cave (an E-W section of more than 3 m height). The more or less 2 m deep sedimentary sequence comprises three stratigraphic units, including the second one which seems to correspond to an accumulation of granite blocks without any visible anthropogenic remains.

The thick upper stratigraphic unit (z=150-250 cm) is composed of a succession of horizontal powder-silted layers born from the granite boulders break-up mixed with anthropogenic ashes. It corresponds to a succession of recurrent occupation layers. In addition some levels present clastic residues of granite, more or less numerous and thick (millimeter to centimeter).

Finally, in the lower half of the sequence, a level of human occupation indicators is still visible at the base of the sequence more than 1.8 m below the level of the current sediment surface. The last sedimentary layers reached in from 2017 present a different structure from the overlying levels, with sediment indurations and the absence of the ashy matrix found in the higher levels. A very different lithic assemblage, with technical characteristics similar to those of the MSA, was discovered at the lowest levels.

The stratigraphic sequence, divided in three mains complexes (Figure 14), could be summarized as follows:

- <u>Complex I</u> (z=150[7]-250 cm): This complex, mainly composed of silt and ashes of anthropic origin with abundant vegetal remains and charcoals is divided into nine sub-

[7] The altimetric level 0 is located ~150 above the nowadays sediment surface

horizontal mix layers (now labelled from a (top) to j (bottom)). The presence of ash/charcoal and the large number of artefacts recovered from this stratigraphic complex demonstrate the existence of intense anthropic activities.

- Complex II, between z=-250 cm and z=-280/300 cm probably corresponds to granite blocks collapses episods. The few artefacts discovered within these layers could correspond to upper layers infiltrations and infilling between the blocks and not to in situ human occupations layers.
- Complex III (from z=280/300 cm) is made of an indurated arenitic matrix, without presence of ash or organic material. The substratum has not been reached.

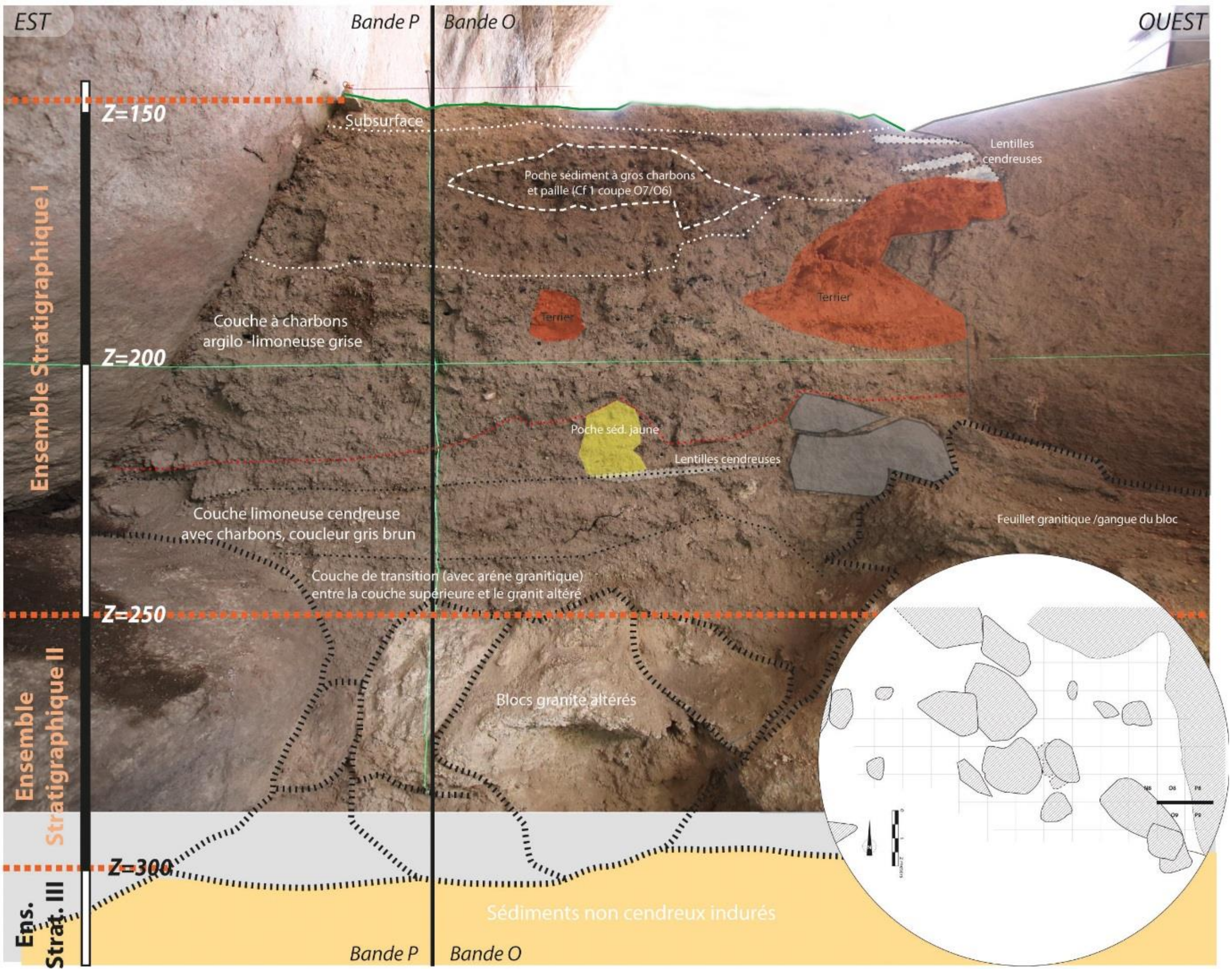


Figure 14: Stratigraphic section of 8/9 transversal bands (Squares NOP8/NOP9**)**

The radiocarbon ages (Table 5) obtained since the beginning of the excavation of the site have allowed us to establish a chronology of human occupation, ranging from ~3700 cal BP (z = 250/260) to ~2000 BP cal BP (z = 150/160) for the upper part of the sequence. Two main occupational phases within the upper Complex is highlighted by the C14 dating sets, as presented in Figure 15, one between c. 3.8 and 3 ka cal BP and a second from c. 2.7 to 2 ka cal BP.

Only one age is currently chronologically framing the third unit (from ~300cm). This age, as well as the (few) lithic remains recovered (N=52), which have different technical features (elongated products, bifacial points…) from the upper unit, indicate a terminal Pleistocene period of occupation. Ongoing excavation of this lower unit (the substratum has not yet been reached) will allow emphasizing this trend towards a possible MSA-LSA transition.

Table 5: Radiocarbon ages of the archeological sequence of Leopard Cave (after Pleurdeau et al. 2017)

Lab#	Year	Square		Depth (cm)	Nature	Conventional Radiocarbon Age BP	Age Cal BP (2 sigma)
SacA34262	2013	N6	Unit I	143,5	Charcoal	2150 ± 30	2160 ±145
UBA-38617	2018	P7	Unit I	150-160	Seed	1991 ± 33	
Beta - 270163	2010	N7a	Unit I	157,5	Tooth	2190 ± 40	2165 ±195
Beta - 270164	2010	N7b	Unit I	163	Tooth	2270 ± 40	2267 ± 96
UBA-30945	2016	P7	Unit I	175,5*	Charbon	2209 ± 33	2187 ± 125
Beta - 236963	2009	N7a	Unit I	166-176	Charcoal	2430 ± 50	2515 ±185
SacA34261	2013	M6	Unit I	159	Charcoal	2565 ± 30	2620±125
CA_DAT_AD63C	2017	P8	Unit I	168	Charcoal	2105 ± 45	2100 ± 185
UBA-30946	2016	P7	Unit I	192	Charcoal	3064 ± 32	3212 ± 135
Beta - 236964	2009	N7a	Unit I	196-206	Charcoal	3250 ± 40	3460 ± 100
CA_DAT_AD63A	2017	P8	Unit I	203**	Charcoal	2267 ± 45	2230 ± 115
Beta - 236966	2009	N7	Unit I	254-279	Charcoal	3180 ± 40	3342 ± 105
SacA42295	2015	N7	Unit I	263,5	Charcoal	3465 ± 30	3700 ± 125
SacA42299	2015	N7	Unit I	271,5	Charcoal	3000 ± 30	3110 ± 120
CA-DAT_AD63B	2017	P8	Unit II	240-250	Charcoal	4508± 45	5090± 210
SacA53511	2018	O7	Unit II	290	Charcoal	4945± 30	5650± 60
SacA513109	2017	O7	Unit III	317	Charcoal	13040 ± 70	15540± 270

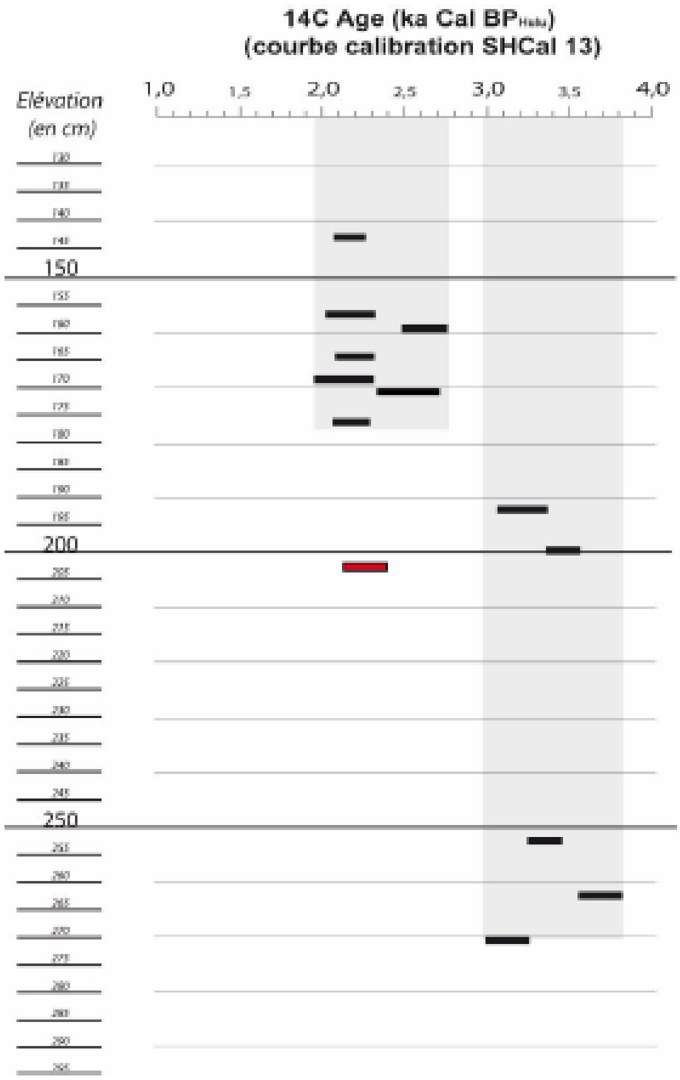


Figure 15: Radiocarbon ages of the upper Complex of Leopard Cave according to the elevation (2 sigma, SHcal13).

2.1.2. Lithic materials

The lithic industry represents more than 1,000 plotted artifacts from the upper unit. With the notable exception of a few pieces of allochthonous chert, it comes from the exploitation of local quartz nodules (~ 30%) and basalt (~ 70%). The thermic actions, resulting from the intensive presence of hearths over a large part of the sequence (ashy matrix of the sediment) affected the original nature of the remains of a large part of the material (very often cracked or split). These alterations often make the technological reading of the pieces difficult.

Nevertheless, a first general study had showed that the majority of quartz pieces are fragments and / or debris, resulting from intensive debitage. The nuclei are dimensionally very small (a few centimeters) and do not have a diagnostic organization of the debitage. The fragments, as well as these nucleus, show above all the use of a bipolar percussion on anvil, having caused a major fragmentation of the material. The basalt pieces, which are often altered (thermal actions during or after burial), provide more precise information about the operative diagrams involved several reduction modalities: Flaking debitage from unipolar reduction with opposite edges; elongated flakes debitage from convergent reduction; heavy-duty tools profution (with sharp and/or pointed edges) (Guillemard in Pleurdeau et al., 2017, Figure 16).

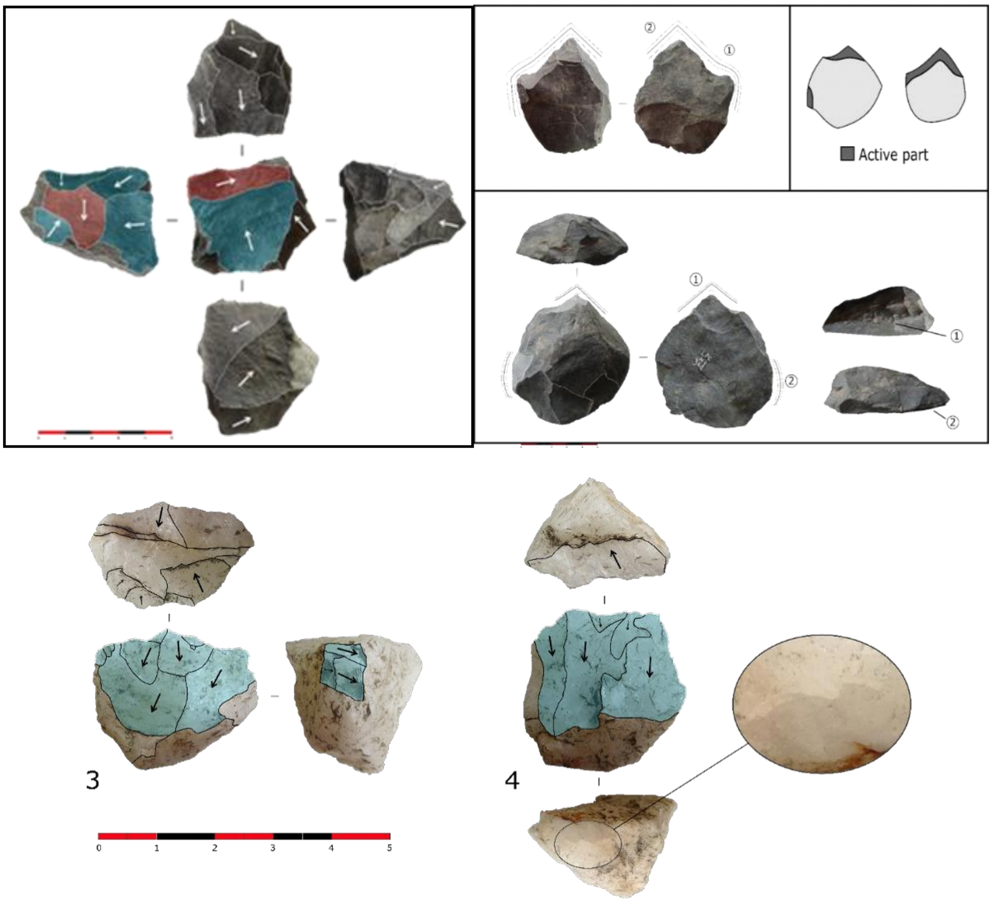


Figure 16: Example of lithic materials from Upper complex of Leopard Cave

2.1.3. Faunal remains

The excavations also yielded very abundant faunal remains (over 6500). In general, the remains are poorly preserved, with more than 50% that could not be identified due to the high fragmentation during the taphonomic processes (corrosion, bad weather and carbonization). These post-sedimentary processes might also have damaged the surface of the bones and thus limited the preservation of anthropogenic cut marks, only visible 1% of the bones (Lesur in Pleurdeau et al. 2018).

Fragments of egg shell (mainly ostrich, but also other birds like guinea fowl) account for 66% of the identified remains. This high number of egg shell fragments shows the importance of this material to the inhabitants of the site. The presence of dozens of ostrich eggshell beads (OEB) illustrates their use for ornamentation. In addition, one-third of the eggshell fragments are burnt, potentially suggesting their consumption or use of the whole eggs in a cooking vessel.

Among the vertebrate remains, there is a great diversity of taxa, especially among mammals. Of these, the majority corresponds to medium-sized animals such as impala, springbok or domestic goats (sheep and goat). Smaller antelopes (cliffspinger and steenbok), warthog, hyrax, hare and small carnivores are also present. In addition to these, there was a discovery in 2012 of a pierced cat mandible, which cannot be identified as wild or domestic, and which shows no trace of possible consumption.

The analysis seems to show that there is no major change in the list of fauna throughout the sequence. In addition, all identified species are still present in the area today, suggesting that environmental conditions were close to those of today. The presence of these species seems to attest that the environment surrounding the rock shelter consisted of three eco-zones composed of a soil covered with perennial grass, bushes and scrub, steppe trees as well as species of woody plants. The inhabitants of the site have exploited many available resources such as mammals but also reptiles and birds (Lesur in Pleurdeau et al. 2018).

Due to the poor conservation of the remains, it is difficult to get an idea of the techniques used by Leopard cave occupants to exploit the environment. Larger animals such as impalas or springbok have been hunted, but no artifacts found suggest specific techniques. Some bones show signs of butchery but, again, their small numbers do not allow these activities to be modeled.

As already said, several bones morphologically attributed to domestic caprines (sheep *Ovis aries* or goat *Capra hircus*) were found in the shelter, including three teeth directly dated around 2.3 ka BP and seen as the first evidence of animal domestication in the entire Southern Africa (Pleurdeau et al., 2012, Figure 17).

Like DNA, the peptide signature is specific to each species, or even to each individual. Proteomic analysis were therefore initiated on these dental remains, in order to discriminate the remains of Leopard Cave (goat or sheep), but also to develop an analysis protocol adapted to remains from arid environments (Le Meillour et al. 2018). The peptide identified as specific markers on the archaeological teeth of Leopard cave are finally associated with the species

Antidorcas marsupialis or springbok, a species of small wild bovid still present today in these environments and already abundant on the site and indicate that it is probably necessary to revise the assignment previously made on morphological criteria. The presence of three markers specific to springbok indicates that the remains of Leopard Cave should rather be placed in the sub-family of antilopines rather than caprines (Le Meillour 2017, Le Meillour in Pleurdeau et al. 2018).

Figure 17: Small bovid tooth from Upper Complex I of Leopord cave, initially identified as caprine

2.1.4. Human remains

The very first human remains discovered in the shelter is a human tooth unearthed in 2015, in layer 6 (z = 175-180). Radiocarbon dating of a nearby charcoal has confirmed an age of approximately 2200 cal BP. This molar is in a poor state of preservation since only the dental crown, broken in 3 parts, has been found (the roots are totally missing). It is a second upper right decidual molar for which advanced occlusal wear and the presence of a well-developped interproximal contact facet on the distal surface would indicate an individual age of about 10-11 years. In the current state of discoveries made at Leopard Cave (i.e. no other immature human remains), it would be a deciduous molar naturally lost on the site.

In 2018, a human zygomatic has also been recovered from Square P8 (z=220-225), within the Upper Complex I.

2.1.5. Pigments and rock art

Leopard Cave is a rock-painting site, with several representations of animal figures and other faded pictures on the wall. In the archaeological layers, hundreds of pigment blocks, as well as a large corpus of material associated with these coloring materials (e.g. passive and active grinding stones used for the transformation of the pigment blocks and suggesting an *in situ* preparation of painting powder), and other objects carrying traces of pigments on their surfaces have been discovered within a large part of the sequence (between 3,5 and 2 ka cal BP) (Figure 18).

The Erongo massif is home to thousands ancient rock paintings most of which are concentrated in the granitic massifs of the Brandberg, Spitzkoppe, Twyfelfontein and the Erongo (Mauran et al 2018; Breuil 1955; Nankela 2017). A recent pXRF analysis made by Mauran et al. (2018) has highlighted a high alteration of the paintings as shown by the presence of Sulfur and Calcium minerals in most of the analyses. They also suggest a possible local sourcing of the raw material used in the paintings. The paintings are mainly composed of white and ochre and iron oxide red pigments and they are characterised by a presence of animals, human figures and associated with the hunter-gatherer San populations of Southern Africa who have existed in the area for several thousands of years. Like many aspects of prehistoric research in Namibia, this part was neglected despite its rich rock art culture, possibly due to geological and topographic conditions that are less favourable to the accumulation of sediment and the registration of the stages of site use. However, Leopard Cave has presented an occasion to witness such; a premier in the region so far, unveiling painting raw materials as well as tools used for the production of powdered colorants.

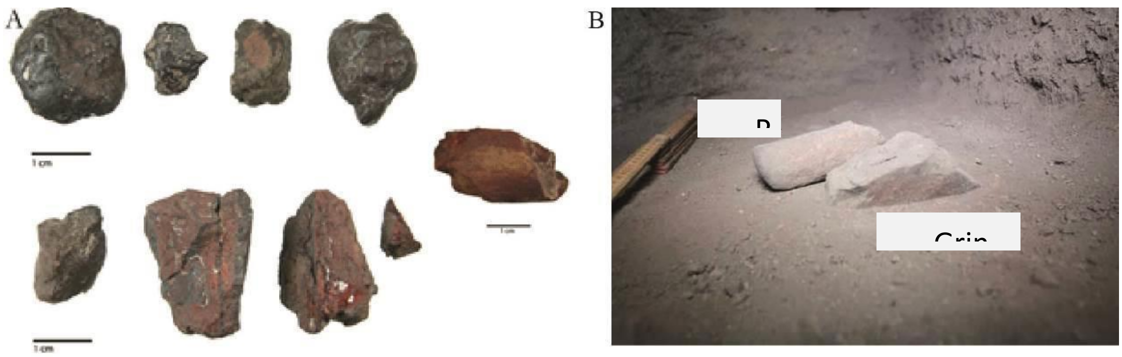


Figure 18: A. Examples of colouring material recovered from Complex I of Leopard Cave. B Association of in situ grinding stones with colored residues.

2.1.6. Present day environment

The Erongo region comprises three different eco-zones: mountainous kopjes, plains and river formations) (Figure 19). These have to be taken into consideration as they influence the distribution of vegetal and faunal resources and subsequently also subsistence strategies of early communities (Wadley 1979). The current climate around Leopard Cave falls within the desert/Nama Karoo biome also known as the "Karoo shrubland" of northwestern Namibia characterised by mountainous areas and open plains and mean temperatures of 18°C and summer rainfalls of around 100-500 mm with grass cover and mostly low shrubs that are drought-resistant (Mitchell 2002b, Sletten et al. 2013). The area becomes relatively hot in the summer with temperatures reaching 40°C. Thus the vegetation around the site consists predominantly of sparsely distributed drought-resistant species (Table 1) mostly from the Capparaceae family consisting of very few *Boscia* and *Maerua* species, Fabaceae (Mimosoideae/Caesalpinoideae) characterised by a wide variety of thorny Acacia species and *Adenolobus* and *Parkinsonia* species. Also present are *Combretum apiculatum*, *Terminalia prunioides*, *Commiphora* species, *Cyphostyemma* species on the mountain tops, an assortment of *Grewia* species, *Ximenia americana, Ziziphus mucronata* and *Vangueria infausta* and a few plants belonging to the Euphobiaceae family. Poaceae (grasses), and other small herbs and creepers such as the wild melon, such as *Citrullus* lanatus are seasonal. The Erongo escarpment is well known for its rock art sites even though they have not been explored as was put into light in the 1950s by Abbé Breuil.

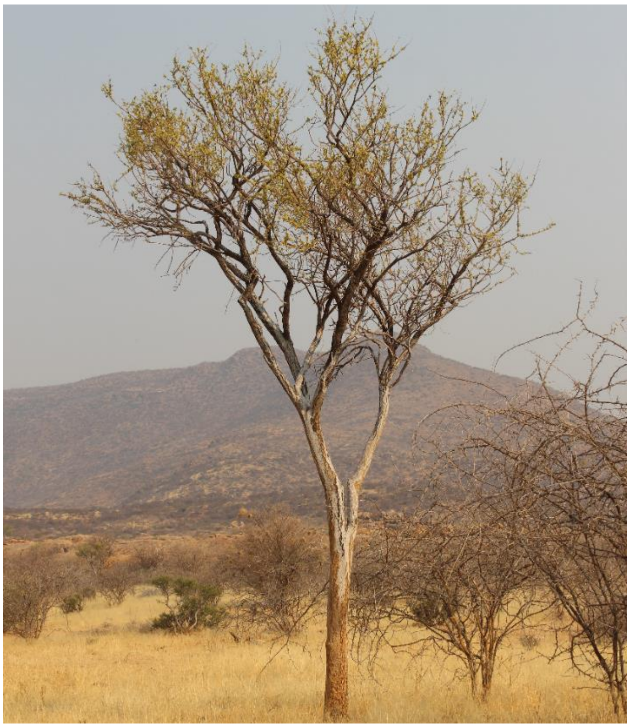


Figure 19: Current environment in close proximity to the site of Leopard Cave

2.2. Toteng 1 (Botswana)

The Toteng sites are located around the village of the same name, between the extremities of the Okavango Delta and Lake Ngami not far from the confluence of the Kunyere and Nchabe Rivers (Robbins et al. 1998)(Figure 20). They were discovered in 1991 by an archaeological survey team led by A.C. Campbell (Campbell et al. 1992). Among the eight inventoried sites (labelled 1 to 8), two localities have been particularly studied: Toteng 1 and Toteng 3, with Toteng 1 containing the deepest archaeological deposits (Robbins et al. 2005, 2008).

These two sites document human occupation layers attributed to the Later Stone Age, with hundreds of archaeological finds (microliths, bone arrows points, Ostrisch eggshell Beads…). During these early investigations, refuse middens with Bambata pottery, together with bones from domestic animals (cattle and sheep/goat) were uncovered. An age of 1700 BP was established for the levels having delivered Bambata pottery and livestock remains on the basis of bulk radiocarbon ages. These levels are posterior to an earlier occupation without pottery or domesticated animals dated to 2640 BP (Campbell 1992).

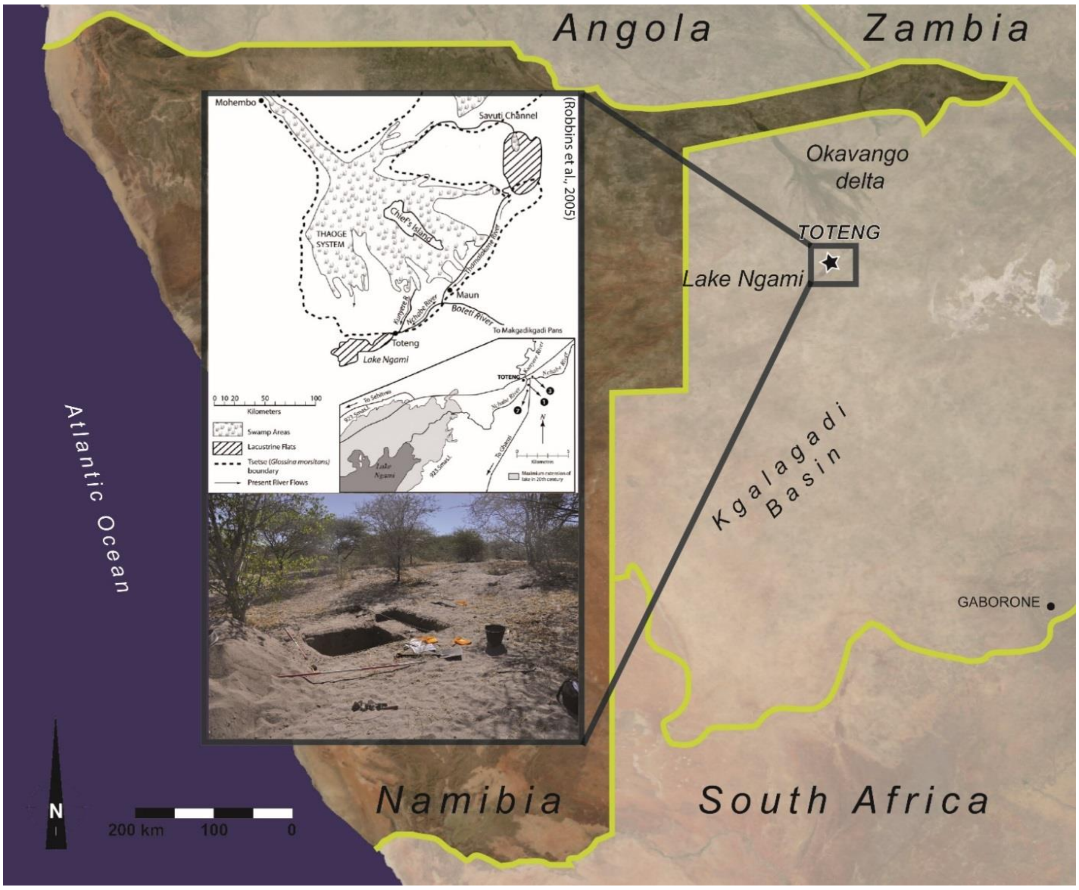


Figure 20: Location of the Toteng sites (after Robbins et al., 2005), with view of the Toteng 1 in 2016

On the basis of these discoveries, revealing the archaeological potential of the Toteng sites for documenting the arrival of herding practices in the region, an archeological and environmental reconnaissance mission took place in 1996 near Toteng with the aim of studying the Holocene environments in the Lake Ngami Lake Sediment Zone (Robbins et al. 1998).

Then, with the aim to better understand the chronology and stratigraphy of the occupations of Toteng 1 and 3, a new excavation mission was organized in 2003-2004 by an international team (Robbins et al. 2005, Figure 21). This expedition allowed to better understand the archaeological context of the sites, as well as to provide additional chronological data.

Finally, in the frame of our present work, we organized a short expedition at Toteng 1 in 2016, in order to sample in situ sediments for the study of the archaeobotanical remains that could frame the environmental conditions of the human occupation. This mission allowed to recover the original stratigraphic section excavated in 2003-2004 and to systematically sample each layers (See Chapter III – Material and methods).

Excavations at the site of Toteng 1 were thus of particular importance because a stratigraphic sequence was uncovered spanning the period when early livestock first appeared in the area cattle and sheep circa 2020±40 BP (LRobbins et al. 2008) making it a reference site both for Botswana and, more generally, for the Southern African Later Stone Age concerning the spread of pastoralism and farming and the understanding of Late Holocene environments.

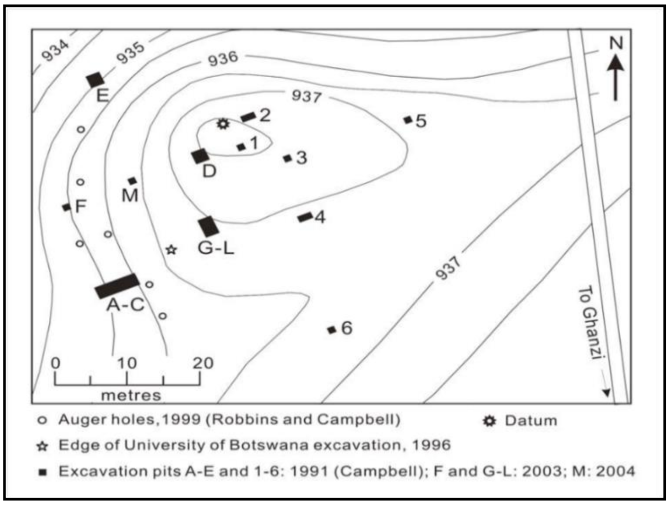


Figure 21: Location of the excavation areas (l) and view of the squares G-L excavation in 2003(r) (Robbins et al., 2008)

2.2.1. Stratigraphy and dating

The location of the 2003-2004 excavation at Toteng 1 was chosen according to the results of the test pits realised in 1991. Among the tested areas, the squares labelled G, H, I, J, K and L were given priority as they had allowed the discovery of both the livestock bones and the deepest stratigraphic sequence. A total of eight squares were opened during the 2003-2004 excavation: F-L (Figure 21).

A more than 1 m deep sequence (Figure 22), representing more than 6 m^3 of sediments was unearthed. It revealed four (approximately) horizontal stratigraphic units (SU 1-4), defined by their sediment characteristics (Robbins et al. 2008) as follows:

- SU 1: basal deposits of bedded pedogenic calcrete,
- SU 2: nodular silty-sand unit, bioturbated, with numerous animal burrows and roots;
- SU 3: black silty-sand)
- SU 4: organic rich silty-sand.

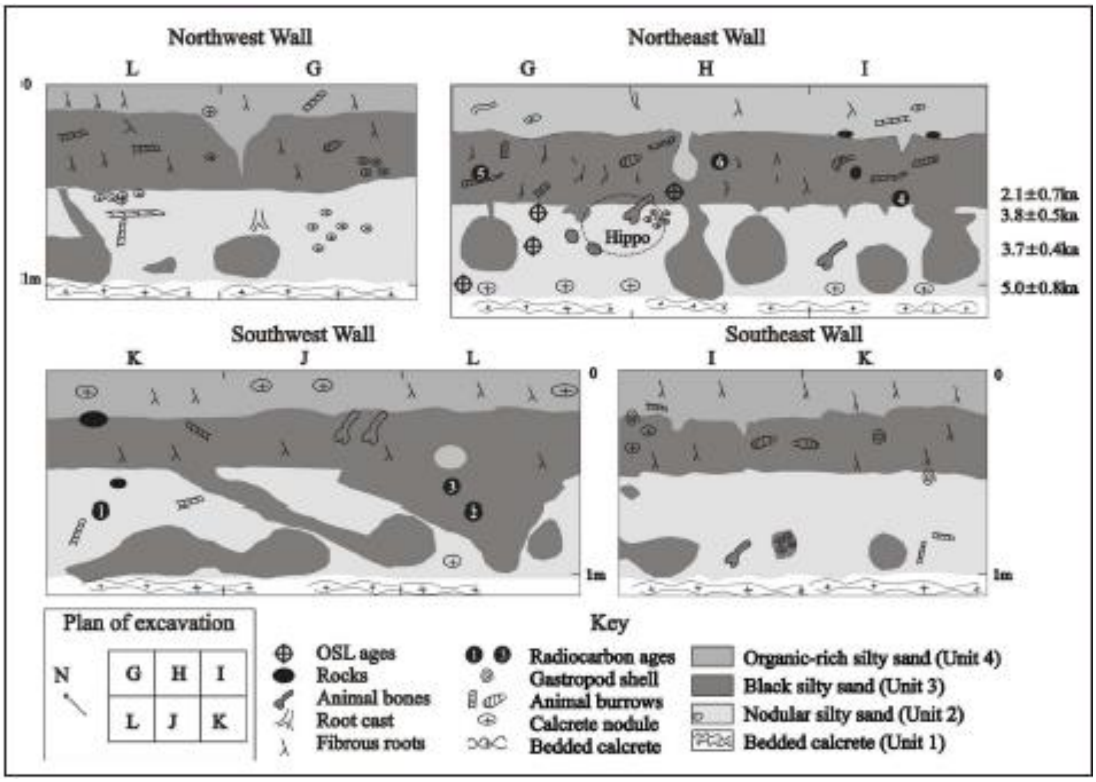


Figure 22: Stratigraphic sections from the six excavated squares and ages obtained for the Toteng 1 archaeological site (Robbins et al., 2008)

The presence of the bioturbated sediments is clearly localised, particularly in SU2, where the presence of darker sediment coming from SU3 are clearly visible.

The chemical and textural analysis of Units 2-4 shows a predominance of silt-sized particles with a clear presence of organic material (darker colours) and carbonate (lighter colours). Sand-sizes sediments decreased from SU 2 to SU 4.

A program of dating helped to chronologically frame the archaeological sequence of Toteng 1. Both OSL and radiocarbon samples were analysed following the 1991 and 2003 expeditions (Campbell et al. 1992, Robbins et al. 2005, Robbins et al. 2008). They gave ages for the stratigraphic Units 2, 3 and 4 ranging from ca. 5000 to 600 cal BP. The OSL ages show that the sediments of Unit 2 accumulated from at least ca. 5000 to 4000 cal BP and those of Unit 2 was deposited from ca. 2000 to 600 cal BP (Table 6). The radiocarbon ages (Table 7) are consistent with these OSL dates. Particularly, three livestock bones (*Ovis aries* and *Bos taurus*) initially belonging to Unit 2 were dated and provided ages between ca. 2000 and 1350 cal BP (Robbins et al. 2005, Robbins et al. 2008).

Table 6: OSL ages from Toteng 1 sequence.

Lab #	Sample #	Unit & depth	U (ppm)	Th (ppm)	K (%)	Annual Dose (Gy/ka)	Paleodose (Gy)	Age (ka)
UGA03-117	TOT1 – 1	2 : 110 cm	1.1 ± 0.1	0.9 ± 0.4	0.21	0.7 ± 0.05	3.3 ± 0.05	5.0 ± 0.8
UGA03-119	TOT1 – 1a	2 : 78 cm	1.3 ± 0.1	0.7 ± 0.5	0.22	0.7 ± 0.06	2.6 ± 0.2	3.7 ± 0.4
UGA03-120	TOT1 – 1b	2 : 75 cm	1.4 ± 0.2	1.2 ± 0.6	0.23	0.8 ± 0.07	2.9 ± 0.3	3.8 ± 0.5
UGA03-121	TOT1 – 2	3 : 55 cm	1.2 ± 0.2	1.5 ± 0.6	0.22	0.7 ± 0.07	1.5 ± 0.5	2.1 ± 0.7

Table 7: AMS ages from Toteng 1. Calibrated using OxCal 4.3 and IntCal 13 curve (Robbins et al. 2005, Robbins et al. 2008)

Lab #	Identification #	Square & depth	Age	Calibrated age BP (2 σ)
Beta 18669	O. aries, bone	Toteng 1, Sq. K, 75-80 cm	2020 +/-40 BP	2111 – 1835 cal BP
Beta 1904888	B. taurus, bone	Toteng 1, Sq. L, 70-75 cm	2070 +/- 40 BP	2094 – 1890 cal BP
Beta 186670	B. taurus, tooth.	Toteng 1, Sq. L, 55-60 cm	1480+/- 40 BP	1405 – 1283 cal BP
Beta 184609	Charcoal	Toteng 1, Sq. I, 55-60 cm	1560 +/- 60 BP	1531 – 1307 cal BP
AA 58186	Charcoal	Toteng 1, Sq. G, 45-50 cm	1639 +/- 33 BP	1565 – 1406 cal BP
AA 58188	Charcoal	Toteng 1, Sq. H, 40-45 cm	571 +/- 31 BP	624 – 505 cal BP
AA 58187	Charcoal	Toteng 1, Sq. F, 35-40 cm	643 +/- 31 BP	650-542 cal BP

Excavations at Toteng 1 were thus of particular importance because a stratigraphic sequence was uncovered spanning the period when early livestock first appeared in the area cattle and sheep circa 2020±40 BP (Robbins et al. 2008) making it a reference site in both Botswana and southern African Later Stone Age concerning the spread of pastoralism and farming and the understanding of Late Holocene environments.

Seen the importance of the site and the absence of sampling for botanical remains during previous excavations, the author undertook a stratigraphic sounding at the site in 2016 (see Chapter III. Material and methods).

2.2.2. Archaeological remains

From the surface the excavations revealed historic remains dating to the 19th century superposed on a LSA midden with both Bambata pottery and other artefacts such as beads and domestic livestock remains including positively identified cattle, sheep and goats. The Bambata pottery associated with pottery and livestock has an average date of approximately 1710 BP at the Toteng sites in general while however later occupation periods including surface layers through to Later Stone Age layers dated from c. 3830 ±50 BP contain a significant amount of scatters of debitage, isolated bone points, decorated potsherds and well-preserved bones of large animals like crocodile, hippopotamus as well as fish. Also present are lithic retouched microliths and a few grinding stone fragments and Bambata pottery usually recovered in association with domesticated animal remains. Other findings from the site include ostrich eggshell in the form of both finished and unfinished beads. (Robbins et al. 2005, Robbins et al. 2008) (Table 8).

Table 8: Toteng 1 artifact distribution from squares G-L.

Soil Unit	Lithics	OEB	Bone points	Undecorated sherds	Bambata sherd	Other decoration	Total
4 (0-35 cm)	221	6	5	52	3	4	291
3 (35-70 cm)	206	15	1	29	8	8	267
2(70–110 cm	198	6	7	9	2	0	222
1 (110-130)	37	1	1	0	0	0	39
Total	662	28	14	90	13	12	819

Pottery

Apart from surface finds, Bambata pottery was found mainly within SU3 (35-60 cm) at Toteng 1. Nevertheless, the first appearance of these decorated sherds in LSA deposits were dated to about 2000 BP in Unit 2. Bambata pottery is a typologically attributed type of decorated vessels characterised by very thin walls. They include jars and bowls and they derive their name from the Bambata cave in Zimbabwe where they were initially discovered.

The Bambata pottery at Toteng was one of the initial few complete assemblages to be retrieved from a sedentary settlement while from neighbouring South Africa and Zimbabwe sherds are very few and fragmentary. They were then probably related to seasonal settlements and usually treated as “trait intrusions” (Huffman 1994, Campbell et al 1998, 2008). Apart from Bambata pottery, traces of thick rim pottery with thick pointed bottoms associated with pastoral Khoi and short-necked painted vessels attributed to the Early Iron Age Bantu communities are also found.

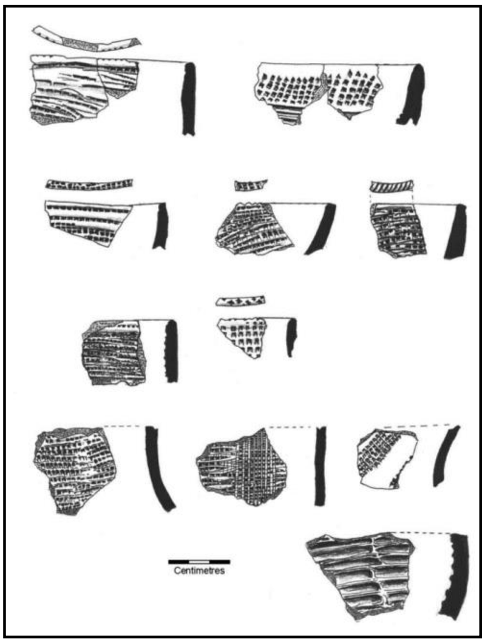


Figure 23: Bowl, possible bowl and possible jars of Bambata pottery from Toteng presenting comb-stamping, incisions and with red ochre(Robbins et al. 2008).

Lithics

A total of 662 stone artefacts were recovered from squares G–L, some with traces of backing and retouch. The number of lithic tools varies between 0 and 4 per 5 cm level throughout the excavation. Among the retouched tools are segments/crescents, backed bladelets, double backed drills and a mixture of both a few large and small scrapers, all bearing Later Stone Age features.

Raw materials such as silcrete and different coloured types of chert, quartz/quartzite and chalcedony are found through the deposit of the G-L block. Chert and silcrete are found today in the local river around the Toteng area.

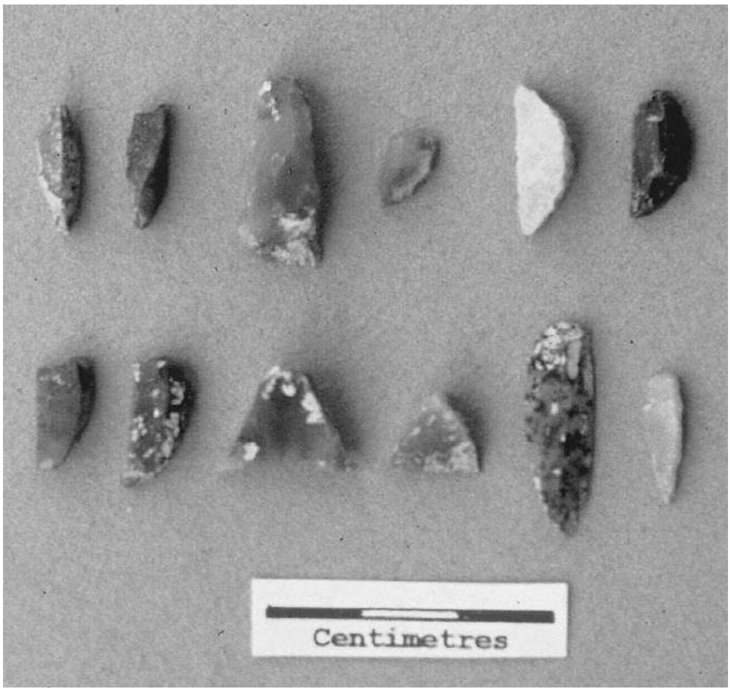


Figure 24: Lithics artifacts from Toteng 1, including backed drill and tools, as segments, trapezoid and distally backed points (Robbins et al., 2008)

Non lithics products

Bone remains include fragmented bone points and link shaft fragments throughout almost all of the squares excavated in 2003-4, confirming the 1991 findings (Morris et al. 2008). Ostrich egg shell beads were also found including unfinished beads and fragments detailing the different stages of bead manufacturing. Rough-edged beads, raw undrilled bits, partially drilled beads, complete and fragmented beads at different stages of manufacture. The complete beads ranged from 6.5 to 2.5 mm in diameter, with a mean diameter of 4.3 mm with apertures with a mean diameter of 1.25 mm. Some bone point/linkshaft fragments, typical LSA element, were also recovered from the excavations (both 1991 & 2003/4)

2.2.3. Faunal remains

A total of 929 bone and shell fragments from the 2003-4 excavations were identified from Toteng 1 revealing a wide spectrum of birds, bovids, rodents, suids, reptiles, caprines, some carnivores as well as fish. Bones of catfish, tortoise, monitor lizard, crocodile, hippopotamus, buffalo, lechwe, sitatunga, hartebeest, steenbok, duiker, sheep, and cow were thus recovered. All of the wild animals, as well as those recovered previously by Campbell, are known to have inhabited the Lake Ngami area historically.

Domestic animals were identified from both Toteng 1 with cattle (B*os taurus*), sheep (*Ovis aries*), and possibly goat (*Capra*). Some of these remains have been directly dated, allowing the archaeologists to situate the appearance of domesticated animals in this region from around 2000 BP (Robbins et al. 2005, 2008).

The cattle remains (N=3 for those surely determined) from Toteng 1 provides the earliest known remains of this species in Southern Africa (Figure 25). They belong to SU 3 and 2.

Two securely identified sheep remains have been recovered in SU 2 and 4, whereas other possible caprine were also speculated for seven other bones. The sheep astragalus has been dated to 2020±40 BP and thus belong to the very earliest remains of caprines recovered in all Southern Africa, also with those of Leopard Cave (Namibia, ca. 2200 BP), Spoegrivier Cave (South Africa, 2105 BP) or Blombos cave (South Africa, 1960 BP), which have all been discovered in Later Stone Age contexts.

Even though the fascinating faunal remains were those of domesticates, finds such as a hippopotamus skull and a lion metatarsal also stand out. Most of the remains are from adult animals. However there are a high number of fragmented bones preventing a precise identification. No slaughtering techniques could be deduced and neither could the animals be sexed. The faunal assemblage is dominated by mammals still present in the vicinity of the site today. The predominance of grazers shows that environmentally the conditions resemble the current ones and water species such as lechwe and sitatunga suggest the present of a water source in the vicinity, the lake and rivers.

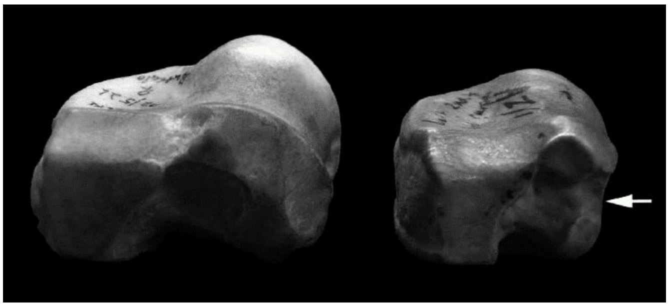


Figure 25: Comparison between buffalo and cattle carpal from Toteng (Robbins et al. 2008)

Fish bones, mostly catfish, and tortoise-shell fragments were found in almost every 5-cm level of Toteng 1. The sitatunga found at 95–100 cm and the lechwe (105–110 cm) are both wetland antelope, suggesting the proximity of swamps adjacent to the lake or rivers—a conclusion consistent with the previously mentioned OSL-dated sediments. A unique discovery at Toteng 1 was the intentional burial (perhaps for ritual purposes) of a hippopotamus head, the remains of which extended between 90 and 110 cm.

2.2.4. Organic material

Organic material from the site were first dated from earlier excavations where livestock bones were dated (Robbins et al. 2005) but more were added from the later excavations. The area was also sampled for the first ever optically stimulated luminescence (OSL) dating from the Toteng sites and the dates served to provide comparisons with AMS and bulk radiocarbon dates (Robbins et al. 2008).

2.2.5. Lake Ngami as an important water source

Dated sediments from Toteng was able to shed light on the nature of water fluctuations at Lake Ngami and finds like freshwater mammals and fish make the lake a very important source of information on how the lake influenced subsistence strategies but also to understand the palaeoenvironmental conditions and changes in Ngami during the Holocene. Lake Ngami is found within the Ngami basin that is 55 km long containing a few outcrops and sand ridges. The lake itself is situated in the north part of the Kgalagadi desert in the vicinity of the Toteng village and Maun town in the northwest district of Botswana (Figure 20). The area has a semi-arid climate with an annual precipitation of approximately 400 mm. The landscape around Lake Ngami area is characterised by aeolian and fluvio-lacustrine landforms associated with the Okavango Delta and its main water source being the Okavango River (Figure 26). Other sources of water being the Thamalakane and the Kunyere rivers (Shaw 1985). Historical sources state that Lake Ngami has fluctuated from being totally dry recording significant seven dry phases since 1810. The latest drought the lake went through was recorded in 1982 and it is reported that the surroundings were then littered by dying livestock. A completely dry phase was reported before 1951 and the lake was dry again in 1973-1974. Prior to this period from ca. 5500–4500 and again from 4000–3500 BP the lake was a permanent, extensive water body standing at an elevation of about 936 m. A noteworthy drop in the water level was recorded between 3700 and 2100 BP. It rose at around 2000 BP and later dropped again by 1200 BP. Even though the lake presents a series of changes, the Holocene in general is characterised by low water levels. During the Palaeo-Makgadikgadi stage, the Okavango Delta and the Ngami, Mababe and Makgadikgadi basins were linked together to form a single very large water body**.** The Makgadikgadi Paleolake is now dry and Lake Ngami is its remnant**.** Apart from fish, large crocodiles were also found in the lake. Large wild mammals such as elephant, rhinoceros, hippopotamus, buffalo, giraffe, kudu, lechwe, reedbuck and impala are also found in the archaeological record. Birds such as wild ducks, pelicans, migrating flamingos and other birds are also present. The presence of these animals portrays the lake as a very important area for hunting, fishing and foraging. During these flow fluctuations, there was flowing or standing water near the Toteng 1 and 3 sites.

Figure 26: Present day Lake Ngami. Photo: M.Mvimi 2016

The lake basin contains ancient lake ridges and shorelines suggesting the presence of ancient lakes. The primary source of water for the basin and for Lake Ngami has always been overflow from the Okavango River delta. In the past 2000 years, people lived in the vicinity of the lake probably with seasonal occupations when the water levels in the lake receded. Historic accounts including those by D. Livingstone mention the importance of the lake as a source of fish with a wide variety being present and fishing practices taking place. To date, (personal observation 2016) the lake continues to be a source of food to the communities living around it (Robbins et al. 2005).

2.2.6. Present day landscape and vegetation

The evolution of landscapes in northwest Botswana has by far been studied more effectively than other parts of the country and they still remain a source of geomorphological and palaeoenvironmental Holocene information even for Southern Africa as whole. This is the area around the Lake Palaeo-middle Kgalagadi and the Makgadikgadi of aeolian and lacustrine landforms of low relief covering an area associated with the Okavango Delta system (Thomas et al. 2003).

Figure 27: The current surroundings of Toteng

The vegetation type around the Okavango Delta, is influenced by the ever changing water patterns resulting in complex environmental patterns. Mosaic-like vegetation patterns from permanent swamps, seasonally flooded types of swamps and grasslands to riverine woodlands and savannahs that are never under water occur (Ramberg et al. 2006) (Figure 27).

From observations around the site, the soils are aeolian in nature and the Nchabe and Kunyere rivers are dry during the winter months. Low lying ground cover comprising of grasses and other seasonal herbs open and open woodlands dominated by a variety of Acacias are very common *Berchemia* and Combretaceae (mainly *Terminalia*) species are also familiar. The fauna found in the site, at least for the mammals and birds are still found in the area today, mostly observable around Maun town as well as the wet Okavango Delta.

Pastoralism is practiced in the Toteng village and larger area today and people keep sheep, cattle and goats. Horses are also available and they are used as a mode of transport, stray horses known as the Kgalagadi horses that have been introduced during the colonial period also roam the area as stray horses and use the lake as a source of water all year round.

2.3. Geduld (Kunene, Namibia)

Geduld is situated at (20.17S 15.50E) in the Kunene region of northwestern Namibia, on the northern bank of the Ugab river, 35 km southwest of the modern town of Outjo (Figure 28). The vegetation around the site falls into the Mophane, thornbush, Damara thornveld and mountain savannah biome. The area is a summer rainfall area receiving ca. 400-1000 mm of rain annually. The 24 plant varieties were discovered and the synthesis on the fruit production of the plants shows that Geduld must have been used as a seasonal settlement.

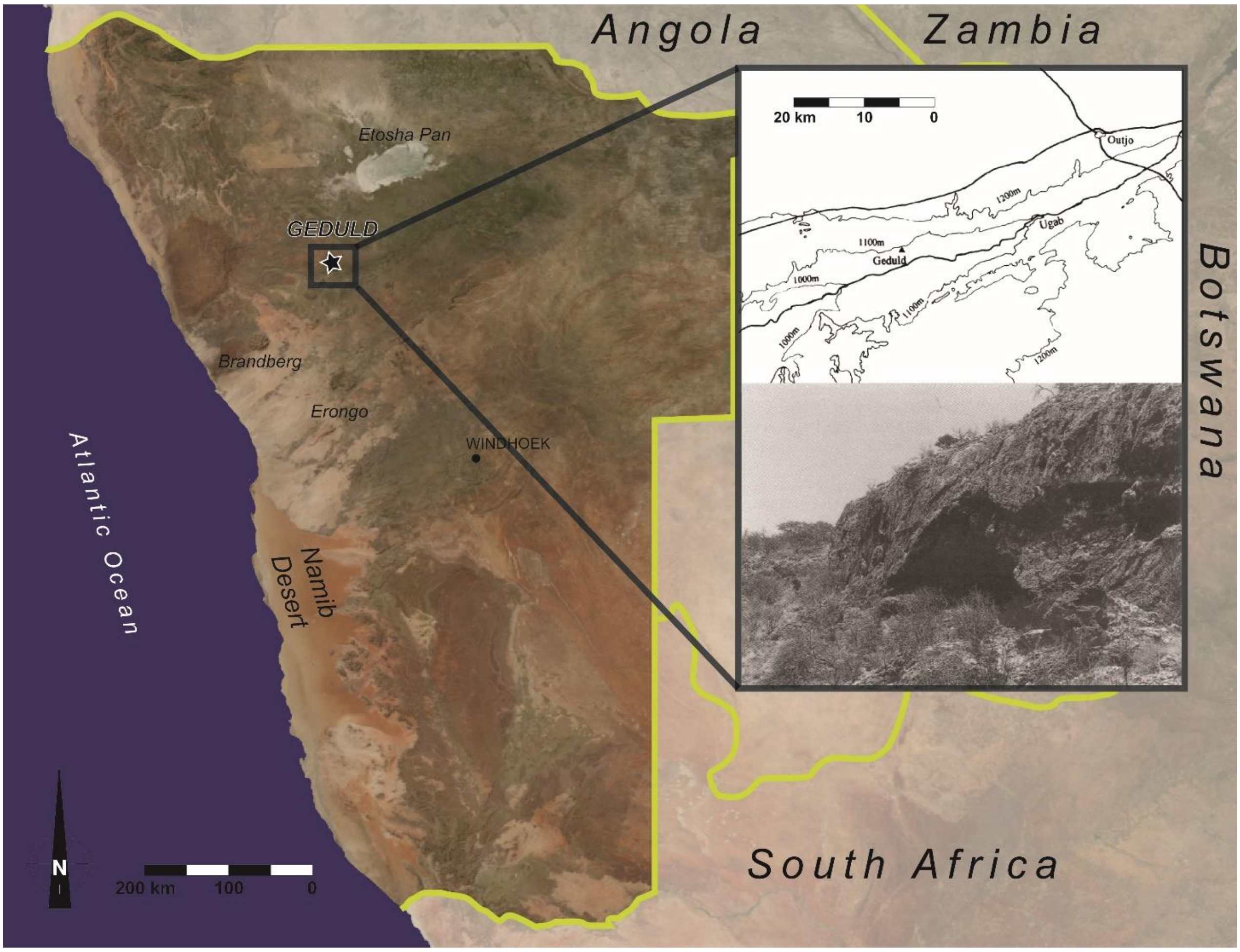


Figure 28: Location of Geduld (Namibia) (after Smith et al. 1995)

2.3.1. Stratigraphy and datings

Excavation at the site of Geduld took place between 1978 and 1986 (Smith et al. 1995) . A first test pit was excavated measuring 1x1 m, Square B5 and later eight more squares were opened in extension to these squares namely B4-B9 and C5-C7 which are a horizontal extension to squares B5 and B7, giving a 6x1 m with a 2x2 m at B6-B7 and C5-C7 (Figure 29).

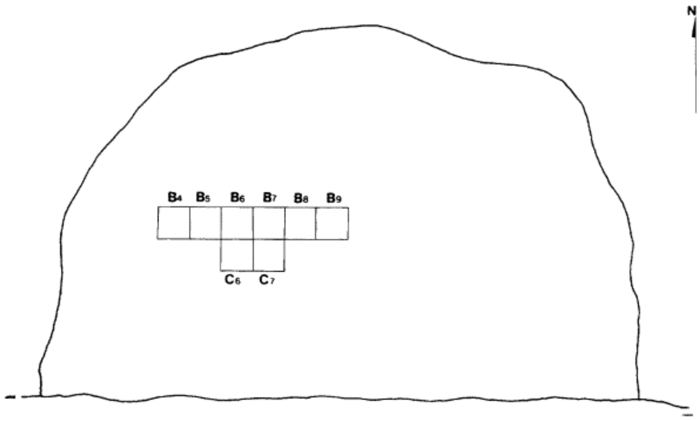


Figure 29: Plan of Geduld excavation (Smith et al., 1995)

More than thirteen stratigraphic layers have been identified, mainly composed of soft ash intersected by some (burnt) organic bedding material and dung layers. Some local bioturbation was also visible. Consequently, the integrity of the infilling has been questioned by J. Kinahan (1995) who highlighted the presence of possible disturbance which would possibly disconnect livestock remains that could have easily migrated down the sequence from their original position.

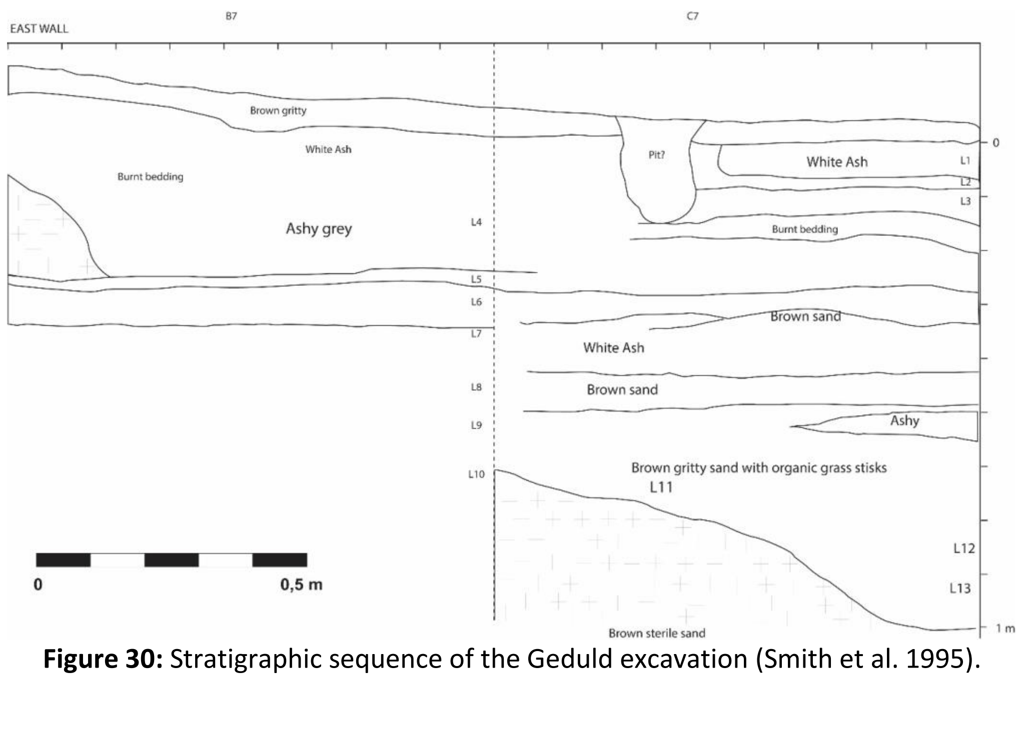


Figure 30: Stratigraphic sequence of the Geduld excavation (Smith et al. 1995).

Radiocarbon dates on organic material show that the site occupation ranges from 2300±50 (L13, z=72cm) to 800±50 (L1A, z=4cm) (Smith et al 1995, Smith 2008). New dates (2018) from charcoal from square B9, Layer 3, gave age of 1676±25 B.P.

Table 9: Radiocarbon ages obtained at Geduld (after Smith et al. 1995)

Lab#	Year	Square	Layer	Depth (cm)	Nature	Conventional Radiocarbon Age BP
Pta-4416	Smith et al., 1995	C7	L1A	4	Charcoal	800 ±50
Pta-4416	Smith et al., 1995	B6	L5	26	Dung	1790 ±80
Pta-4419	Smith et al., 1995	B5		30-40	Charcoal	1790 ±50
Pta-2720	Smith et al., 1995	C6	L7	36	Charcoal	1980 ±50
Pta-4413	Smith et al., 1995	C7	L8	46	Charcoal	1970 ±40
Pta-5875	Smith et al., 1995	C7	L9	51	Charcoal	2090 ±45
Pta-5871	Smith et al., 1995	C7/B7	L10	55	Charcoal	2040 ±45
Pta-5873	Smith et al., 1995	C7	L11	63	Charcoal	2110 ±60
Pta-4414	Smith et al., 1995	C7	L13	72	Charcoal	2300 ±50
UBA-38618	This study, 2018	B9	L3	-	Charcoal	1676±25

2.3.2. Material cultures

The excavation produced a variety of material culture including a ceramic sequence dating to around 2000 B.P, and ornamentations made of ostrich eggshell and a stone tool assemblage and organic material like charcoal and seeds as well as ash deposits.

During excavation a large quantity of lithic material, amounting to more than 23 000 pieces, was recovered. The lithic artefacts include debitage material, cores and retouched stone tools. Microliths including segments and backed blades, scrapers and an adze and also a grinding stone that could possibly have been an anvil were also discovered. The microlithic remains conform to the Late Stone Age period as they are similar to those found in other sites of the same period in Namibia.

Customised bone items, both finished and unfinished bones, burnt bones, notched bone, burnt ostrich egg shells and tortoise shell remains were found in squares B5, B6 and C7.

Both burnt and worked ostrich egg shells were also discovered. The ostrich egg shells beads were analysed by Jacobson (2010) comparing the diameter of the OEB and concluding that there is a notable increase in the shell diameter from the earlier to the later periods. Apart from the OES ornaments, both mollusc shell and seed beads were found, the seed beads found connected by a fibre string. Decorated ceramics dominated by thin-walled vessels were also pound at the site. In square B7, level 2, and B7, level 4-7 a small triangular blade and another identified iron object were discovered.

2.3.3. Faunal remains

The excavation allowed the recovery a mammalian assemblage consisting mainly of bovids (78%, including Damara dik-dik, hartebeest or Steenbok), reptiles and birds as well as marine animals (seal) (Table 10). Micro-mammalian fauna, reptiles and amphibians were also identified from almost all levels.

Particularly, among the small bovid assemblage, some domestic stock remains dating to 1800 BP were identified. Sheep bones have thus been recovered from Layer 4 (astragal, phalanx, teeth) from different squares. Charcoal from this same layer 4 have been radiocarbon dated to 1790± 50 BP, confirming the old appearance of domesticated animals in the sequence. Nevertheless, these remain have not been directly dated, which have limited the implication of Geduld in the first southern African herding practices debates.

Table 10: Faunal spectra from Geduld (Smith et al., 1995)

	Surf/L1	L2	L3	L4	L1-4	L5	L6	L7	L8	L9	L10	L11	L14	Total	%
MAMMALS:															
seal								1			1			2	0,9
hare			1					1		1				3	1,4
cf. hare		7						2	1					10	4,7
cf. genet	1													1	0,5
cf. mongoose	2.			1				1						4	1,9
equid				1			8	3						12	5,6
dassie	1		3	2	1								1	8	3,7
cf. dassie			4		1									5	2,3
rhino	1			1										2	0,9
hartebeest		1												1	0,9
dikdik	1													1	0,5
grey duiker						1		2						3	1,4
sheep	1			5										6	2,8
Bovidae sp. indet:															
small	2	4	8	10		5	7	22	5					63	29,3
medium	1	2	14	9		6	6	8	1					47	21,9
medium large	4	3	7	5		9	3	2		3			2	38	17,7
large			6	1				1	1					9	4,2
TOTAL:														**215**	**100**
BIRDS:															
francolin	1													1	
hornbill	?1													1	
common kestrel			?1											1	
Cape turtle dove			1											1	
helmeted guinea fowl							2	2						4	
gen. et sp. indet.				1									1	2	
TOTAL:														**10**	
REPTILES:															
bullfrog	1													1	
tortoise	29	44	20	48	9	38	36	120	17	3	7	4	2	377	
snake	1		3											4	
reptile sp. indet.	5	5	2	2			3						1	18	
unident. bone frags (mass in grams)	795	495	540	1099	108	975	733	1363	172	55	21	13	22	6391	

2.3.4. Botanical remains

For botanical remains, most of the identifications were those of seeds, Jacobson et al (1995) mentioning that the rest of the plant remains were difficult to identify. From observation, these unidentifiable plants remains include twigs, bark and sometimes roots from trees.

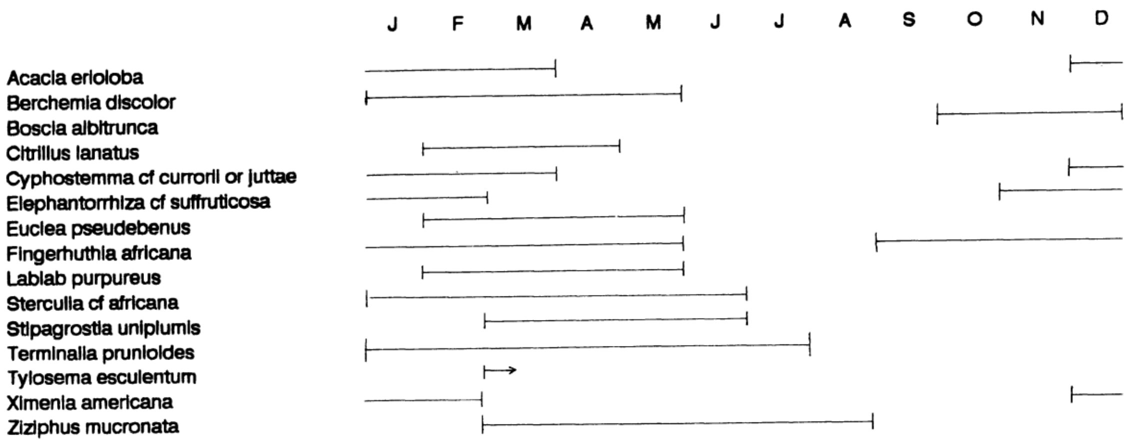


Figure 31: Fruiting seasons of plants identified from Geduld (Smith et al., 1995)

Following the flowering patterns most the plants are, most of the fruit is produced in late summer and they are food plants. The plants could also be used as medicine or infusions and mostly firewood.

Geduld is very small to draw conclusions on cultural transitions that may have occurred in the region. The questions still remain whether the inhabitants of Geduld formed an entirely pastoral society or of they remained a hunting community in contact with herders from whom they occasionally acquired some domestic animals. The presence of plants for animal care and feed such as *Lablab purpurus* and *Ricinus communis* suggest that the inhabitants of Geduld practised animal care which mean that they owned livestock. The presence of iron tools raise questions about the acquisition of metal items and the identity of the people as in the region Iron smelting was introduced by Bantu speakers around 2000 BP.

The same applies to the presence of pottery: was it produced locally or acquired through exchanges of products with other groups?

Whatever the case, Geduld has delivered a limited quantity of material from a single excavation but the material is very good reference in answering the questions on the introduction of pottery and livestock interestingly so as the former precedes the latter in the area as well as the earliest history of food production. As is the case with all LSA livestock remains in the region (Toteng, Spoerivier etc.) the livestock remains are very limited, making it difficult to make a solid association between the beginning of livestock acquisition and development. The unchanging nature of lithic technologies during periods of pottery and later livestock introduction is interesting for understanding the identity of LSA communities.

Chapter III – Archaeobotanical material and methods

1. Description of the study material

The study material from the three sites concerned by our work – Toteng, Leopard Cave, and Geduld – consists of macrobotanical remains, that is plant elements that can normally be distinguished by the naked eye (usually > 1 mm) in opposition to microbotanical remains such as pollen and phytoliths that will necessitate the use of a microscope to be observed. Most of our remains correspond to wood fragments but other elements from the vegetative part of plants (twigs, fragments of bark and herbaceous stems) are also present in the samples as well as seed and fruit remains. Table 11 lists the different categories of plant remains that have been analysed from the three sites.

Table 11: Categories of plant remains studied from each of the three sites

Site	Charcoal	Dry wood	Charred seeds/fruits	Dry seeds/fruits	Mineralised seeds/fruits
Leopard Cave	X		X	X	X
Geduld	X	X	X	X	
Toteng	X				

While the majority of ligneous remains were found in a carbonised state, most likely due to the use of wood as fuel, seeds and fruits were more often preserved by desiccation. Indeed, the arid conditions prevailing at all three sites situated at the edge of the Kgalagadi desert allow the conservation of organic material in a dry state, a type of preservation that is otherwise rare on archaeological sites.

In Leopard Cave a small number of seeds belonging to two taxa (*Grewia* sp. and *Croton* sp.) have been preserved by mineralisation. This type of conservation implies that the original organic material has progressively been replaced by mineral components. Two different processes can be responsible for this (Messager et al. 2010). In some plants the replacement of specific tissues, for example fruit stones (botanically endocarps), by minerals can occur naturally while the plant is still alive and this phenomenon is called bio-mineralisation. Bio-mineralisation has been shown to occur in specific taxa such as hackberry (*Celtis*) or in nutlets from the Boraginaceae family. In other cases, it is an environment rich in mineral salts that is responsible for the mineralisation of organic material. In archaeological contexts this is common for example in latrines or wells where humidity and different mineral components such as phosphates and calcium occur together. In both cases the inorganic nature of the replacement minerals means that the structures become resilient to decomposition and this is recognised as the reason for the abundance of certain taxa at many archaeological sites (Shillito & Almond, 2010). Given the conditions at Leopard Cave the first type of preservation – by bio-mineralisation – seems more likely but due to a lack of adequate literature on this phenomenon within *Grewia* and *Croton* species we prefer not to draw a definite conclusion.

The preservation of botanical macroremains is comparatively good on all of the studied sites. Charcoal and wood pieces occur in different sizes sometime measuring up to 3 cm as it is the case in certain hearths in Leopard Cave. Most of the seeds were found intact even though some were split in halves or even more fragmented (Figure 32).

Figure 32: A mixture of carbonised and desiccated fruit remains from Geduld (square B7, level 4)

Even though the conservation conditions are generally favourable in the whole study area differences between the three sites can be observed. The two rock shelters (Leopard Cave and Geduld) are situated in the Erongo escarpments and, except for bioturbation mostly by burrowing rodents, they are protected from other erosional factors that will affect open-air sites such as Toteng. On the latter site the environment is characterised by aeolian and fluvio-lacustrine conditions and the archaeological settlement is exposed to flooding, wind erosion as well as animal trampling that might hamper the preservation of fragile organic material. Subsequently charcoal pieces are less numerous and appear more fragmented at Toteng than at the other two sites where botanical remains are in general both more abundant and better preserved. Still this type of rock-shelter sites is very rare in southern Africa given the generally flat topography of the region.

The fact that the desiccated botanical remains may look very similar to modern plant parts raises the question about the authenticity of their suggested age. To further investigate this case, we consulted literature that reveal that it is not uncommon to find exceptional preservation conditions on earlier or contemporary sites located in semi-arid conditions in Southern Africa (Prior & Williams, 1985; Sievers, 2006).

Furthermore, seeds from Geduld and Leopard Cave were C14 dated. These include seeds from layers where previous C14 dates were obtained on charcoal in order to determine the age of the site. These dates did indeed attribute some of the "modern-looking" seeds (square P7, level 150-160 cm) to an expectedly old date: 1991±33 BP. Still, in another case a seed found in a lower level in Leopard Cave (square O8, level 200-205 cm) the C14 dating indicated a more recent date (88±30 BP). This might suggest an intrusion by burrowing rodents whose burrows were regularly observed during excavation and the material was excluded from our study assemblage.

2. Sampling methods

Somewhat different methods for sampling of macrobotanical remains were applied to the three sites concerned by our study. At Leopard Cave systematic sampling for both animal and plant remains was carried out since the beginning of the excavations in 2009, under the direction of D. Pleurdeau (MNHN). Botanical remains collected by the American team led by Leon Jacobson during the excavations at Geduld between 1978 and 1986 were stored in the National Museum of Namibia. Finally, when searching for plant remains from Toteng 1 we learned that no archaeobotanical remains had actually been retrieved during the excavation of the site. This lack of material from an important LSA site motivated us to go back to the site in 2016 in order to conduct systematic sampling from the different layers.

2.1. Leopard Cave

Botanical sampling was started at Leopard Cave since the excavation in 2012. From 2013 until 2018 the author participated in the yearly fieldwork in order to collect supplementary wood and seed remains as well as to constitute a local reference collection (see below). In this study, only the material collected in 2012 and 2015 is concerned but the remaining samples will be examined in the framework of future studies.

During the fieldwork in 2015, botanical remains were collected from squares P7 and O8 at the intersections of sub-squares a/b-c/d (Figure 33, Figure 34).

We collected seven soil samples from the stratigraphic sequence revealed in square O8 (Figure 34). These were chosen from the different layers that constitute a more than 1 m high W-E profile and correspond to a period spanning from 2190±40 to 3250±40 BP according to the C14 dates obtained by the dating of charcoal fragments. Our samples came from dark to greyish silty and/or ashy deposits primarily containing vegetal remains as well as occasionally granitic fragments distributed along the profile, from a maximum depth of 220 cm to 140 cm. Sediments were collected from more or less circular zones (diameter 12-26 cm) dug into the sediment profile with the help of a trowel and then conditioned in 2 L labelled plastic bags. A total weight of 23 kg of soil was collected in this way.

In parallel, plant remains were collected during the excavation of square P7 either by hand picking or in the form of sediment samples. Thus, large charcoal pieces were extracted manually from two concentrations of large-size charcoal pieces found in situ and interpreted as hearths. The first of these is named Hearth 1 (*Foyer* 1 or F1) and corresponds to a circular structure situated at a depth of 180 cm. A similar concentration but with fewer charcoal fragments was found adjacent to F1 at a distance of 23 cm and was named F2.

Finally, charcoal samples were also collected within sediments from ashy deposits. Both these soil samples and those collected from the stratigraphy (see above) were dry-sieved with a sieve with a 10 mm mesh. The large fraction was sorted by the naked eye. Granite fragments were eliminated; lithic pieces, charcoal, seeds/fruits and faunal remains were sorted, conditioned in bags and labelled. The fine fraction was collected and botanical remains were extracted by bucket flotation carried out on the site. Very few seed and charcoal remains were found in the fine fraction of samples.

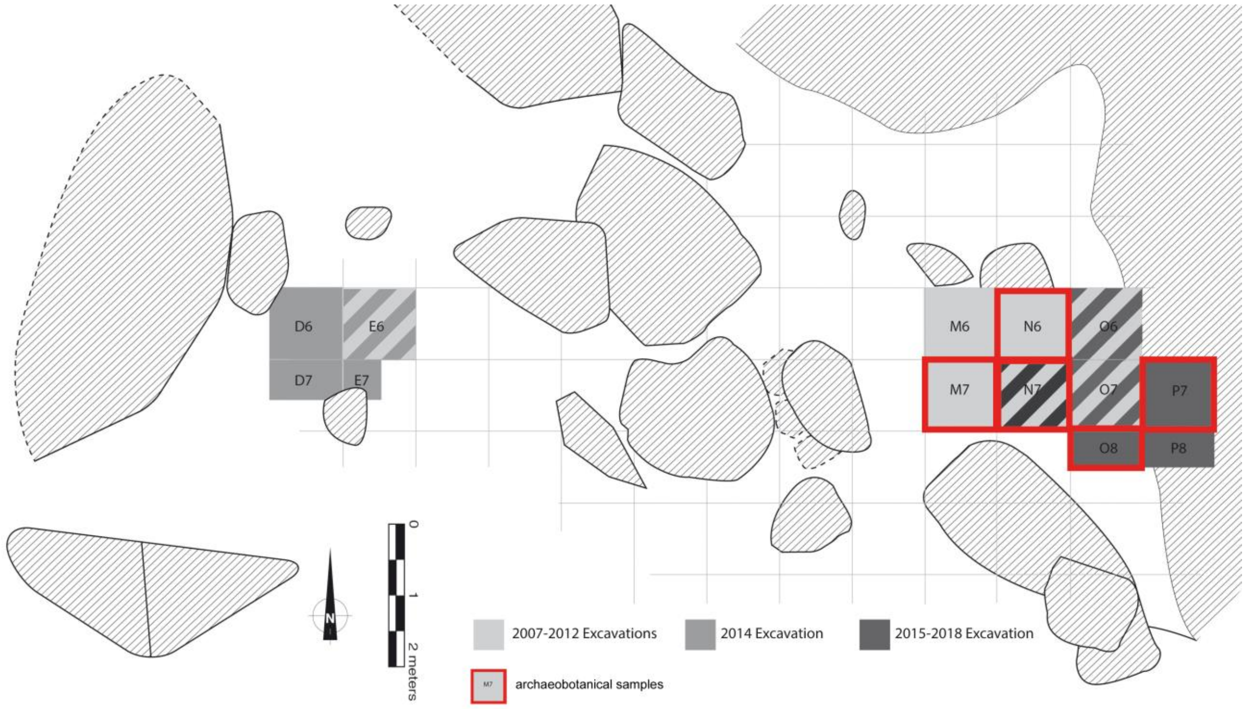


Figure 33: General overview of the excavation area at Leopard Cave, red squares indicate zones that were sampled for archaeobotanical remains

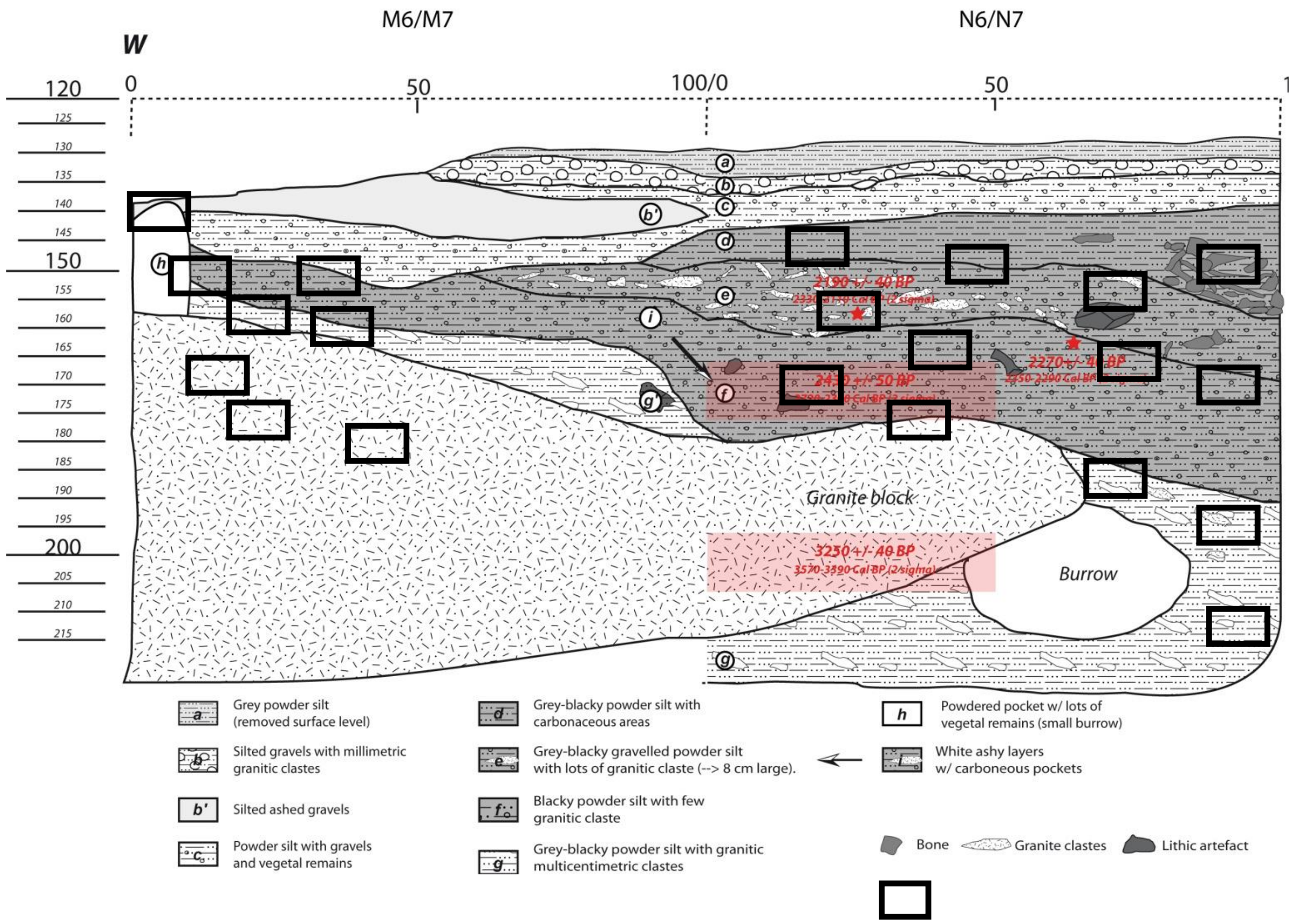


Figure 34: W-E profile of square O8 in Leopard Cave

2.2. Geduld

Botanical remains from Geduld were collected during the excavations conducted at the site from 1978 to 1986 under the direction of L. Jacobson. They originate from different squares and levels named during the archaeological fieldwork (Table 12) and according to the radiocarbon dates obtained span a period from at least 2300±50 BP to 1676±25 BP.

Table 12: List of samples studied from Geduld

Square	Level	C14 date layer	Description
B5-6	L1/4	/	Bedding
B6	L5	1790±80 BP	Ash/bedding
B6	L7	/	Ash/bedding
B6	L6	/	Ash/bedding
B7	L5	/	Ash
B7	L7	/	Ash/bedding
B7	L6/L7	/	Ash/bedding
B8	L3	/	Gritty/ash
B8	L4	/	Dung/ash/hearth
B8	L1/4	/	Dung/ash/hearth
B9	L1/3	1791±50 BP, 1676±25 BP	Dung/ash/burrow
C6	L8	/	Bedding/ash
C7	L8/L10	/	Ash
C7	L11/14	2300±50 BP, 2110±60 BP	Sand/grass

There is no precise indication in the subsequent publication (Yates et al. 1995) of how plant remains were collected but the nature of the samples stored in the National Museum of Namibia in Windhoek suggests that dry sieving of sediments had been practised. Charcoal pieces and seed remains were stored in boxes corresponding to the different stratigraphic units. Sometimes they were found mixed with other archaeological material including coprolites and other plant remains, in other cases they had been separated in labelled bags.

Most of the seed and fruit remains, found both in a carbonised and desiccated state, had already been the subject of a preliminary study (Yates et al. 1995) allowing the identification of 24 botanical taxa. We still chose to include this material in our study in order to verify identifications and to compare the results with those of the charcoal study.

A total of 33 samples from Geduld containing botanical remains were found in the National Museum and could be exported to Paris for study thanks to the kind permission by Mrs Fousy, curator.

2.3. Toteng 1

The site of Toteng 1 was surveyed and excavated by Alec Cambell and his team within the framework a joint mission (1992-2003) bringing together the National Museum of Botswana and the University of Botswana (Huffman, 1994; L. Robbins et al., 1998 ;L. H. Robbins et al., 2008).

When consulting the archaeological collections from Toteng kept in the Botswana National Museum in Gaborone, we discovered that archaeobotanical material was almost non-existent, probably because previous studies did not target this type of studies. Given the importance of the site for our period and especially the presence of the earliest domesticated animals attested in Southern Africa so far (see chapter II) we decided to go back to the site in 2016 and open a stratigraphic trench that would allow the sampling of plant remains.

Finding the original excavation was somewhat difficult and it was only after an hour of navigation with a GPS and thanks to a member of the National Museum of Botswana who was present at the time of the 2002 excavations that we managed to locate the precise location. Once the previous excavation trench had been delimited, we excavated an area of 2x1 m divided into two 1m^2 squares named N and O (Figure 35). The sampling was done on the west-facing section on the half intersections (50 cm each) of each square (Figure 36). 9 samples were obtained, the highest at a depth 20 cm and the lowest at a depth of 110 cm. Spits with a horizontal diameter of 10 cm and a depth of 20 cm were selected for sampling. A total of 18 kg of sediment was collected in this way and conditioned in 5 L Mini-grip bags before transport to the National Museum of Botswana where the samples were treated by flotation. During excavation and sieving, some charcoal pieces and seeds were manually retrieved. At the National Museum of Botswana, the sediment was first dry-sieved through a 2 mm mesh and larger charcoal and seed fragments were handpicked. The sieved sediment was kept and later bucket flotation was done. The archaeological sediment was poured into 10 L buckets filled with water. The floating charred remains were recovered by the sieving through a fine-meshed textile that was then hung to dry in the sun. Finally, the dry botanical material was wrapped in aluminium foil, labelled and packed in small Mini-grip bags. In total 198 charcoal fragments were recovered in this way. The site was very poor in seed remains producing only 9 *Acacia* seeds. These were moreover retrieved only from the uppermost levels of the excavation (0-20 cm) and were considered to correspond to modern pollution. Indeed, the presence of an *Acacia tortilis* tree growing very close to our trench probably explains the presence of seeds in the uppermost layers.

Figure 35: Excavation of Toteng 1 in 2016

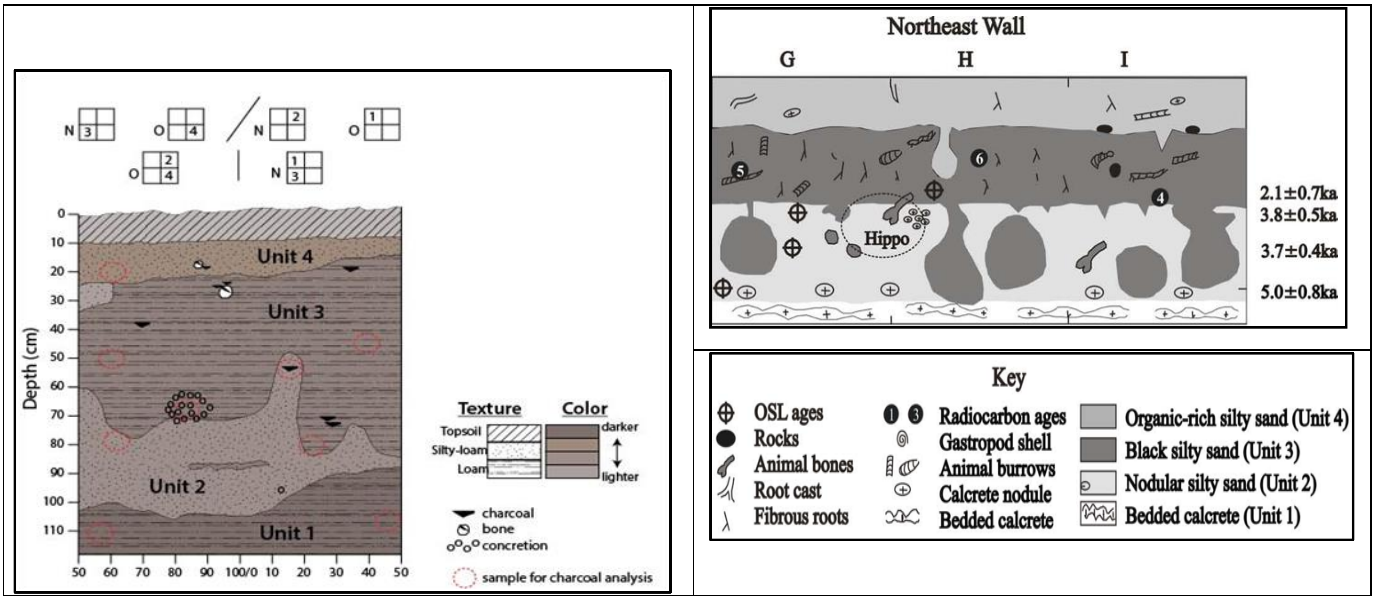


Figure 36: Section from the 2002-03 excavation (l) and drawing of the stratigraphy revealed in 2016 (r)

3. 3. Laboratory methods and botanical identifications

Identification of botanical remains included in the PhD was carried out in two laboratories specialised in archaeobotany: the laboratory hosted by the Institut Català de Paleologica Humana i evolucio social in Tarragona, Spain and the laboratory of the research unit 7209 (*Archaeozoology, Archaeobotany: Societies, practices and environments*) in the National Museum for Natural History in Paris (Figure 37). The laboratory work was carried out alternatively under the supervision of Dr E. Allue in Tarragona and M. Tengberg in Paris. Moreover, two visits to the Institut für Archäologische Wissenschaften at the Goethe-University in Frankfurt am Main allowed us to benefit from the special expertise in African archaeobotany that is developed there by the team directed by Pr Neumann.

Figure 37: Use of a reflected-light microscope for charcoal analysis in the archaeobotanical laboratory of the National Museum for Natural History, Paris

3.1. Charcoal analysis

To prepare the charcoal for identification we fractured the charcoal pieces with the help of a razor blade according the three sections wood: transversal, longitudinal radial and longitudinal tangential. The next step was to observe the anatomical features of the archaeological wood under an Olympus BX51TRF incident light microscope at different magnifications (x50-x1000). Salt in a Petri dish placed on the microscope stage was used to hold the charcoal in place during analysis. Chosen charcoal pieces were prepared for photography and pictures were realised using a JEOL (x10-x20000) JSM-5000 Neoscope Scanning Electron Microscope.

In order to identify the wood samples we followed the International Association of Wood Anatomists (IAWA) standards (IAWA Committee, 1989). For comparison we used wood anatomical atlases and anthracological catalogues (Neumann et al., 2001) as well the Inside Wood Internet database (InsideWood, 2004 onwards). These references have been of great help but none of them is specialised on taxa from our study region.

Reference collections held in the archaeobotanical laboratories in Paris and Tarragona were consulted but did not always contain the representative species. The collection in the Natural History Museum in Paris is for example oriented rather towards the arid regions of the Middle East and even though to some of the genera are common to this region Southern Africa (*Acacia, Maerua, Boscia*…) precise species are not. In this respect our visits to the specialised laboratory at the Goethe University in Frankfurt, where there is a large reference collection of African woods, as well as the advice from the specialists working there, were particularly precious. Still, even there reference collections and research projects are predominantly oriented towards West Africa even though some investigations have also concerned our study region as explained in Chapter I.

Even though the diversity of taxa is comparatively low at the three sites due to the arid environment (see results and discussion) their identification was in many cases rather problematic. *Acacia*, the predominant genus at all three sites, comprises a large group of species (in Southern Africa) that show very similar anatomical characteristics all while presenting a large intra-specific diversity (Neumann et al. 2001). Except for a few species, for example *A. nilotica* that show particular characteristics (in this case, clearly defined circumvascular parenchyma), it is thus not possible to push the identification further than to the genus level (*Acacia* sp. or when several types are observed: *Acacia* spp.). Moreover, other genera, in particular *Dichrostachys,* equally of the Fabaceae family, could sometimes not be distinguished from *Acacia* and in these cases the two were grouped together as *Acacia*/*Dichrostachys.* To tell apart the anatomically close genera *Boscia* and *Maerua* from the Capparaceae family was another challenge and often these two had to be grouped together as *Boscia/Maerua*.

Facing these difficulties we also relied on Ekblom et al. (2014) by applying the 'type' concept. This model uses a type to represent a morphological or, in the case of wood charcoal, an anatomical category that is distinguished from others by a single character or a significant character combination. Therefore a 'type' may represent one or several species in tropical environments. These conceptual types become very useful when the wood anatomy does not allow for an unambiguous botanical determination.

3.2. Seed analysis

Seed and fruit remains from Leopard Cave and Geduld were separated from the surrounding sediment and charcoal matrix with the help of a binocular microscope. The same microscope, allowing magnifications of x8-x50, was used for observing and describing the morphological criteria (size, shape, ornamentation of the seed coat/endocarp, etc.) that were used for the identification of remains. The botanical determination of seeds/fruits was more straightforward than that of charred wood remains. Many of the species were already well known by the author and to confirm the identifications we used different sources. In the laboratory we consulted *The Digital Atlas of Economic Plants in Archaeology* (Neef et al. 2011) as well as reference collections, in particular those collected by the author in the field (see below). Further confirmation could then be obtained both by Christine Sievers, specialist in Southern African archaeobotany at the University of the Witwatersrand, and by our informants within the Damara and San communities in the Erongo region (see Chapter IV). Finally, comparisons with reference material held in the Botanical garden of Botswana in Gaborone were also made. Seeds/fruits were photographed using a camera mounted on the optical microscope.

3.3. Constitution of a reference collection

Given the difficulties mentioned above and the fact that Southern Africa has so far been the subject of few archaeobotanical investigations we choose since the beginning of the PhD to put effort into creating collections of wood and seeds/fruits representing the flora present in our study region. The reference collection does not only help to do identifications and classification of the archaeological material for this study, but the aim is to set a foundation for a catalogue that could be used to build a regional for southern Africa reference collection in future.

Reference specimens were collected during the months of June and July in 2014, 2015 and 2016 from three different areas (Figure 38). On the one hand we collected samples from the plant formations surrounding the sites of Toteng (NW Botswana) and Leopard Cave (NW Namibia). On the other hand, we acquired samples from the Botswana Botanical Garden (which belongs to the Botswana National Museum) in southeastern Botswana. Mr Mafokate from the latter institution was particularly helpful in confirming the identification of our specimens through the examination of the herbarium sheets associated with the wood samples (Figure 39). For the identification of plants in the field we used several floras of the local vegetation (van Wyk and van Wyk 2007, Coates-Palgrave 2002).

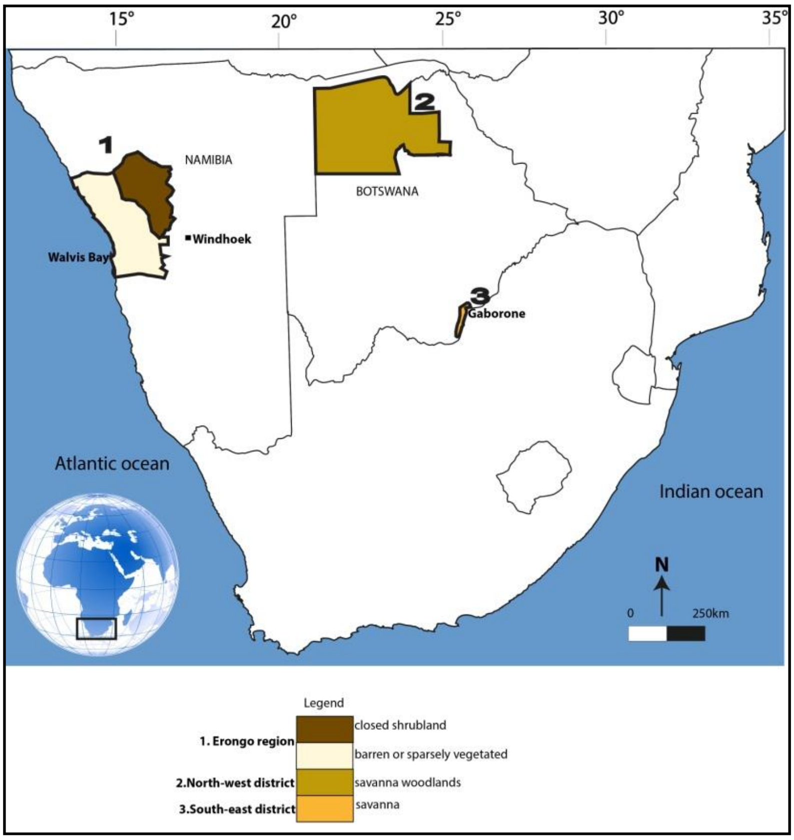


Figure 38: Areas in Namibia and Botswana where the reference material was collected

Despite the distance between the three areas, they experience similar environmental conditions and partly host the same types of plant formations. Thus, when a particular species was present in several localities we chose, for saving time, to collect the species only once.

Woody parts in the form of tree trunks and parts of branches were cut with the aid of a cutter, an axe, shears before being dried in the sun (Figure 39). In order to prepare the specimens for direct comparison with charcoal samples under a reflected-light microscope they were burnt in a muffle furnace in the National museum of natural history in Paris, France. Descriptions of the features were made following the criteria of the IAWA List of Microscopic Features for Hardwood Identification. Pictures were taken with a Scanning Electron Microscope (SEM), observations were made and the results are given in the form of a catalogue where 22 specimens are described (see the appendice).

Other parts of the plant including seeds, fruit, inflorescence and sometimes roots were also collected. Leaves, flowers and other diagnostic elements were dry-pressed, labelled and organised in the form of a herbarium (Figure 40).

Figure 39: Labelled dried wood cuttings before charring

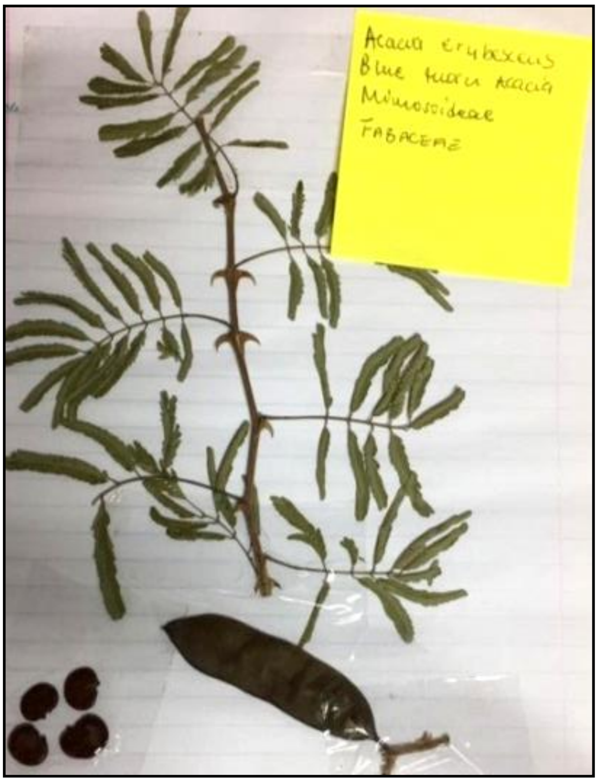


Figure 40: Example of herbarium sheet with leaves and fruits/seeds from *Acacia erubescens*

Table 13: List of species in the reference collection with their family, Latin and vernacular name as well as with the part of the plant collected (F/INFL – Flower/inflorescence; FR/S – Fruit/seed)

N°	Family	Scientific name	Vernacular name	Wood	F/INFL	LEAF	FR/S
1	Anacardiaceae	*Lannea schweinfurthii*	False marula	x		x	
2		*Sclerocarya birrea*	Marula	x			
3		*Ozoroa paniculosa*	Resin tree				x
4	Apiaceae	*Steganotaenia araliacea*	Carrot tree	x			
5	Bombacaceae	*Adansonia digitata*	Baobab	x		x	
6	Burseraceae	*Commiphora glandulosa*	Tall fire-thorn corkwood	x			
7		*Commiphora*	Pepper-leaved	x		x	
8		*Commiphora viminea*	Zebra-bark corkwood	x			
9	Capparaceae	*Boscia albitrunca*	Shepherd's tree	x			
10		*Boscia foetida*	Stinky sheperd's tree	x		x	
11	Combretaceae	*Combretum apiculatum*	Red bushwillow	x			
12		*Combretum imberbe*	Leadwood	x		x	x
13		*Combretum zeyheri*	Large-fruited bushwillow				x
14		*Terminalia prunioides*	Purple-pod terminalia	x			x
15		*Terminalia sericea*	Silver terminalia	x			
16	Euphorbiacea	*Croton gratissimus*	Carrot tree	x			
17		*Bridelia mollis*	Velvet bridelia			x	
18	Fabaceae	*Acacia anthelmintica*	Worm-bark false thorn				x
19		*Acacia erubescens*	Blue thorn acacia	x	x	x	x

20		*Acacia erioloba*	Camelthorn acacia				x
21		*Acacia mellifera*	Black thorn acacia	x		x	x
22		*Acacia karoo*	Sweet thorn acacia	x			
23		*Acacia nigrescens*	Knobthorn acacia	x			
24		*Acacia robusta*	Riverthorn acacia	x			
25		*Acacia tortilis*	Umbrella thorn	x		x	x
26		*Adenolobus garipensis*	Butterfly leaf	x			
27		*Cassia abbreviata*	Long-tail cassia	x		x	
28		*Colophospermum mopane*	Mopane	x		x	
29		*Dichrostachys cinerea*	Sicklebush	x	x	x	x
30		*Mundulea sericea*	Cork bush				x
31		*Ormocarpum trichocarpum*	Caterpillar pod			x	
32		*Peltophorum africanum*	African wattle			x	x
33	Loranthaceae	*Tapinanthus oleifolius*	Mistletoe			x	x
34	Malvaceae	*Azanza garckeana*	Snot apple	x		x	
35		*Dombeya rotundifolia*	South African wild pear	x			
36	Moraceae	*Ficus abutilifolia*	Large-leafed rock fig	x			
37	Moringaceae	*Moringa ovalifolia*	Motinga	x			
38	Olacaceae	*Ximenia americana*	Blue sourplum	x		x	
39		*Ximenia caffra*	Sourplum	x			
40	Rhamnaceae	*Berchemia discolor*					x
		Ziziphus mucronata	Buffalo thorn			x	x
41	Rubiaceae	*Gardenia volkensii*	Bushveld gardenia	x		x	
42		*Vangueria infausta*	Wild medlar	x			
43	Sapotaceae	*Sideroxylon inerme*	White milkwood	x			
44	Sterculiaceae	*Sterculia africana*		x			
45	Thymelaeacea	*Corchurus olitorius*	Bush okra		x	x	
46	Tiliaceae	*Grewia flava*	Velvet raisin	x	x	x	x
47		*Grewia flavescens*	Sandpaper raisin	x			
48	Vitaceae	*Cissus cornifolia*	Ivy-grape	x		x	x
49		*Cyphostemma currori*	Cobas	x			

The reference collection constituted as described above comprises a total of 49 species (Table 13) representative of 20 different families of the Angiosperm (flowering plants) group. Among these 38 have provided a wood sample; 17 species have provided both a wood sample and other parts of the plants. Some families are better represented than others, for example the Fabaceae (N=15) and the Combretaceae (N=5), because of the presence of several species in the study areas.

CHAPTER IV – PLANT USE AMONG PRESENT-DAY DAMARA AND SAN POPULATIONS IN THE ERONGO REGION, NAMIBIA

Contact may take many forms, not all of which lead to dependency, abandonment of foraging or incorporation into "more powerful" social formations (Solway and Lee 1990)

1. Objectives of the ethnobotanical study

To reconstruct past practices from the archaeological remains of material culture can often be quite challenging. The record at hand is usually very incomplete and patchy and this is even more so in archaeobotany where the bulk of organic material has disappeared through time. Moreover, the lack of comparative work from our study region makes our understanding of past environments and subsistence activities more difficult.

Even though there is no direct comparison between populations living in the Kgalagadi basin today and the Late Stone Age communities that we study in our work, ethnobotanical enquiries can, besides being interesting and important as such, provide us with hints on the exploitation and the use of local plant resources of which some may have been present in the region also in the past. Even though some researchers dispute this approach, it is most helpful when it comes to interpreting material from archaeological contexts as they put people into spaces with objects they move and manipulate therefore allowing us to envisage these actions even in contexts from which the actors have since long disappeared.

To better understand and reconstruct the history of the people and their culture applicable for archaeological inferences, it is important to let the populations under study to participate actively in the investigation. Contrary to past years, current ethnographic work seems to be heading in this direction. Recently the providers of traditional ecological knowledge themselves are seen more and more at the centre of these studies. This helps researchers to avoid falling into pre-fabricated fixed models when they interpret archaeological data. The omission of this may also result in the inclusion of redundant points of views that may be stuck to unmoving classifications. In the region, a good example is the application of ethnographic studies being incorporated in linguistic and archaeological questions (Rapold and Widlok 2008).

In order to gather general information on the exploitation and use of plant resources in the arid environment of the Erongo region, we decided to conduct an ethnobotanical survey within two different communities living close to Leopard Cave: a group of sedentary inhabitants from the Damara ethnic group living in the small village of Tubusis and members of the San population demonstrating traditional plant uses in the framework of the San Living Museum. Our surveys took place during a total of four days in September 2017 and October 2018. Maria Randy from the University of Namibia took part in the ethnobotanical surveys. Questions were oriented towards issues of special interest for our understanding of past plant uses such as the collection of wood for fuel and construction, the role of wild plants in the diet, the knowledge and use of medicinal plants, seasonality of foraging, etc.

2. Ethnobotanical study within a Damara community

2.1. Description of the village of Tubusis

The small village of Tubusis (21° 32' 2'' South, 15° 27' 4'' East) is located on the left side of the gravel road D306 leading to Usakos, on the western foothill of the granitic Erongo Mountain and within the Gaingu Communal Conservancy (Figure 41) (Angula, 2010). The village is situated about 60 km from Usakos, 50 km from Spitzkoppe, 80 km from Okombahe and Omatjete and 60 km from Omaruru (MTC Namibia EIA report 2018).

The local climate is semi-arid to arid with mean annual temperatures of 18°C and peaks reaching around 40°C during the hot season. The mean annual rainfall, mostly occurring as summer precipitation, varies between 100 and 500 mm. The arid conditions influence on the vegetation cover that belongs to the desert/Nama Karoo biome, also known as the “Karoo shrubland” of northwestern Namibia. It is characterised by open to very open scrublands dominated by drought-resistant species from the Fabaceae (Mimosoideae) and Capparaceae families as well as seasonal grasses and other herbaceous plants, among them several creepers (Mitchell 2002, Sletten et al. 2013).

Figure 41: Location of Tubusis in the Erongo region

At present around 800 persons are registered in the village of Tubusis (2011 Namibia census). Most of the middle-aged working class inhabitants live and work in nearby towns such as Swakopmund, Usakos and Omaruru and as far as Windhoek. Usually they return to the village to spend time with their families in weekends and public holidays. Retired and unemployed adults as well as small children and those going to primary school (6-14 year old) reside permanently in the village. Grandparents look after the young children in the absence of their working parents. The great majority of the population belongs to the Damara ethnic group with a few exceptions corresponding to persons from other tribes who arrived through marriages, work or run commercial activities.

In addition to around 130 homesteads, the village comprises a boarding primary school, a church, two supermarkets, a communal water-tap and two drinking spots. For amenities, including groceries and medical care, the inhabitants commute to the nearby towns of Usakos and Omaruru. A gravel road runs through the settlement where commuters hitchhike to reach the nearby towns. In spite of the village's proximity to bigger and more modern towns, its inhabitants still acquire the majority of their resources for everyday needs from the natural environment, mostly because of their modest social and financial status.

The opposite side of the road is used as a grazing ground and for collecting fruit, sap or small prey like tortoise, rodents and birds. Our photos of this area (Figure 42, Figure 43) were taken in October 2017 e.g. during the dry season. There is almost no ground cover and most of the trees, except the evergreen *Boscia* species, have lost their leaves. Barren as it may seem most of the vegetal material used in the village still comes from this type of biotope.

Figure 42: View of one part of the village of Tubusis with surroundings

Figure 43: Landcape opposite the village of Tubusis with granite foothills in the background and open *Acacia erubescens* woodland with grazing herd in front

2.2. The Damara ethnical group

The Damara are a Khoekhoegowab dialect speaking group found in Southern Africa making 8.5% (about 100 000 inhabitants) of Namibia's present-day population (H. Soodyall and Jenkins, 1993). One of the oldest tribes in Namibia, the Damara speak a Khoi-San language but they have a different biological history altogether. While they are currently found in the north central parts of Namibia in the Kunene region, some parts of the Erongo region and also spread in other parts of Namibia (Figure 44) mostly for professional activities (Mendelsohn 2008) the origin of this group is still poorly understood. A number of studies on this subject are however currently underway. The Damara were previously classified as Khoehkoe and the indigenous and earliest inhabitants of the area that is now Namibia, but linguistic studies reveal that they speak the Damara Khoekhoegowab dialect language that many scholarly writings ascertain they inherited from their Nama slave masters. The study of mitochondrial DNA suggests that they are closely related to the Herero Bantu group. On the other hand, lexical comparison between the Central

Khoe and Damara Khoekhoegowab groups give a glimpse of the their relationship, possibly raising questions on why a Khoe language and a negroid non Khoe or San group would share language aspects, but it cannot give answers about the origins of the Damara people (Haacke, Wilfrid, 2008). One school of thought suggested they could be one of the first inhabitants of the region who had to be subordinate to their later arrivals with livestock into servitude. Most Bantu herd goats and sheep together and the Damaras are no exception; today they are goat and sheep herders and some of these conform to the names ''Damara goat'' and ''Damara sheep'') (Pleurdeau et al., 2012) which are well adapted to harsh and arid environmental conditions (Badenhorst, 2006). Sheep though are much earlier domesticates for the Khoekhoe and they give the notion that the Khoekhoe may have originally favoured sheep over goats. Apart from livestock farming and the infertile land for ploughing, the Damara also highly rely on collecting wild seeds and fruits, including honey and grass grains for subsistence (Sullivan, 1999)

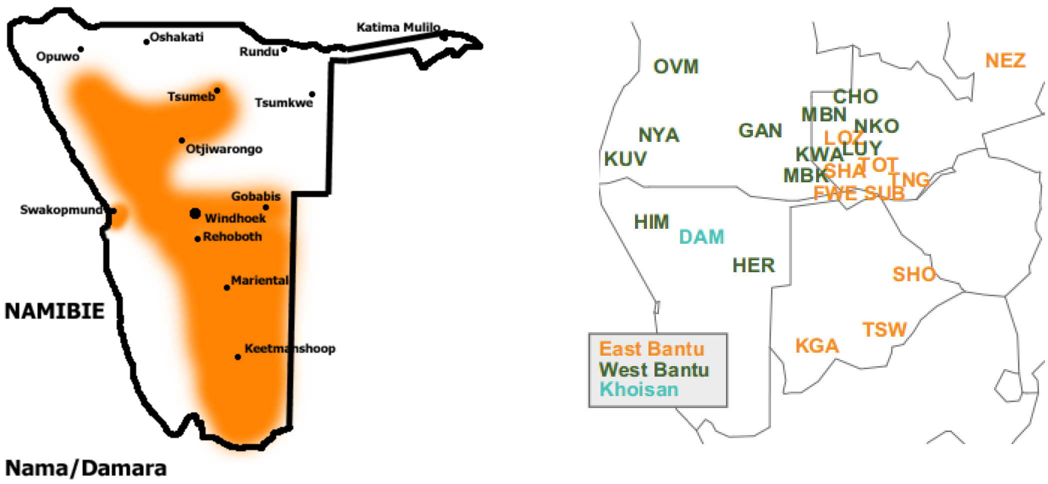


Figure 44: Map of Namibia showing the current distribution of Damara populations; orange colour on the left and green "DAM" on the right (sources: Wikipedia and Barbieri et al., 2014)

2.3. Methodology

After having visited the whole village of Tubusis that extends on about 800 m from one end to the other we chose to visit more thoroughly five of the homesteads and exchange with their inhabitants on their use of local plants. Our “informants” were mainly selected according to the villagers’ recommendations indicating the presence of a particularly knowledgeable (often an elderly) person (Figure 45).

The interview method involved the conducting of open questions and responses were noted down in a notebook while a voice recorder was used to record the whole interview process. Participatory observations were also made and some informants brought us around on “guided visits” and thus provided detailed descriptions of different households and their surroundings, of the vegetation cover and the use of plants. We took pictures of these different aspects and also recorded videos in necessary instances as support material. Transcriptions of all these media were made.

Concerning the plant taxa most if not all names were indicated in the native Damara language and throughout this chapter we use both the vernacular and Latin name.

Below we describe the information obtained from each of the chosen households before the rendering of some more general remarks. As can be noticed the information on plant uses varies according to the composition of the household and family practices. We complete this chapter by a summary table comparing the uses of plants by the two groups living in the same type of environment at a few kilometres distance.

Our visit to the Tubusis village took part during the dry season and thus not all plant uses could be observed directly. For example, many fruits were not available in October and only the vegetative part of these species could thus be observed.

Figure 45: A Damara woman and man living in Tubusis

2.4. Description of plant uses for each household

Household 1

The head of this (matriarch) household is Mrs Sophia Matsuis who has lived in Tubusis since 1987 and works in a hostel. Her granddaughters Sophia Matsuis Jr. (10 years) and Deborah Auses (25 years) were also present during our visit.

As one of the village elders Mrs Matsuis is very knowledgeable about the history of the village as well as about plants. She was particularly conversant on medicinal plants that she harvests, prepares and administers to her patients. She also provided us with information on the use of plant materials in the architecture of her house, plant foods and the surrounding vegetation. She did some demonstrations on living plants but also made references to others that we could not directly observe in the present-day surroundings.

The fence surrounding Sophia's house and its yard has been constructed by associating standing gum-poles (store-bought treated *Eucalyptus*) and locally collected stems and branches. Among the latter we could identify *Acacia eurubens* and *Acacia nigrescens* that accounted each for around 1/3 of the fence material. *Boscia albitrunca* was also used (around 1/5) as well as some branches from species that we could not identify. To maintain upright position of the palisade, poles were dug into the ground and are spaced at an average distance of 1.5 m and a horizontal wire was used to keep them together.

Sophia's late husband built the house from scratch but she could not recall the exact year of the construction. Several square or rectangular structures made from mud, concrete bricks, corrugated iron and provisional material like garden mesh and empty plastic bags surround a rectangular yard of ca 20 x 30 m. The largest one is used as the bedroom for the whole family and the courtyard in front of it is the sitting and cooking area. A second structure located at the far corner of the yard is used as storage for firewood and kitchen utensils and can also be used as a living area in the rainy season. Sophia mentioned no specific choice of wood for construction and combustion but indicated that wood is mainly acquired according to its availability and sometimes durability. She also attested that firewood, which is only collected as dry wood, has recently become scarce around Tubusis and is therefore brought from neighbouring villages and fields. Building material is obtained from felled trees, usually in the proximate surroundings of the village but nowadays constructions wood is also collected from further afield in order to to avoid exhausting fruit resources, general food supply and animal feed from sparsely vegetated areas. An example of a tree that she considers very important to preserve is *Acacia erubescens* that produces a resin that she and her grandchildren collect as a delicacy or for selling. She underlines that this collecting is occasional and not for everyday use. Moreover, Sophia Matsuis provided us with specific information on the uses of fruit and wood from *Spirostachys africana*, *Boscia albitrunca* and *Acacia karoo*.

Household 2

The main informant in the second household, visited on September 6th in 2017, was 34-year old Dorothea !!Garoes. Six other family members were present at the time of our interview. Dorothea moves between Tubusis and her farm, some ten kilometres away, where her husband permanently resides. She was born and raised in Tubusis by her grandmother who was the village's traditional doctor who taught her daughter about plant use both as a medicine and for everyday use.

When she is present in Tubusis, Dorothea lives with her extended family consisting of six persons in a homestead that used to belong to her late grandmother. Just like in household 1 the yard of this family is surrounded by a fence made with a mixture of eucalyptus poles, *Boscia albitrunca* (ca ½) and *Acacia erubescens* (ca ¼) completed by a mixture of unidentified wood elements. The compound encompasses three sheds made of corrugated iron and wood, including different acacia species. Two structures act as bedrooms and the third and smallest structure is the kitchen and storage area for both wood and foodstuffs. Firewood is also stored outdoors near to the kitchen. Cooking is done outdoors and in the kitchen area during the rainy season. A !nxara tree stands by the entrance and the family sits under its shade during the day to cool off. Cacti and sisal plants were planted in the backyard for their medicinal virtues by family members. Mrs Dorothea's interview included a tour to explore plant life in the surrounding areas and the mountainous area of Tubusis, resulting in a much larger number of individual plants from this household. She was conversant on *Boscia albitrunca*, *Acacia erubescens*, *Commiphora wildii* (Figure 46), *Lippia javanica*, *Aloe gariepensis*, *Harpagophytum procumbens* and *Terminalia prunioides* among others.

Figure 46: Ms Dorothea !!Garoes demonstrates the use of *Commiphora wildii* all while being recorded on a voice recorder (Photo M. Mvimi)

Household 3

This household comprised only one person: Mr Loman C. !Owos-ôab, who is a teacher 42 years old. Mr !Owos-ôab is originally from Tsumkwe but he has been living in Tubusis for the past ten years where he teaches at the local boarding primary school. He is a tenant of a one bed-roomed brick house. The rectangular yard is fenced with a mixture of palisades from different tree species that are put together with wire. The palisades are relatively old and worn out therefore not very easy to identify. Since he was not present at the time of construction, the respondent cannot be relied on to give the wood types used for building but states that the wood is chosen on the basis of durability and resistance to parasites. He only talked about the plants that are in and around his homestead. He has a small fireplace and wood in the open beside the house but mentions that he uses a gas stove to cook sometimes. He knows especially well some species that he uses on a daily basis: *Acacia karoo* and *Acacia tortilis* for fuel and *Boscia albitrunca* and *Boscia foetida* for fruit.

Household 4

The 60-year old woman who was our fourth informant preferred to remain anonymous. She stays at home and tends to her goats, chicken and sheep. She has grown children who are working in different towns in Namibia. The fence of her house consists of gumpoles (ca 1/5) associated with local branches from *Boscia albitrunca* (1/2), *Acacia* spp. (1/4) as well as unidentified material. Her homestead measures 30 m x 30 m and the two-bedroom house is located at the back leaving a large courtyard in front of it where firewood is stored and cooking takes place. An *Acacia tortilis* tree growing near the entrance serves as a place to sit and rest during the day. Besides informing us on the use of *Boscia albitrunca*, *Boscia foetida*, *Ziziphus mucronata* (food) and A*cacia tortilis* (fodder) this lady showed us the seeds of a grass species (genus *Sporobolus*) that is collected from ant mounds and eaten raw (Figure 47).

Figure 47: Grass seeds (genus *Sporolobus*) collected from ants nest and consumed

Household 5

Mrs Cecilia Thanises is 72 years old and lives in one house together with three of her relatives, two females and one male. She is one of the first inhabitants of Tubusis but does not recall the year she first settled there. She is the traditional healer of the village. Her homestead is made using the same material as the other houses we visited (Figure 48): a mixture of wild woody plants and meshes and galvanised wire (Figure 49). Her two houses are made with corrugated iron, both the wall and roof and the kitchen house is made up of mesh wire and corrugated iron roofing. Firewood and cooking utensils are kept in this area and cooking is also done here. Excess wood and abandoned utensils are kept behind this structure (. The top is used as a scrap yard. The informant has a very wide knowledge of medicinal plants. She selects carefully the wood that she uses for fire and unlike most of the other informants she believes that certain species are taboo. Mrs Thanises showed us how dried Z*iziphus mucronata* and *Combretum imberbe* leaves are used for treating coughs.

Figure 48: Fencing around the yard of Mrs C. Thanises (Photo M. Mvimi)

Figure 49: Wood used for constructions and fuel stored beside the kitchen in household 5

2.5. General observations

Our observations together with the information provided by the inhabitants show there is a high exploitation of almost all of the locally available plants for consumption (food, fuel and medicine), construction and commercialisation (Table 14). For the village architecture (fences and houses), the inhabitants use a combination of traditional and modern building materials. Most house walls are constructed using cement bricks, corrugated iron sheets, branches and various textiles while some comprise the combination of all the aforementioned materials, merged with wood. The yard fences are also made with a combination of barbed wire, galvanised wire, wood and treated gum poles. Most of the residents have either constructed the structures themselves or received help from relatives to do so.

Free-range pastoralism is practised at a relatively small scale by keeping drought-resilient livestock such as goats, sheep and poultry. Pets such as cats and dogs are also common. Not much large stock like cattle is kept but donkeys and horses are used as modes of transportation or for pulling carts. During the dry season, when grazing land is exhausted, the animals browse on evergreen trees like *A. albida* or *Boscia* species and the owners usually aid their livestock by collecting and storing (in a dry state) wild fruits mostly wild melon (*Citrullus caffer*, *C. ecirrhosus*). They also shake various tress of the Mimosoideae (Fabaceae family), such as acacias and *Dichrostachys cinera,* to make their nutritious pods to fall to the ground. Since the family members residing permanently in the village are usually without formal employment, they alternate in accompanying the animals to feed in the open wood and scrublands during the day.

Almost no cultivation is practised by the villagers because the lack of water. Still, throughout the interviews the villagers mention farms situated at a distance of about 7-10 km where larger herds of cattle and commercial vegetables such as cabbage, carrots, beetroot etc. are cultivated and where a substantial number of Tubusis residents are employed.

Table 14: Summary table of the uses of woody plants in the Tubusis Damara community

Family	Scientific name	Uses	Archaeobotany
Burseraceae	*Commiphora wildii*	Wood, bark - snakes repellent in houses, associated insects used for arrow poison	/
Capparaceae	*Boscia albitrunca*	Leaves - crushed, anti-inflammatory medication for the skin; roots - sliced and boiled/steamed against chest infections ; the wood is toxic and not used for fuel, "the inhaled smoke can wipe off a whole family"; fruit - when eaten fresh	X
Celastraceae	*Gymnosporia senegalensis*	Branches - for making arrows, in association with bluegrass (*Bothriochloa bladhii*) to fix the arrow	?
Combretaceae	*Combretum apiculatum*	Young branches - used to build the hut "!xhabusi"; seeds - mixed with other plant materials to make body ornaments	(X)
Euphorbiaceae	*Croton gratissimus*	Wood - firewood and building material; roots - boiled for pains in chest, back and articulations	Seeds
Fabaceae-Caesalpinoideae	*Adenolobus garipensis*	Twigs - cut for necklaces	/
Fabaceae-Caesalpinoideae	*Mundulea sericea*	Young branches - used to build the hut "!xhabusi", if not long enough joined with *Terminalia sericea*, *Acacia erubescens* and *Senseveria* spp.	(X)
Fabaceae - Mimosoideae	*Acacia erubescens*	Young branches - used to build the hut "!xhabusi"; seeds - mixed with other plant materials to make body ornaments	(X)
Fabaceae-Mimosoideae	*Acacia mellifera*	Wood - firewood	(X)
Fabaceae-Mimosoideae	*Acacia tortilis*	Wood - firewood; root - hollowed out and covered with with animal skin to manufacture quivers	(X)
Fabaceae - Mimosoideae	*Dichrostachys cinerea*	Stem - carved into walking and digging sticks ; gum - trapping birds or as a bait : seeds - mixed with other plant materials for body ornaments	X
Olacaceae	*Ximenia americana*	Fruit - eaten fresh; kernels - body ornamentation, burnt for inhalation, crushed and applied to the nostrils to cure headaches	X
Rubiaceae	*Vangueria infausta*	Roots - crushed for heart ailments	Seeds
Tiliaceae	*Grewia flava*	Wood - fuel; branches - used for bows; leaves - dried for infusion, soaked in water against evil spirits, provide shade; fruit - eaten raw	X

Dry wood for fuel is collected from the woodlands and is stored in the courtyard or in a roofed space during the rainy season. When collected at distances further than 5 km, a donkey or horse-drawn cart is generally used to transport the wood. In 85% of the households fire is made in a sheltered hearth in the courtyard or, when weather is bad, inside the kitchen area. Usually all family members are involved in the collection of wood but in some cases wood loads are bought from vendors who bring it to the village with horse-drawn carts.

3. Ethnobotanical study within a San community

3.1. The San Living Museum in the Omandumba farm

The second ethnic group living near Leopard Cave that we encountered during our ethnobotanical survey are the San. Members of the Ju/'Hoansi local community demonstrate traditional activities in the "San Living Museum" founded in 2008 at the Omandumba farm. We visited this open-air museum at two occasions in the months of September 2017 and 2018 (Figure 50). During the day various activities relative to the San way of living are organised and the information gathered for this study was acquired during several guided tour days. The demonstration took place on the one hand in the San settlement area and on the other hand in the surrounding landscape. The residence entails a makeshift compound, cleared of groundcover. The community does not live in permanent houses but construct temporary huts made of grass and/or plastic bags. The “workplace” is under a boulder and the temporary homestead is behind this spot. Throughout the day, each member of the family performs tasks primarily for tourist attraction. The women do craftwork like beading; making ornaments like necklaces, bracelets and decorations while the men do the guided tours, gather material needed to make the crafts and several other types of crafts like wood-carving. The children mostly assist the adults but at the same time they play around and take care of their younger siblings. During the tours more than one informant is designated, usually one speaks a Ju/'Hoansi dialect and the other as a translator in English.

The landscape around the Omandumba farm (Figure 51) is very similar to that in the surroundings of Tubusis with only slight differences in vegetation cover. Thorny acacias and grasses dominate the open scrub/wood-lands but while *Ziziphus mucronata* is present in Tubusis, *Grewia* and *Ximenia* species are more common fruit trees in the San area. *Boscia albiturunca* and *B. foetida* grow in both places and the fruits of these trees are eaten raw or fermented.

Figure 50: Exchanging with the informants at the San living Museum

Figure 51: The landscape in Omandumba West adjacent the San Living Museum

3.2. The San populations of Southern Africa

Designated as *Bosjemans* or *Bushmen* by the colonisers, the aboriginal communities of hunter-gatherers living of the Kgalagadi desert of Southern Africa are at present preferably called San, a name derived from the local terms *Sonqua* and *Soaqua* (Smith and Ouzman 2004). The San are today found in Namibia, South Africa, Botswana and Zimbabwe (Figure 52). 30 000 of them live in Namibia, making up around 2% of the country's population. Not all San people are related and they usually prefer to be referred to by their respective group (Dan et al. 2010).

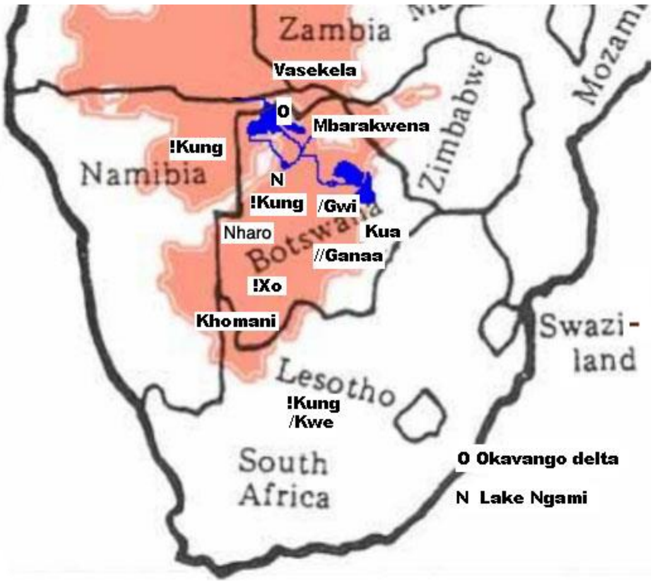


Figure 52: The distribution of San populations in Southern Africa (Pickrell et al. 2013)

Unlike the Damara group, the lifestyle and origin of San populations "who do not possess pottery nor raise livestock" have attracted quite some attention since the 18^{th} century. J. Phillip, superintendent of the London missionary and a militant against the San genocide of the late 18th and early 19th centuries, was together with his colleagues the first to publish on the "Bushmen" in the Cape province (present South Africa). In 1907 the German photographer S. Passarge wrote and illustrated a book entitled *Die Buschmänner der Kalahari* in which he describes his encounters with the indigenous people of the Kgalagadi in present-day Botswana and Namibia (Demangeon 2018, Penn 2013). This description is qualified by Wilmsen et al. (1990) as a "San research that came close to an organised anthropological study".

A "Great Kalahari San debate" is still open on the origin and identity of the San populations (Kurtz 1994). Their linguistic as well as their genetic structure raise many questions and so do their links to the Khokhoe ethnic groups that are also present in the region. Indeed, the two are sometimes designated under the common name of Khoisan. At times, the Khokhoe have been defined as "San populations with livestock" and the San as "Khokhoe groups without livestock". In the 1970s and 1980s scholars proposed a model in which Khoekhoe herders migrated with sheep into territories previously occupied by the San. Still there are contrasting theories on the relation between these groups and how one of them became herders (Barnard 2008). Did the ancestors of the Khoekhoe populations arrive in Southern Africa in the past 2000 years bringing with them livestock or did Khoekhoe and San co-exist in the region as hunter-gatherers previous to the adoption of herding by the Khoekhoe as the result of interactions with Bantu populations? The quest of the culture and identities of the San *versus* the Khoekhoe has been going on for almost five decades, with by far more scholars favouring the idea that some local groups moved from a hunting and foraging way of life to become herders (Smith and Ouzman 2004, Soodyall et al. 2008). Henn et al. (2008) further argues for a possible migration from Tanzania of the Sandawe people who share a Y chromosome trait with the Khoekhoe and San groups of Southern Africa. This migration is allegedly independent of the Bantu migration. Genetic studies show that the San represent one of the oldest lineages known among modern humans (Schuster et al. 2010). The analysis of mitochondrial DNA further shows that the San and the Khoekhoe might share a common matrilineal ancestor while the Y chromosome shows a greater variation between the two groups (Soodyall et al. 2008). Certain phenotypic traits within the San group suggest adaptations to arid environments by means of storing fats in certain body tissues as discussed by Schuster et al. (2010).

While the genetic approach helps us to apprehend the relation between different ethnic groups the cultural and social dimensions of the evolution of aboriginal populations are more difficult to grasp mainly due to a lack of sufficient palaeoanthropolological and archaeological data (Behar et al. 2008). A well-known dimension of the San material culture though is the rock art found in Southern Africa in the form of engravings and paintings believed to have been produced by forager communities. Even though most of their accounts are depicted in the rock art, possible interactions of these people with other groups' calls for further revision of the rock art protocol as it may be a representation of art derivatives from the groups they interacted with.

San and Bantu groups have been involved in ivory trade at least since the 17th century (first written record from 1661) and the Xhosa later traded the ivory with the Portuguese. In the 19th century, there is evidence of intermarriages between the San and these Bantu groups (Jolly 1996). In Namibia, recent San encounters with other groups resulted in their population being reduced by killings as is the case with the German massacre of Damara and San communities in 1904, and displacements of the Ju'hoasi groups from the their land into the Tsumkwe administrative centre (Figure 53). More displacements followed in the 1950s and 1960s resulting in a reconversion of most San to livestock herding (Barnard 2008, Dan et al. 2010).

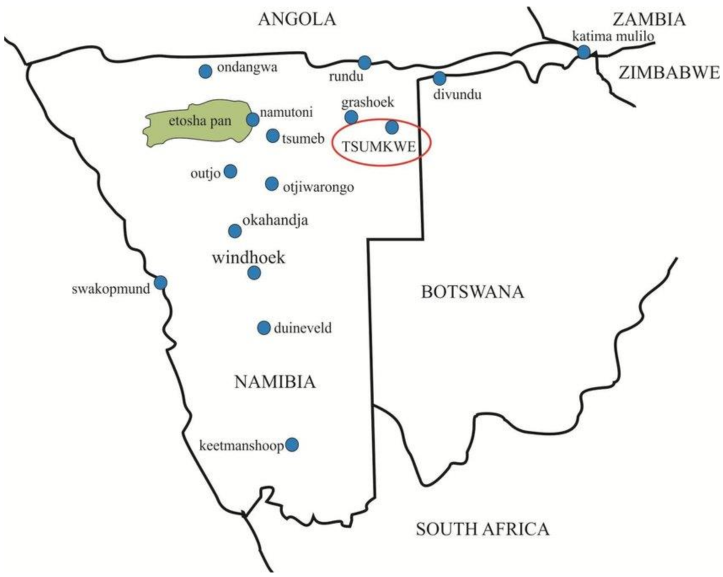


Figure 53: The location of Tsumkwe in Namibia (Sarantou 2018)

3.3. Plant use in the San community from Tsumkwe

The San community participating in the activities of the San Living Museum at the Omandumba farm belongs to the Tsumkwe local group of San populations (Figure 53). During our first visit the principal guide and informant was Temi aged 36 from Tsumkwe who has a good command of the English language. 33-year old Xhoo also came from Tsumkwe but spoke only the local language assisted him. !Kunta #Koma, 24 years, and Herman Khania, 25 years, both born in Aasvoelnes in the Tsumkwe region, were responsible for the second leg of our visit undertaken in September 2018.

Various plants play a very significant role in the daily lives of the Ju/'Hoansi people, from food to tool making and medicine (Table 15). Most of the tools are related to hunting and for processing other materials such as plants and animal hides. During the guided tours that we followed in 2017 and 2018 the informants described the characteristics and uses of more than 20 local plant species based on the know-how they had acquired from their parents and grandparents. Besides demonstrating plant uses on the basis of species currently growing around the Omandumba farm our guides also explained the interactions with trees and herbs featured in the rock art or plants that are not exploited by man but consumed by wild animals. Further, useful plants that do not grow were also used in some of the demonstrations. An example is the Mongongo tree (*Schinziophyton rautanenii*) that has been used in Southern Africa for the past 7000 years. Mongongo nut kernels contain protein, magnesium, iron, zinc, fats and vitamin E. Moreover, branches of the tree are used to create pallets that play a pivotal role for making fire (Figure 54). The thin branches are half-perforated along the horizontal axis and to initiate a fire, a second stick is vigorously brushed against each hole. Grass is usually put around the friction area to quicken the fire starting process.

Figure 54: Fire-stick made from a branch of the Mongongo tree (*Schinziophyton rautanenii*)

Figure 55: A San man working *Sansevieria pearsonii* to make a bird trapping string

The preparation of *Sansevieria pearsonii* fleshy stems for making strings used for bird traps was also demonstrated (Figure 55).

It is important to note the importance of carefully formulating the questions to ask as using ethnography as it might be subjective. In this study for example, the informants would only give responses about plants that are found in their immediate proximities but would not mention some even though they use them occasionally. In the case of plants found in the charcoal assemblage at Leopard Cave and around the site such as *Vangueria infausta* could be accounted for only when specific questions were asked.

Finally the San people (who were initially mobile) but who come to Omandumba for short alternated periods of time source almost all their vegetal materials locally as do also the Damara village community.

Table 15: Use of woody plants by the San community in Omandumba

Family	Scientific name	Vernacular name	Uses	Archaeobotany
Agavaceae	*Agave sisalana*	Wild sisal	Leaves (sap) - crushed and mixed with other herbs for various medicinal uses: reinforce immune system, painkiller, anti-inflammatory for wounds , snake repellent	?
Burseraceae	*Commiphora wildii*	Andosia, Wildii myrrh	Branches - used for perfume both wet and dry ; the tree hosts edible mophane worms ; the sap used as a general anti-inflammatory; used by women as a deodorant	
Capparaceae	*Boscia albitrunca*	ǁhùni.s, Shepherd's tree	Wood - firewood collected dry; bark - chewed dry, as a powder or boiled against diahorrhea or general ailments; root - added to sour milk as a thickening agent; fruit - eaten fresh, soaked overnight to make fruit juice	X
Capparaceae	*Boscia foetida*	xa̋űbȅ, Smelly shepherd's tree	Wood - firewood collected dry; leaves - chewed for stomach ailments, soaked in water against evil spirits, against insomnia; fruit - eaten fresh; the evergreen trees provide shade	X
Celastraceae	*Gymnosporia senegalensis*	(!Xhoes), Confetti spikethorn	Wood - firewood collected dry; leaves - soaked for cooling water	
Combretaceae	*Terminalia prunioides*	xa̋űbē, Purple-pod terminalia	Leaves - animal fodder; fruits - colourful pods displayed for decoration	X
Cucurbitaceae	*Citrullus ecirrhosus*	xa̋űbē, Tsamma melon	Fruits - eaten whole by animals in the wild; seeds - roasted and eaten as a snack	X
Euphorbiaceae	*Spirostachys africana*	Tamboti	Wood - building material; fruit - the grains are collected from ants' nests, eaten raw	
Fabaceae-Mimosoideae	*sap (! Xhonhais), !Xhuung, Acacia erubescens*	Dûùbȅ.s, Blue thorn	Wood - firewood collected dry, fence poles; sap/gum - collected, stored and sold by people of all ages in the village especially school pupils; fruit - dry fruits fed to animals animals; boring insects generate a powder from the stem that is applied by women to their faces for beauty purposes	(X)
Fabaceae-Mimosoideae	*Acacia erioloba*	ǁgáná.b, Camel thorn acacia	Wood - firewood collected dry and fence poles; bark - kept indoors as an air-freshener; leaves - animal fodder	(X)
Fabaceae-Mimosoideae	*Faidherbia albida*	Anas!	No specific uses, evergreen leaves could be eaten by animals	(X)
Fabaceae-Mimosoideae	*Dichrostachys cinerea*	ǁgȍé.s, Sicklebush	Wood -occasional firewood when wood is rare, toxic thorns	X
Fabaceae-Mimosoideae	*Acacia karoo*	ǁkhùű.s, Sweet thorn	Wood - firewood collected dry; fruit - eaten fresh before reaching maturity, dried fruit fed to animals	(X)
Pedaliaceae	*Harpagophytum procumbens*	Devil's claws	Root - treats all ailments (cleanses blood), anti-inflammatory	?
Poaceae	*Sporobolus* spp.	Sangwee(sp), giant rat's tail grass (?)	Fruits - collected from ants' nests for human food (consumed raw)	
Rhamnaceae	*Ziziphus mucronata*	X!aros, Buffalo thorn	Root - crushed, used against infections during childbirth	X
Sterculiaceae	*Sterculia africana*	Aarup, Tick tree	Bark - crushed and taken orally in powder form; sap - extracted and used while fresh against gastric disorders; leaves - crushed and boiled for medical purposes	
Verbenaceae	*Lippia javanica*	ho!xhobrosi, Fever tea/Lemon Bush	Leaves - boiled as an infusion	?
Xanthorrhoeaceae	*Aloe gariepensis*	Aloe vera	Leaves - general anti-inflammatory effects	?
	Fruit (!xhunxharas)	Rosobiebuom	Wood - construction palisades and fences; fruit - dried fruit fed to animals	
	?	!xôôs	Stem, leaves - human food	
	?	Simoenhip	Leaves - used for animal food and as an anti-inflammatory	
		Wild or boxing glove cactus	Leaves - bitter sap extracted from fresh leaves for medical purposes, treatment against high blood pressure, kidney problems and cancer, general anti-inflammatory, reinforces immune system booster; highly sought-after due to its medicinal properties	?

The comparison of the wood use between two ethnic groups living in the same environment is interesting (Table 16). The members of the Damara community are more eclectic when it comes to using wood as fuel. They collect almost all trees and shrubs available in their environment for making fire. Even though they do not fell trees for firewood, it is apparent that they do not use some of the wood from the trees that they deem fruit trees with edible fruit or fruit used in a variety of activities. They also do not burn wood from plants where they use the branches. Unlike the Ju/'Hoansi who omit the use of certain plants for fuel like all *Boscia* species because of taboo and the possibility of them inciting possible respiratory illness. Some persons of the Damara community in Tubusis simply mention that they prefer not to use certain wood types in the fire by tradition, e.g. they were considered as bad or forbidden by earlier generations.

Table 16: Comparison of the wood species used by the Damara and San communities

Family	Species	Damara	San
Burseraceae	*Commiphora wildii*	X	X
Capparaceae	*Boscia albitrunca*		X
Capparaceae	*Boscia foetida*		X
Celastraceae	*Gymnosporia senegalensis*		X
Combretaceae	*Combretum apiculatum*		
Combretaceae	*Terminalia prunioides*		X
Euphorbiaceae	*Croton gratissimus*	X	
Euphorbiaceae	*Spirostachys african*		X
Fabaceae-Caesalpinoideae	*Adenolobus garipensis*	X	X
Fabaceae-Caesalpinoideae	*Mundulea sericea*	X	X
Fabaceae-Mimosoideae	*Acacia erioloba*		X
Fabaceae-Mimosoideae	*Acacia erubescens*	X	X
Fabaceae-Mimosoideae	*Acacia karoo*	X	X
Fabaceae-Mimosoideae	*Acacia mellifera*	X	X
Fabaceae-Mimosoideae	*Acacia tortilis*	X	X
Fabaceae-Mimosoideae	*Dichrostachys cinerea*		X
Fabaceae-Mimosoideae	*Faidherbia albida*	X	X
Olacaceae	*Ximenia americana*	X	X
Rhamnaceae	*Ziziphus mucronata*		X
Rubiaceae	*Vangueria infausta*	X	X
Sterculiaceae	*Sterculia africana*	X	X
Tiliaceae	*Grewia flava*		X

CHAPTER V – RESULTS

1. Description of identified taxa

A first and major step in our study is the identification of the botanical remains collected at the three sites (see previous chapter). By the application of anatomical criteria and the use of reference collections held in several laboratories as well as specifically collected in the framework of this thesis, we have determined botanically 20 different taxa of ligneous species from wood charcoal (Table 17). While it has been possible in some cases to attain the species level, other fragments could only be determined to the family.

Below follows a presentation of the identified taxa and the anatomical criteria used for these identifications. The descriptions are illustrated by anatomical photographs obtained through the use of a Scanning Electronic Microsope (SEM). The description of wood anatomical criteria is followed by two figures illustrating a selection of dessiccated and charred seed/fruits remains from Leopard Cave and Geduld (Figure 56, Figure 57). These remains were identified by the study of their general morphology compared like the wood to specimens in reference collections and descriptions in specialised atlases.

The presentation of the taxa is followed by the exposition of the quantitative results of our study.

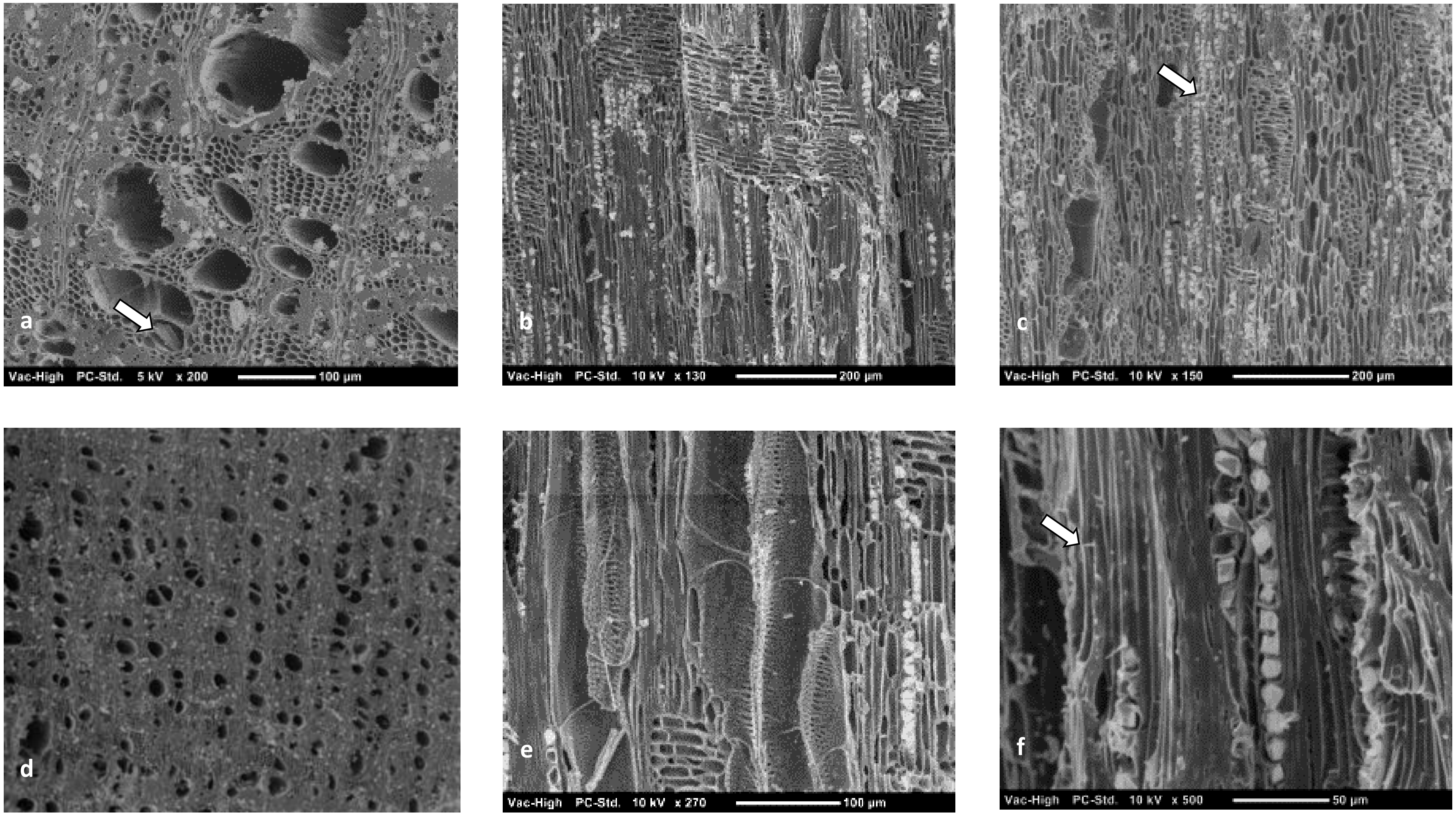
Table 17: Comparison of the anatomic characteristics of the archaeological charcoal

*C. mopane has similarities with *Acacia* type 2; 1*The crystals are in Idioblasts and also present is gelatinous fibre in vessels;
2* Crystals in enlarged cells; 3* Gum and other deposits in ray and vessel cells; 4*Diffuse parenchyma and the presence of enlarged cells
The difference between Boscia /Maerua is that, those from Leopard Cave present no crystals and no tension wood but those from Geduld do.
Boscia type on the other hand has no crystals but has no crystals but has resin canals

Family	Charcoal family and type	Vessel arrangement and pitting						Ray width and height					Ray compostion							Parenchyma						Mineral inclusions						Other
		solitary	radial multiples and/or clusters	Mixed(solitary, in pairs or multiples)	diameter of vessel lumina(µm)	scalariform	alternate	1-2 seriate	1-3 seriate	1-5 seriate	2-5/6 seriate	Ray height	procumbent	upright	Hetereocellular (mixed)	perforated ray cells	parenchyma associated with the rays	Radial canals	septate fibres	vasicentric	banded	aliform	confluent	apotracheal	absent or rare	crystals in parenchyma cells	crystals in ray cells	crystals in fibre cells	Silica in ray cells	Druses	inclusions additional information	Included phloem
Fabaceae/	*Acacia/Dichrostachys*			x	61		x		x			250	x						x	x	x		x			x				x*		
Mimosoideae	Acacia/*Dichrostachys* 2	x			125		x				x	450	x			x					x		x				x			x		
	Acacia type 1			x	200		x				x	460	x							x			x			x					1*	
	Acacia type 2	x			50-100		x		x			560	x							x						x		x				
	Acacia type 2			x	49		x			x		360	x															x				
	Acacia type 4	x			60		x			x		240	x							x	x					x		x				
	Acacia type 5		x		50-100	x				x		370	x						x	x	x					x		x				
	Acacia type 6				80		x			x	x	200			x											x	x			x		
	Acacia type 7	x			100		x				x	430	x							x			x				x					
	Acacia type 7	x			100		x			x		340			x				x	x		x	x				x					
	Fabaceae	x			50-100		x	x				120	x							x		x					x			x	2*	
Fabaceae/	*Colophospermum mopane*		x	x	50-100		x		x			350	x							x		x*				x						
Caesalpinoideae	*Peltophorum africanum*	x			50-100		x		x			150	x				x			x	x	x				x						
Capparaceae	*Boscia /Maerua*	dentritic			<=50		x			x		300	x				x							x			x					
	Boscia /Maerua		x		50-100		x		x			690		x			x							x								
	Boscia type	nested			<=50		x		x			200	x					x		x											3*	
	Capparaceae	x			<=50		x		x			430			x										x						4*	
Combretaceae	*Terminalia prunoides* type		X		50-100		X	X				200	X											X		x				x		
	Combretum molle	x			50-100		x					1,1mm			x					x			x				x		x	x		x
	Terminalia type				50-100		x	x				330	x																			

IAWA Feature Code: 2,5,9,10, 13,22,24,41,47,53,56,61,65,79,83,97,102,104,115,136,142

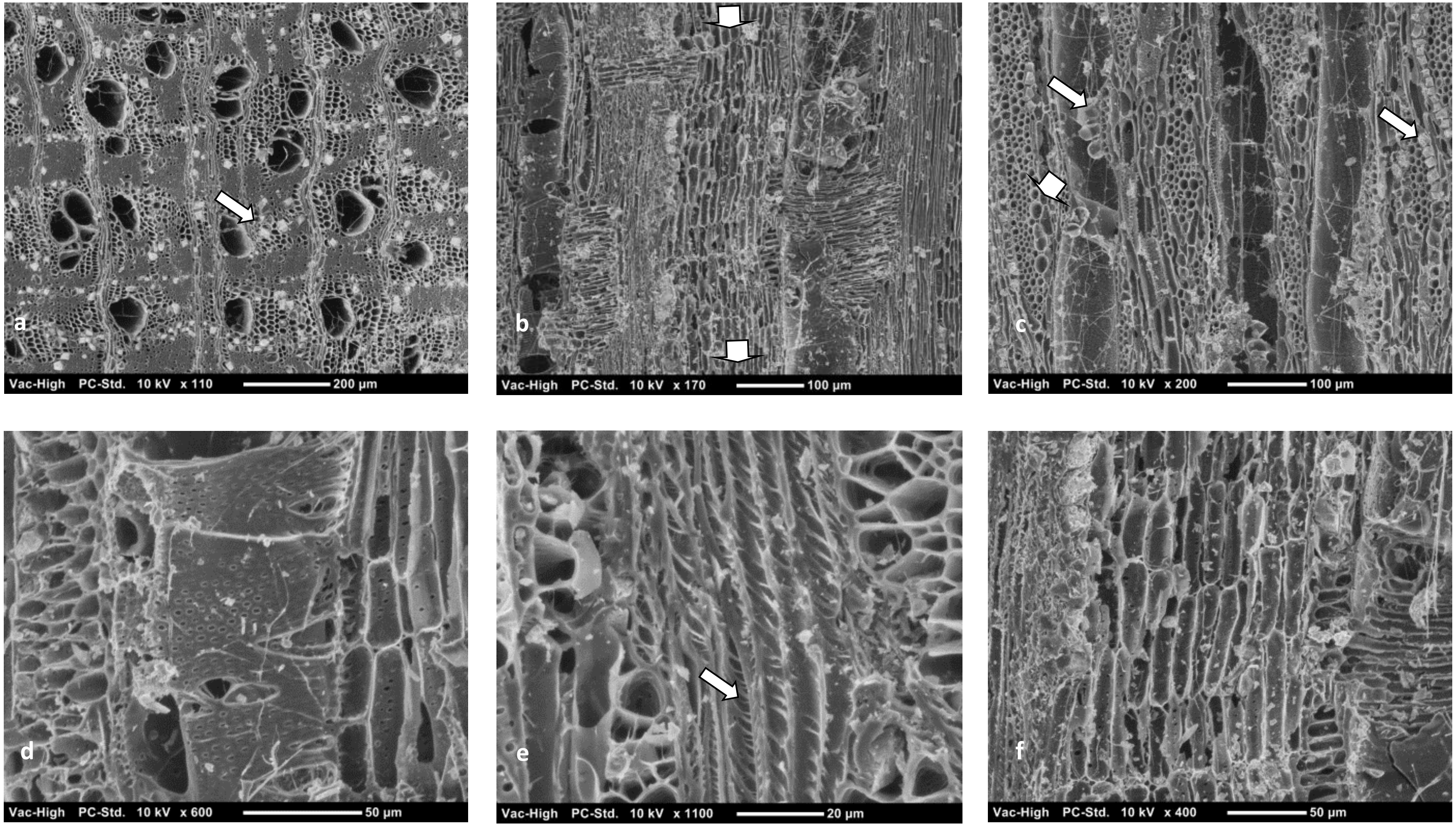
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate and quasi-scalariform intervessel pitting
- Minute intervessel pits: <= 4µm
- Mean tangential diameter of vessel lumina: 50-100µm
- 5-20 vessels per square millimeter
- Mean vessel element length: 350-800µm
- Tyloses present in vessels(a)
- Fibres with simple to minutely bordered pits
- Septate fibres present (f)
- Very thick-walled fibres
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric and confluent
- 2-4 cells per parenchyma strand
- Rays 1-3 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimetre
- Prismatic crystals in fibre cells
- Prismatic crystals in chambered parenchyma cells(c)
- More than one crystal of about the same size per cell or chamber
- Tension wood present



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,10,13,22,24,42,48,60,61,79,83,98,102,104,110,115, 136,141,156,181

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: >200μm
- 20-40 vessels per square millimeter
- Gums and other deposits in heartwood vessels (c)
- Vascular tracheids present
- Helical thickenings in ground tissue fibres
- Fibres with simple to minutely bordered pits
- Thin -to thick-walled fibres
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric and confluent
- 5-8 cells per parenchyma strand (b)
- Rays 1-5 cells wide
- Ray height: >1mm
- All ray cells procumbent
- Sheath cells present (c)
- 4-12/ rays per millimetre
- Prismatic crystals in ray-fibre and parenchyma cells (a and c)
- Prismatic crystals in non-chambered axial parenchyma cells
- Druses in ray parenchyma cells
- Crystals in enlarged cells
- Tension wood present (e)

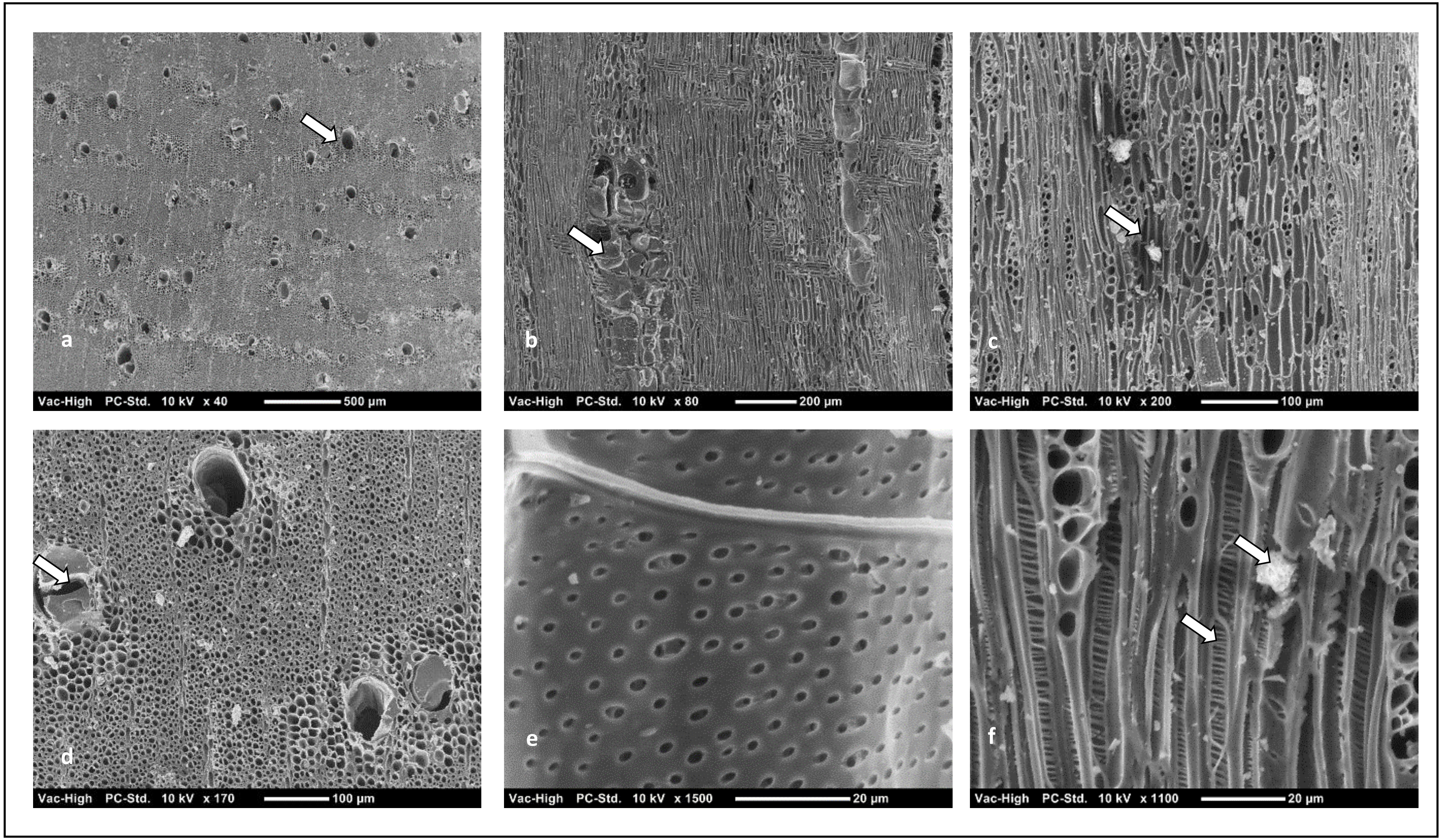


a and d: transversal, b and e: radial, c and f: tangential

Geduld: FABACEAE type

IAWA Feature Code: 2,5,9,10,13,22,24,41,46,56,64,65,69,79,83,94,97,102,104, 115,136,143,144,156,181

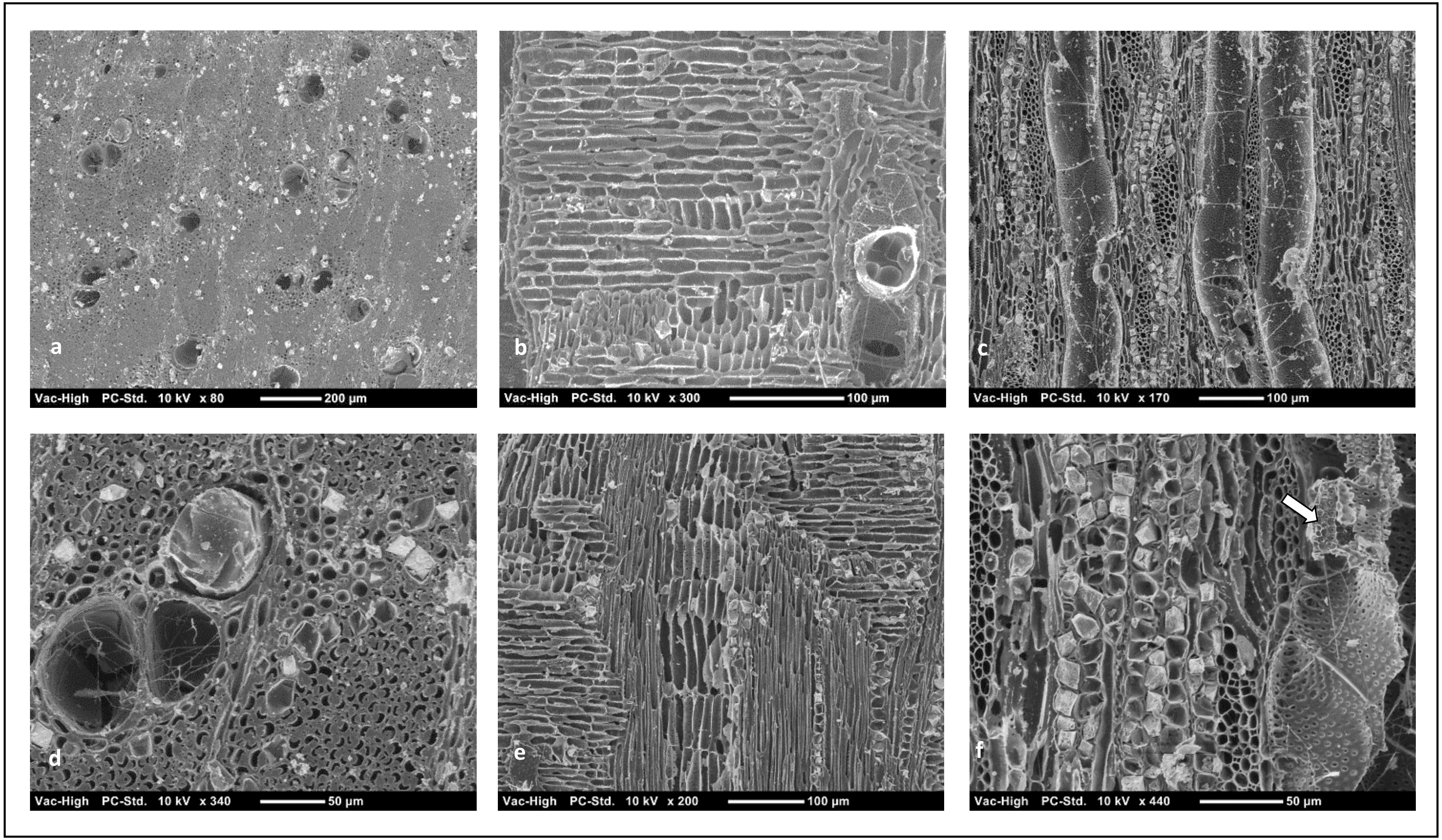
- Growth ring boundaries absent
- Wood diffuse-porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- =<5 vessels per square millimetre
- Tyloses are common in vessel elements(b and d)
- Helical thickenings in ground tissue fibres
- Septate fibres present (c)
- Thin -to thick-walled fibre walls
- Paratracheal axial parenchyma present(d)
- Axial parenchyma vasicentric and confluent (a and d)
- Over 8 cells per parenchyma strand
- Rays 1-3 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimetre
- Prismatic crystals in ray-fibre cells
- Druses in ray parenchyma cells (f)
- Helical thickenings in ground tissue fibres (f)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,10,13,22,24,41,47,56,84,98,10,107,115,136,142,181

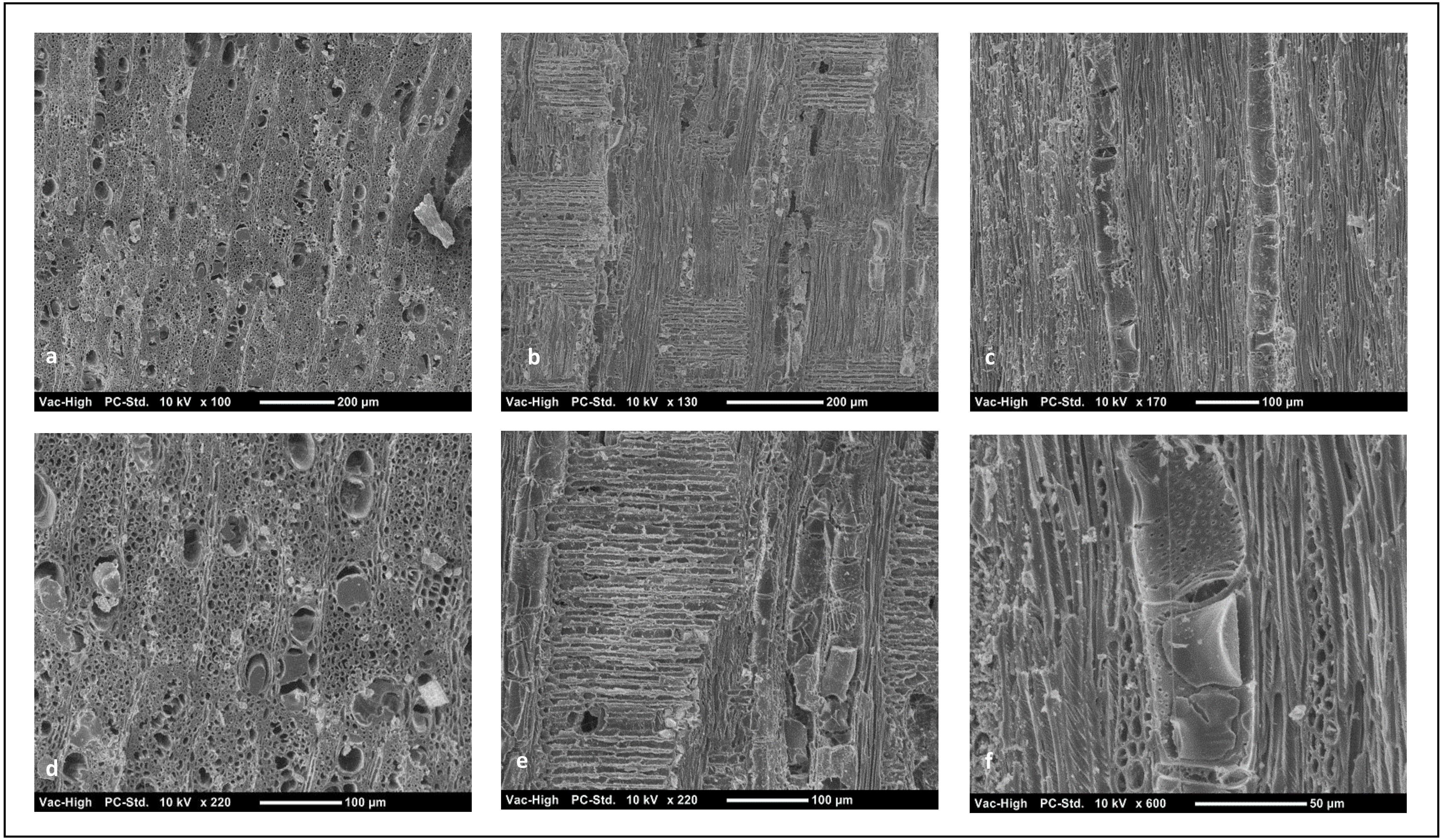
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Vestured pits present (f)
- Mean tangential diameter of vessel lumina: 50-100μm
- 5-20 vessels per square millimetre
- Tyloses and gum deposits in vessels
- Helical thickenings in ground tissue fibres
- Fibres very thick-walled
- Paratracheal axial parenchyma present
- Axial parenchyma unilateral paratracheal is some areas
- Over 8 cells per parenchyma strand
- Rays 1-5 cells wide
- Ray height: >1mm
- Body ray cells procumbent with mostly 2-4 rows of upright and/or square marginal cells
- Minute alternate inter-ray pitting: <= 4μm
- 4-12/ rays per millimetre
- Minute alternate pitting in parenchyma cells: <= 4μm
- Prismatic crystals in fibre cells (especially ray-fibre cells), procumbent rays
- Prismatic crystals in chambered axial parenchyma cells
- Tension wood present
- Idioblasts present
- Gelatinous fibre in vessels



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,13,22,24,42,47,75,79,83,96,98,102,104,115,136,156,181

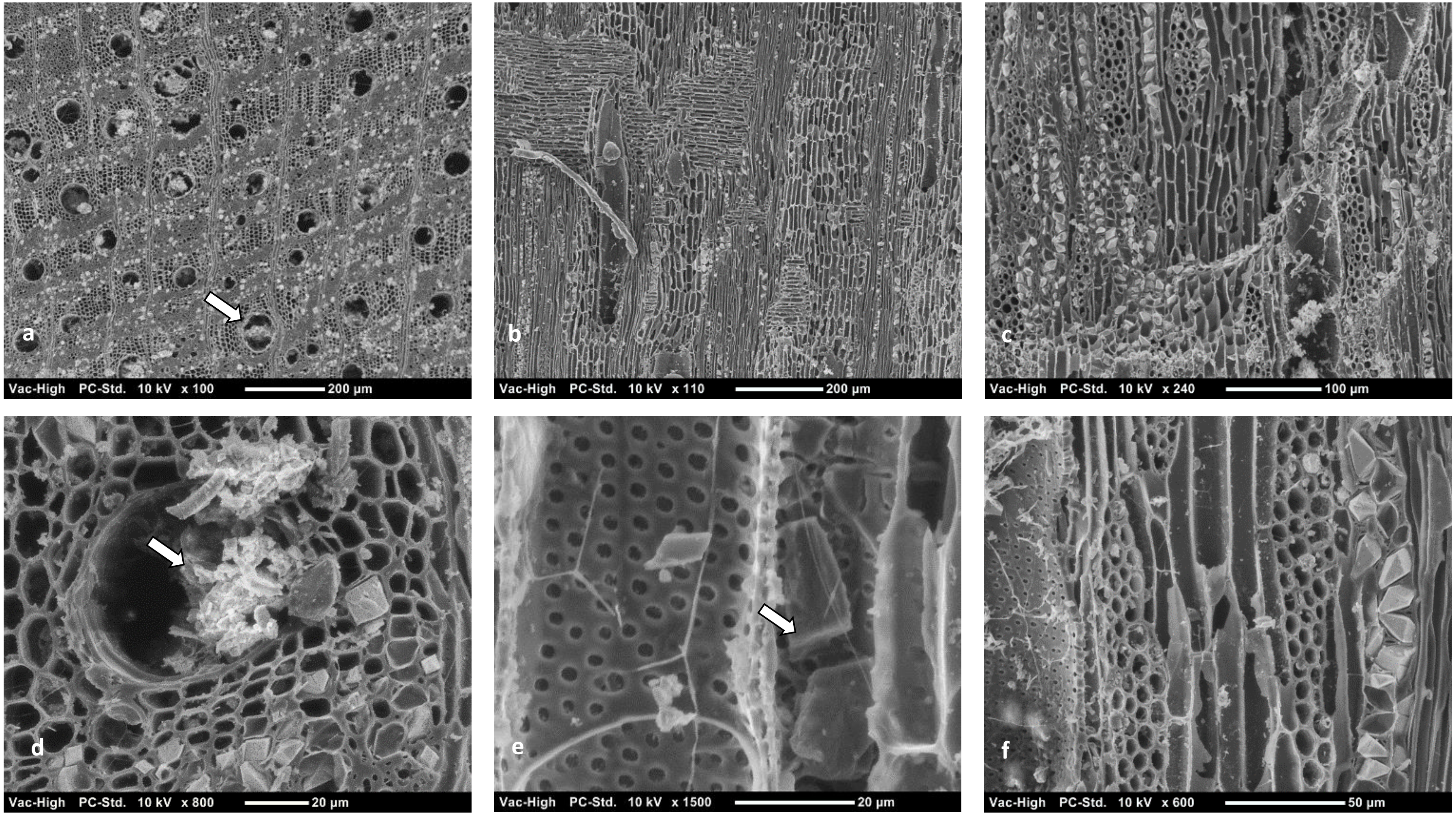
- Also *Acacia* type 2



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,10,13,22,24,41,48,56,84,85,98,102,104,115,136,142,181

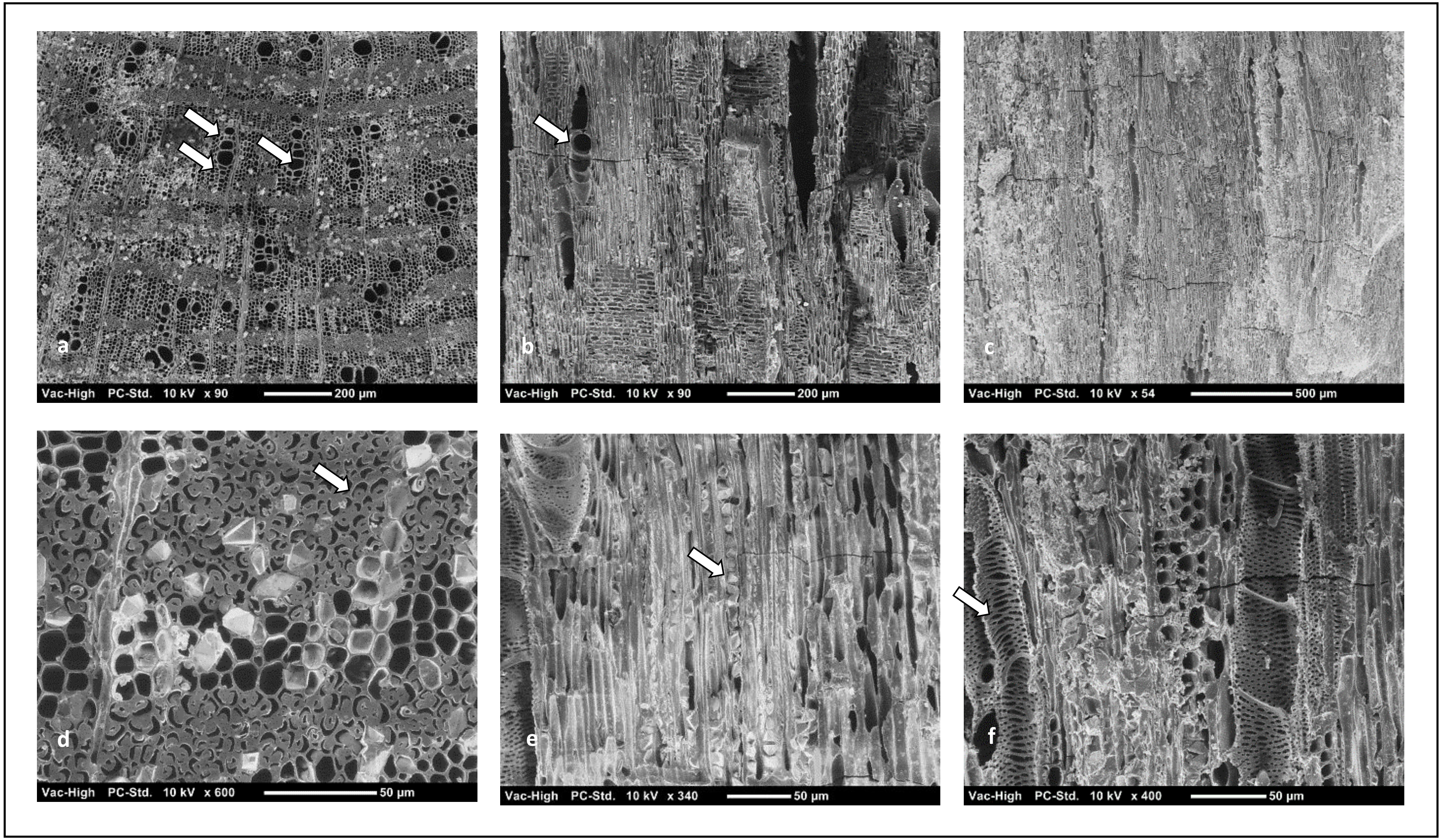
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Small intervessel pits: 4-7μm
- 20-40 vessels per square millimetre
- Non-septate fibres present
- Thin -to thick-walled fibre walls
- Paratracheal axial parenchyma present
- Axial parenchyma bands more than 3 cells wide
- Over 8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-6 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimeter
- Minute alternate inter-ray pitting: <= 4μm
- Prismatic crystals in fibre cells
- Prismatic crystals in chambered parenchyma cells
- Gum and other mineral inclusions present (d)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,7,10,13,22,24,27,41,48,49,60,85,97,102,104,115,136,142,181

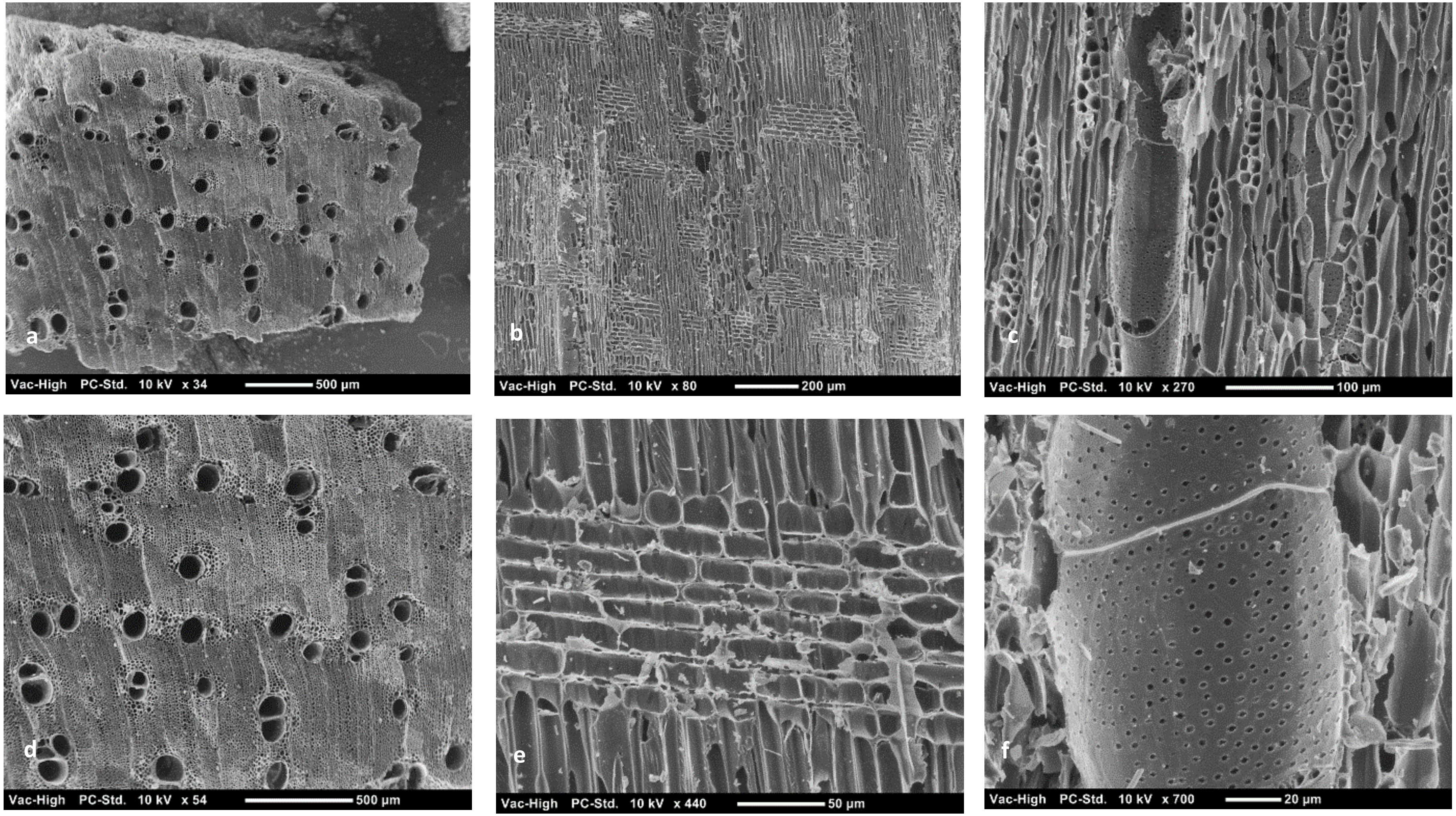
- Growth ring boundaries indistinct or absent
- Wood diffuse porous
- Vessel groups in radial pattern
- Vessels in radial multiples of 4 or more common
- Vessels of two distinctive sizes(a)
- Angular vessel outline present: (a)
- Simple perforation plates (a)
- Alternate intervessel pitting
- Small to large intervessel pits
- Mean tangential diameter of vessel lumina: 50-100μm
- 40-100 vessels per square millimetre
- Vasicentric tracheids present
- Fibre pits common in both radial and tangential walls
- Septate fibres present
- Fibres very thick-walled (d)
- Paratracheal axial parenchyma present
- Axial parenchyma bands more than 3 cells wide
- Over 8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-4 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimeter
- Prismatic crystals in fibre cells (e)
- Prismatic crystals in chambered parenchyma cells
- Other plant deposit in parenchyma cells (a)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,10,13,22,24,27,41,47,60,65,83,97,102,106,115,136,141,181

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- 5-20 vessels per square millimetre
- Tension wood present (d)
- Septate fibres present
- Fibres thin walled
- Paratracheal axial parenchyma present
- Axial parenchyma confluent
- 5-8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-2 cells wide
- Ray height: >1mm
- Body ray cells procumbent with one row upright and/or square marginal cells
- 4-12/ rays per millimeter
- Prismatic crystals in chambered parenchyma cells



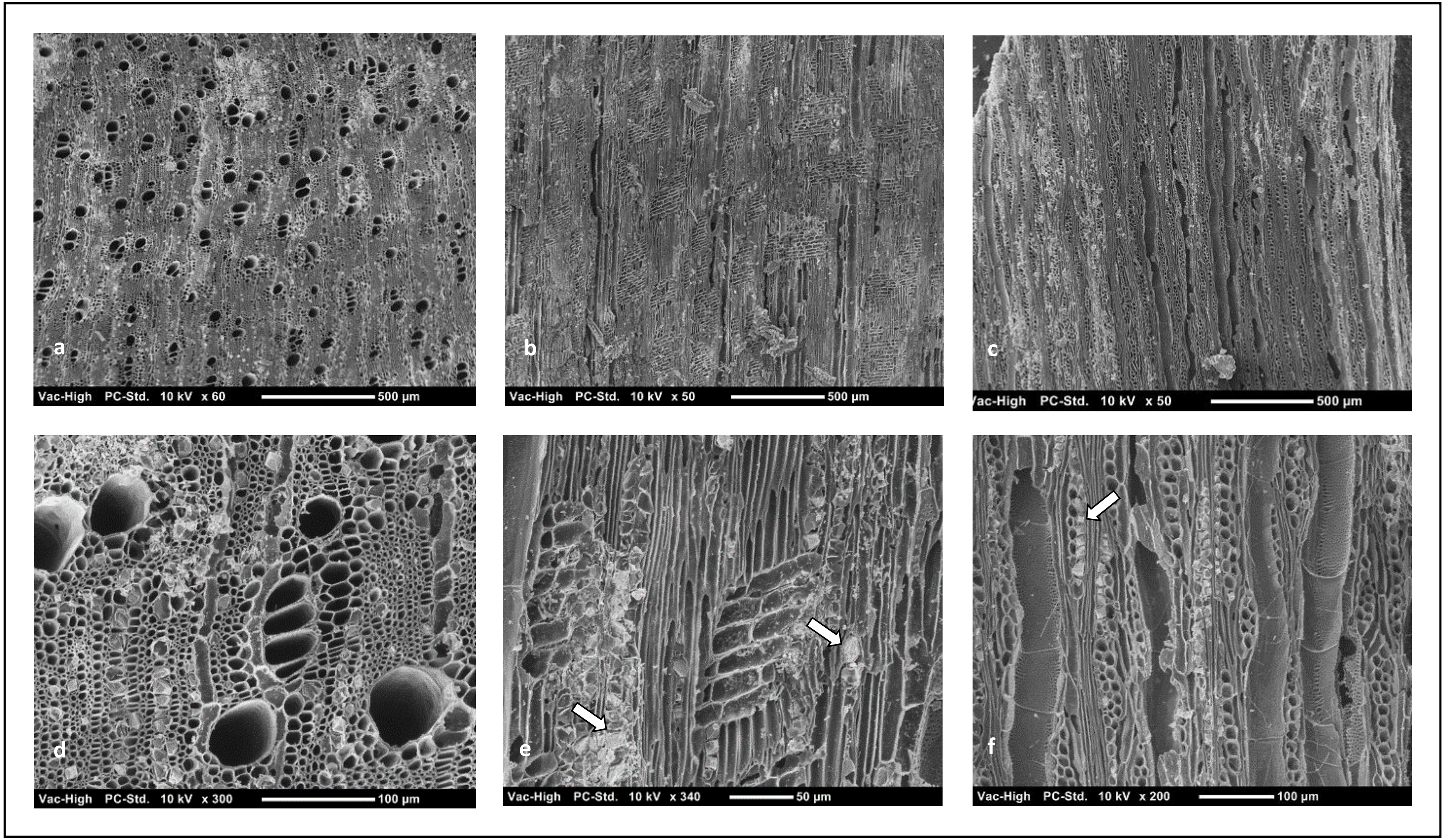
a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,10,13,22,24,41,49,61,79,97,102,104,115,136,142p,156,181

- Growth ring boundaries absent
- Wood diffuse-porous
- Vessels in radial multiples of 4 or more common
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- 40-100 vessels per square millimetre
- Fibres with simple to minutely bordered pits
- Fibres thin-walled
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric
- Over 8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-3 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimeter
- Prismatic crystals in fibre cells (especially ray-fibre cells), procumbent rays and

(f)

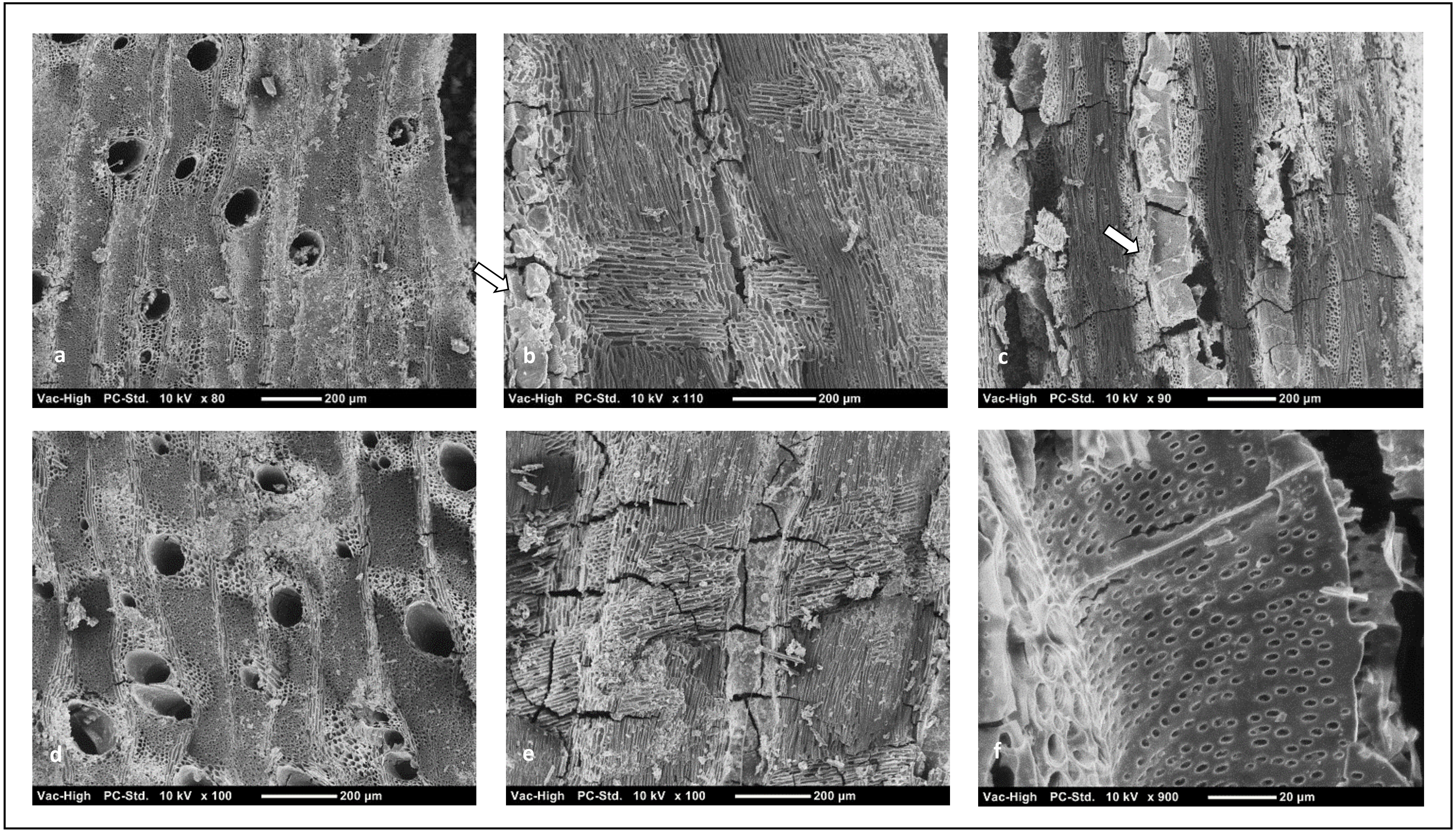
- Prismatic crystals in chambered axial parenchyma cells
- Crystals in enlarged cells(e right)
- Crystal sand present (e left)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,13,22,24,42,47,56,79,83,98,102,104,115,136,181

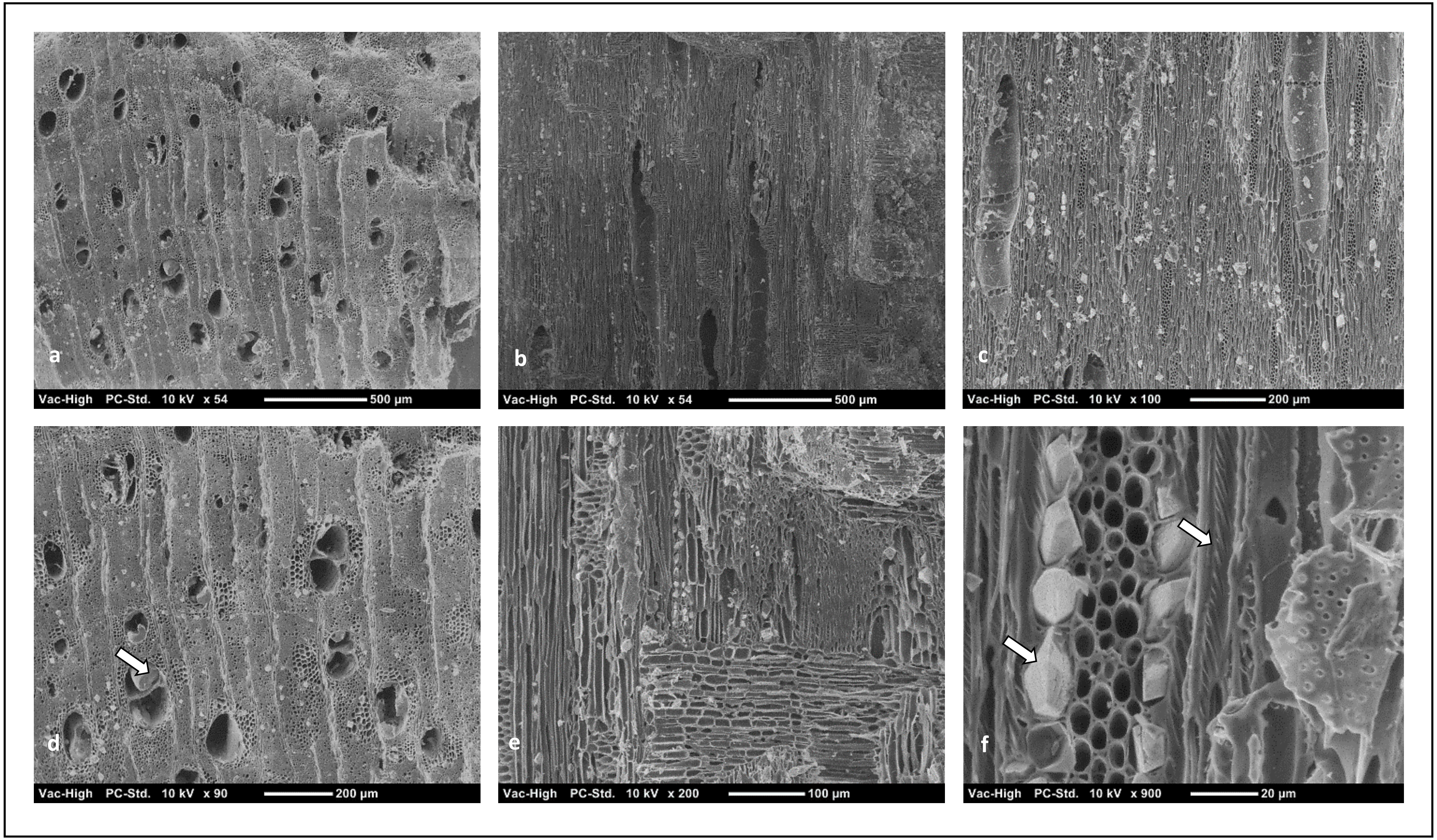
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusvely solitary (90% or more)
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 100-200μm
- 5-20 vessels per square millimetre
- All ray cells procumbent
- 4-12/ rays per millimetre
- Tyloses and druses in vessels(present in vessel elements(c and b respectively)
- Thin-to thick-walled fibre walls
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric and confluent
- Over 8 cells per parenchyma strand
- Rays 1-5 cells wide
- Ray height: >1mm
- Prismatic crystals in ray-fibre cells
- Tension wood present



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,13,22,24,42,47,56,79,83,98,102,104,115,136,181

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusvely solitary (90% or more)
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 100-200μm
- 5-20 vessels per square millimetre
- Tyloses present in vessel elements
- Septate fibres present (e)
- Thin-to thick-walled fibre walls
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric and confluent
- Over 8 cells per parenchyma strand
- Rays 1-5 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimetre
- Prismatic crystals in ray-fibre cells (f)
- Druses in ray parenchyma cells (rounded and crystal)-Toteng 1
- Druses in vessels
- Tension wood present in ground tissue fibres(f)

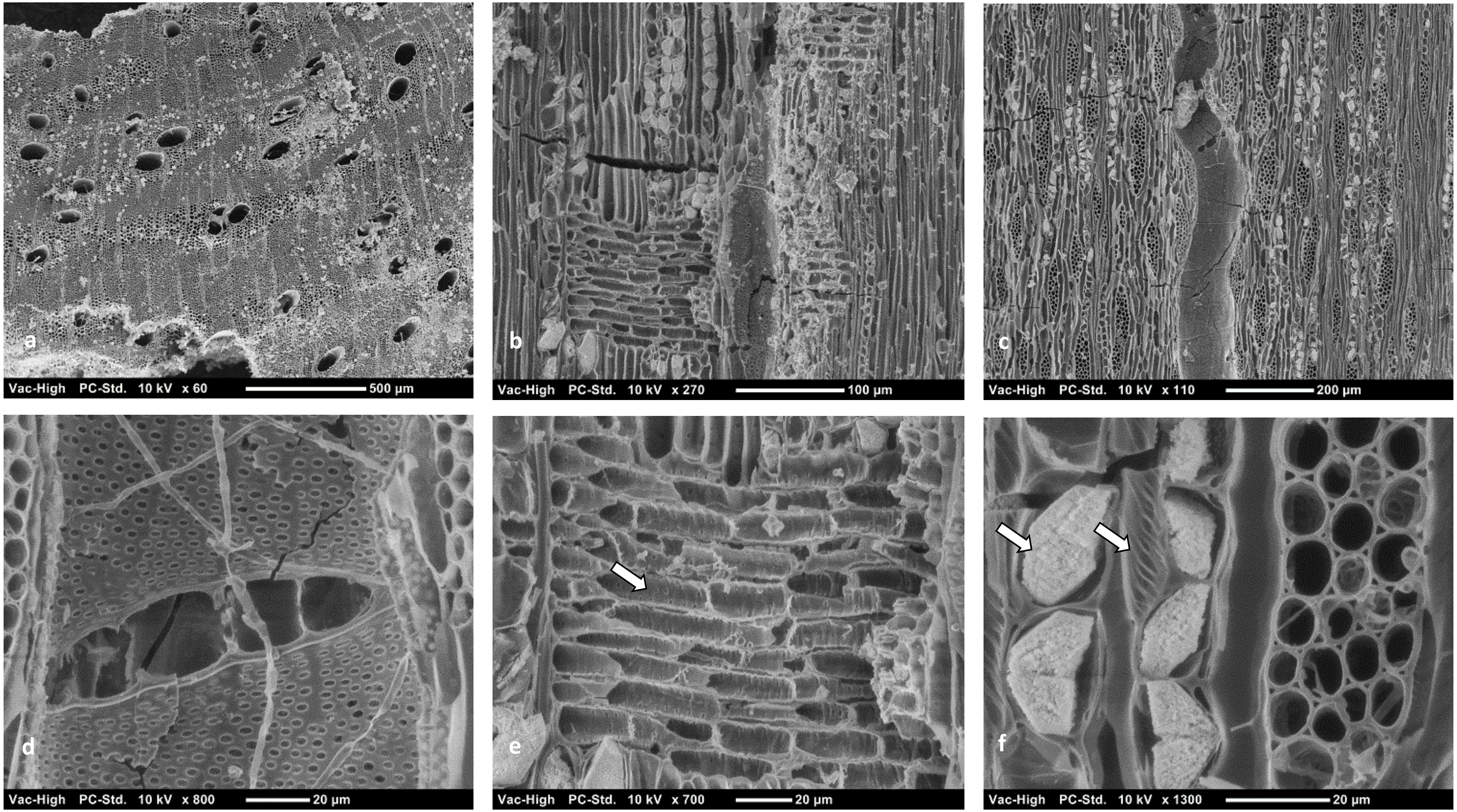


a and d: transversal, b and e: radial, c and f: tangential

Leopard Cave: FABACEAE -*Acacia/Dichrostachys* type 2

IAWA Feature Code: 2,5,9,13,22,24,42,47,75,79,83,96,98,102,104,115,136,156,181

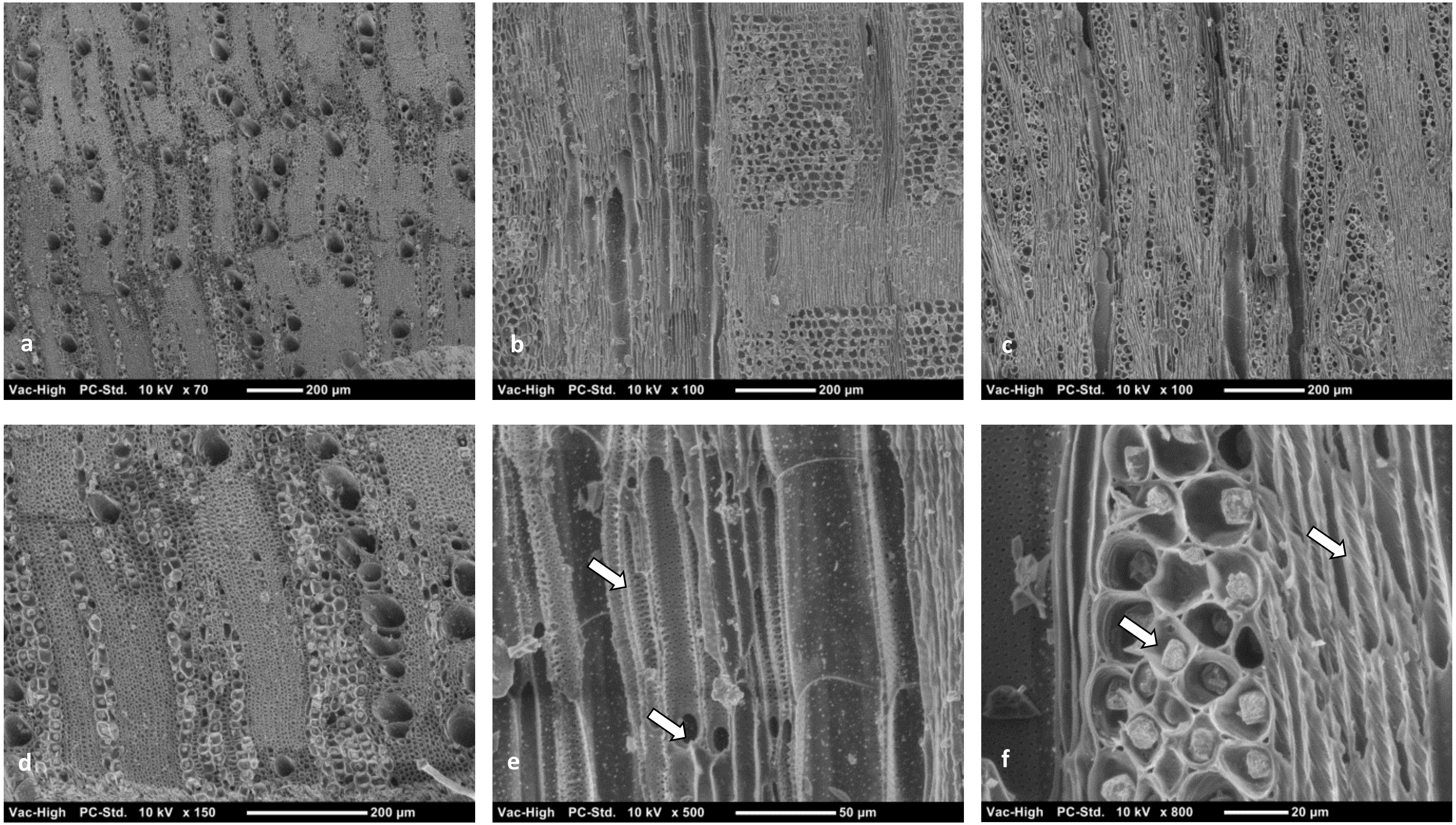
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusvely solitary (90% or more)
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 100-200μm
- 5-20 vessels per square millimeter
- Septate fibres present
- Tyloses present in vessel elements
- Thin-to thick-walled fibre walls
- Helical thickenings?
- Paratracheal axial parenchyma present
- Axial parenchyma vasicentric and confluent
- Over 8 cells per parenchyma strand
- Rays 1-5 cells wide
- Ray height: >1mm
- All ray cells procumbent
- 4-12/ rays per millimeter
- Minute alternate inter-ray pitting: <= 4μm (e)
- Prismatic crystals in fibre cells (especially ray-fibre cells)(f)
- Styloids/Elongated crystals(f)
- Druses in vessels (c)
- Tension wood present(f)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,10,13,22,24,41,49,61,98,102,104,115,136,181

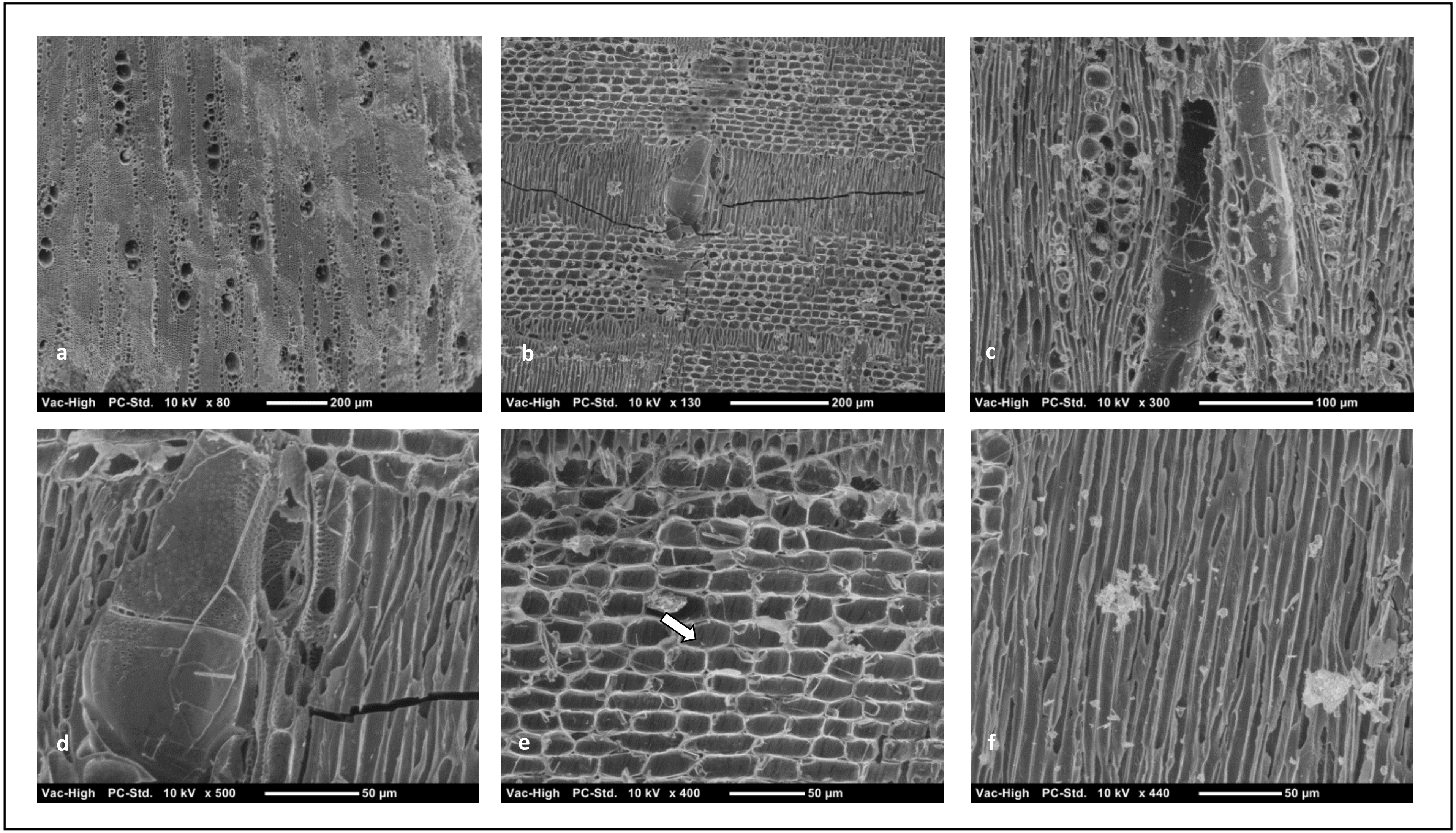
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels in dentritic pattern
- Vessels in radial multiples of 4 or more common(up to 8)
- Solitary vessel outline rounded
- Vascular tracheids around vessel element (e)
- Simple perforation plates (e)
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- 40-100 vessels per square millimeter
- Helical thickenings in ground tissue fibres
- Fibres also with simple to minutely bordered pits
- Fibres thin-walled
- Paratracheal axial parenchyma present
- Axial parenchyma also associated with ray cells
- Axial parenchyma in narrow bands
- Over 8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-5 cells wide
- Ray height: >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- 4-12/ rays per millimeter
- Prismatic crystals exclusively in ray cells(one crystal per cell) (f)
- Tension wood present (f)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,8,10,13,22,24,41,49,61,79,83,86,97,102,104,115,136, 181
(comparisons with Geduld 1452 also probably maerua/boscia)

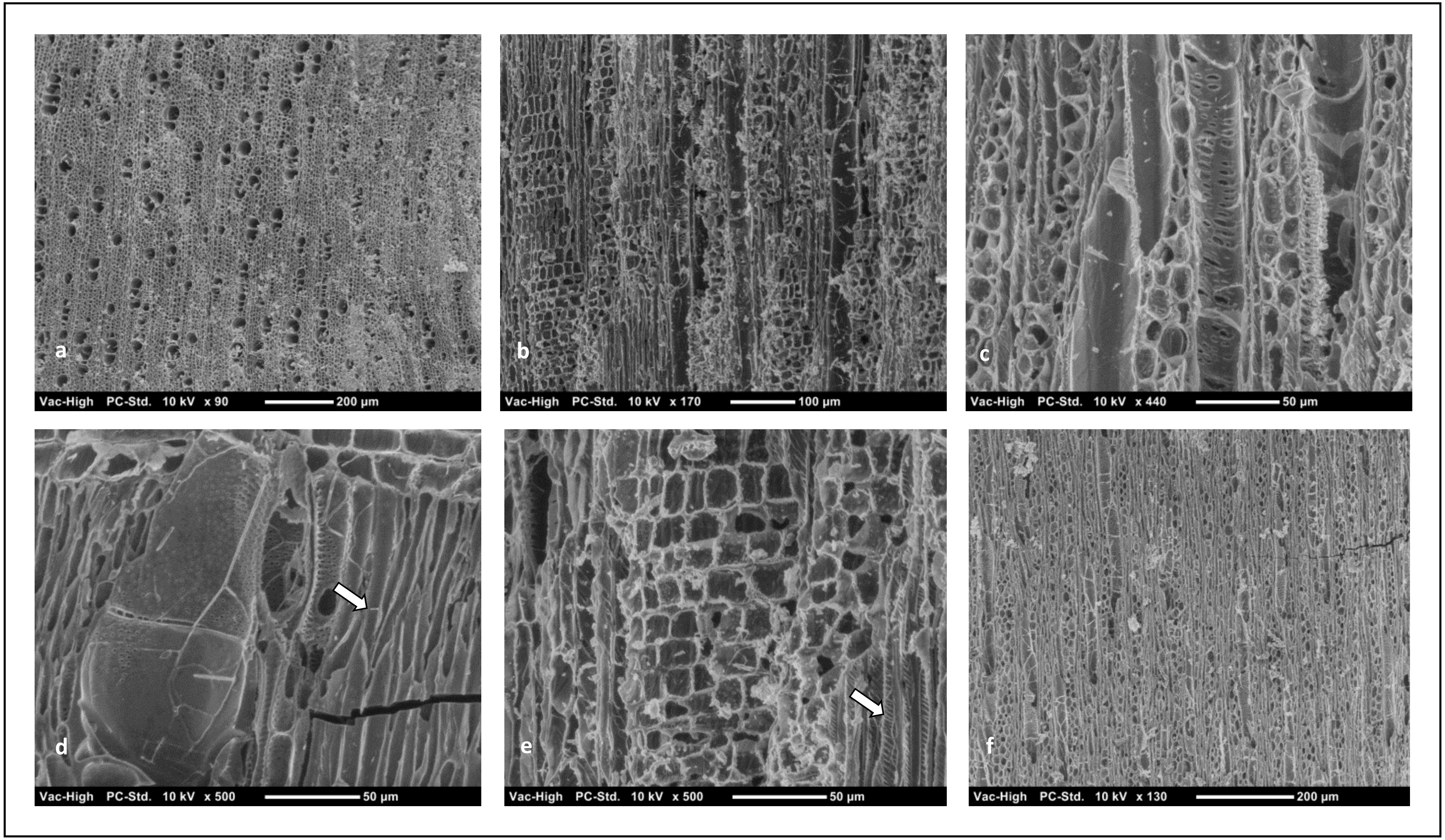
- Growth ring boundaries absent
- Wood diffuse porous
- Vessels in dentritic pattern
- Vessels in radial multiples of 4 or more common(up to 8)
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- 40-100 vessels per square millimeter
- Fibres also with simple to minutely bordered pits
- Fibres thin-walled
- Paratracheal axial parenchyma present
- Axial parenchyma also associated with ray cells
- Axial parenchyma in narrow bands
- Over 8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-5 cells wide
- Ray height: >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Perforation in ray cells
- 4-12/ rays per millimeter
- Very rare occurrence of prismatic crystals in ray cells



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,10,13,27,40,49,61,65,75,79,83,86,97,102,104,115,136,181

- Growth ring boundaries indistinct or absent
- Wood semi-ring porous
- Vessels in radial multiples of 4 or more common
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Large intervessel pits: >= 10μm
- Mean tangential diameter of vessel lumina: <=50
- 40-100 vessels per square millimeter
- Gum and other deposits in vessels and ray cells
- Helical thickenings in ground tissue fibres (e)
- Septate fibres present (d)
- Fibres thin-walled
- Axial parenchyma absent or extremely rare
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-3 cells wide
- Ray height: >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- 4-12/ rays per millimeter
- Tension wood present

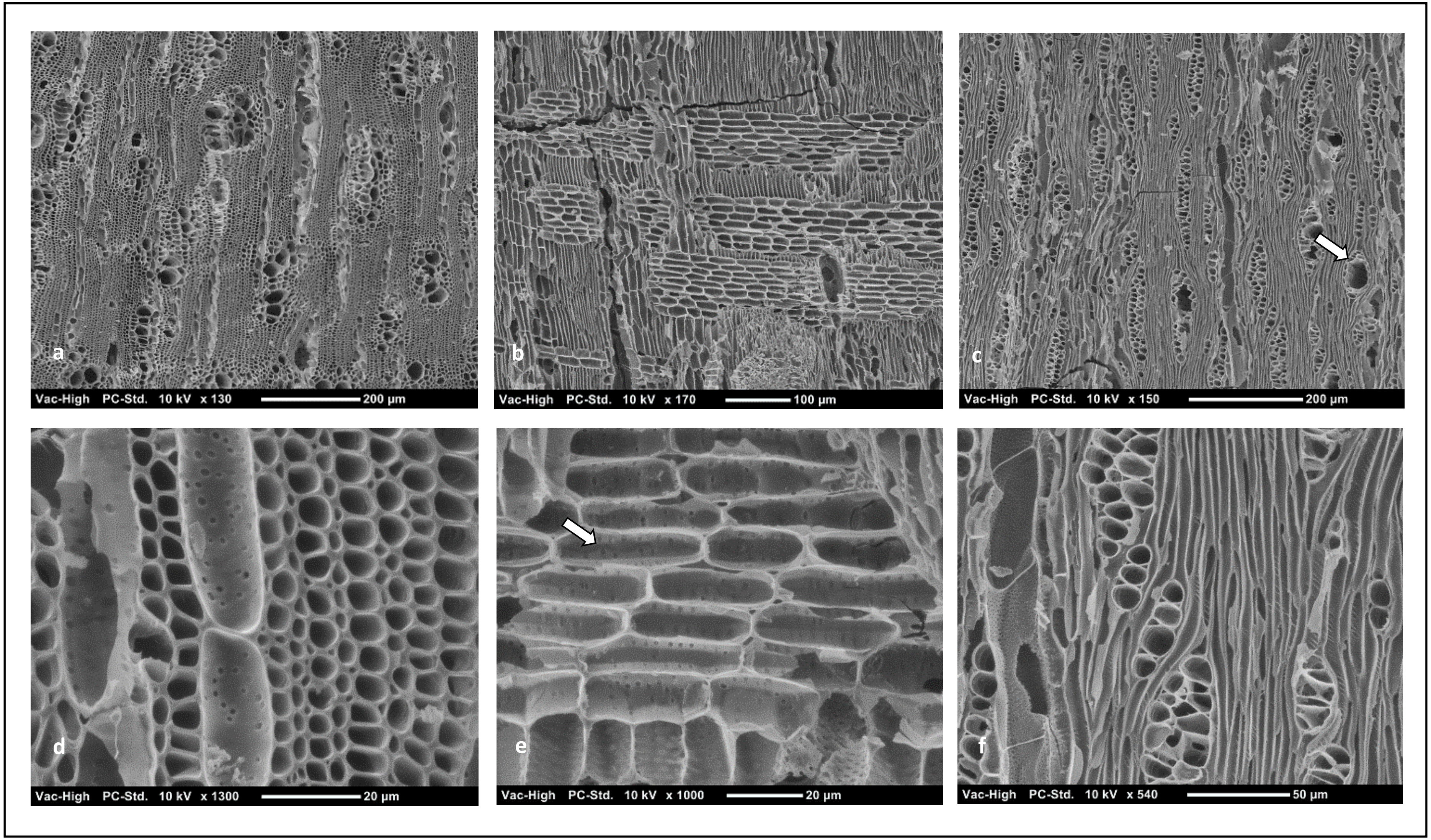


a and d: transversal, b and e: radial, c and f: tangential

Leopard Cave: CAPPARACEAE - *Boscia* type

IAWA Feature Code: 2,5,8,11,13,22,24,40,49,60,61,65,75,76,86,97,102,104, 115,136,181

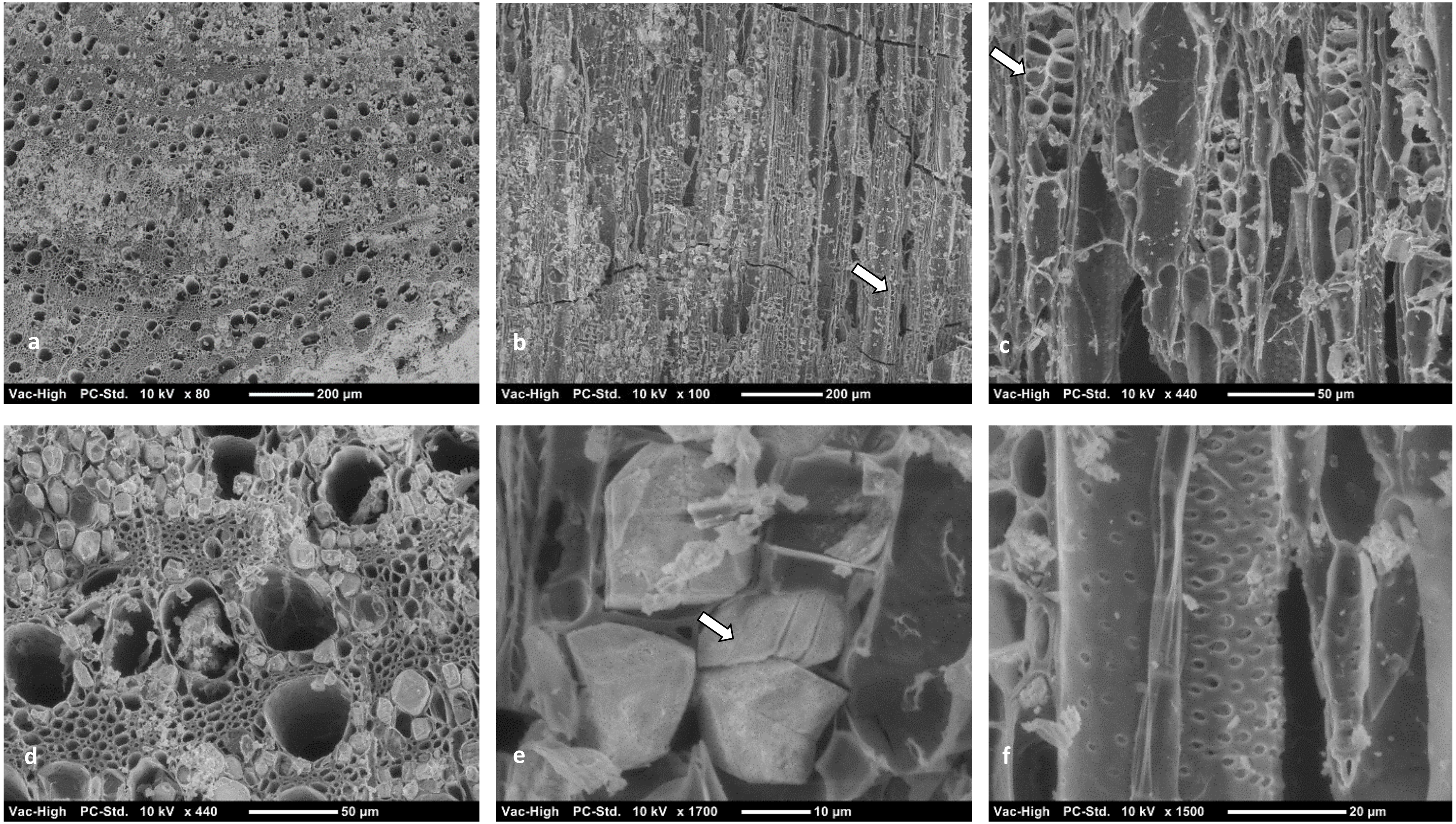
- Growth ring boundaries indistinct or absent
- Wood diffuse porous
- Vessels in dentritic pattern
- Vessels clusters common
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: <=50μm
- Vessels of two distinct diameter classes
- 40-100 vessels per square millimeter
- Vascular tracheids present
- Helical thickenings in ground tissue fibres
- Fibres thin-walled
- Paratracheal axial parenchyma present
- Axial parenchyma also diffuse
- 5-8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-3 cells wide
- Ray height: >1mm
- All rays procumbent
- Perforated ray cells (d and e)
- 4-12/ rays per millimeter
- Radial canals present, with up to 12 boarding cells (c)
- Radial canals with a domed appearance
- Alternate minute interlay pitting
- Tension wood present (e)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,4,9,10,13,22,24,41,50,60,61,65,75,76,86,96,97,102,115, 136,142,181

- Growth ring boundaries indistinct or absent
- Wood semi-ring porous
- Vessels mostly solitary and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Mean tangential diameter of vessel lumina: 50-100μm
- Gums and other deposits in vessels
- >=100 vessels per square millimeter
- Fibres thin to thick-walled
- Axial parenchyma diffuse
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays 1-2 cells wide (b and c)
- Ray height: >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- 4-12/ rays per millimeter
- Gums and other deposits in ray cells
- Gums and other deposits in vessels (a)
- Druses in ray parenchyma cells
- Crystal idioblasts present in ray-parechyma cells (e)
- Prismatic crystals in chambered axial parenchyma cells
- Tension wood in ground tissue fibres

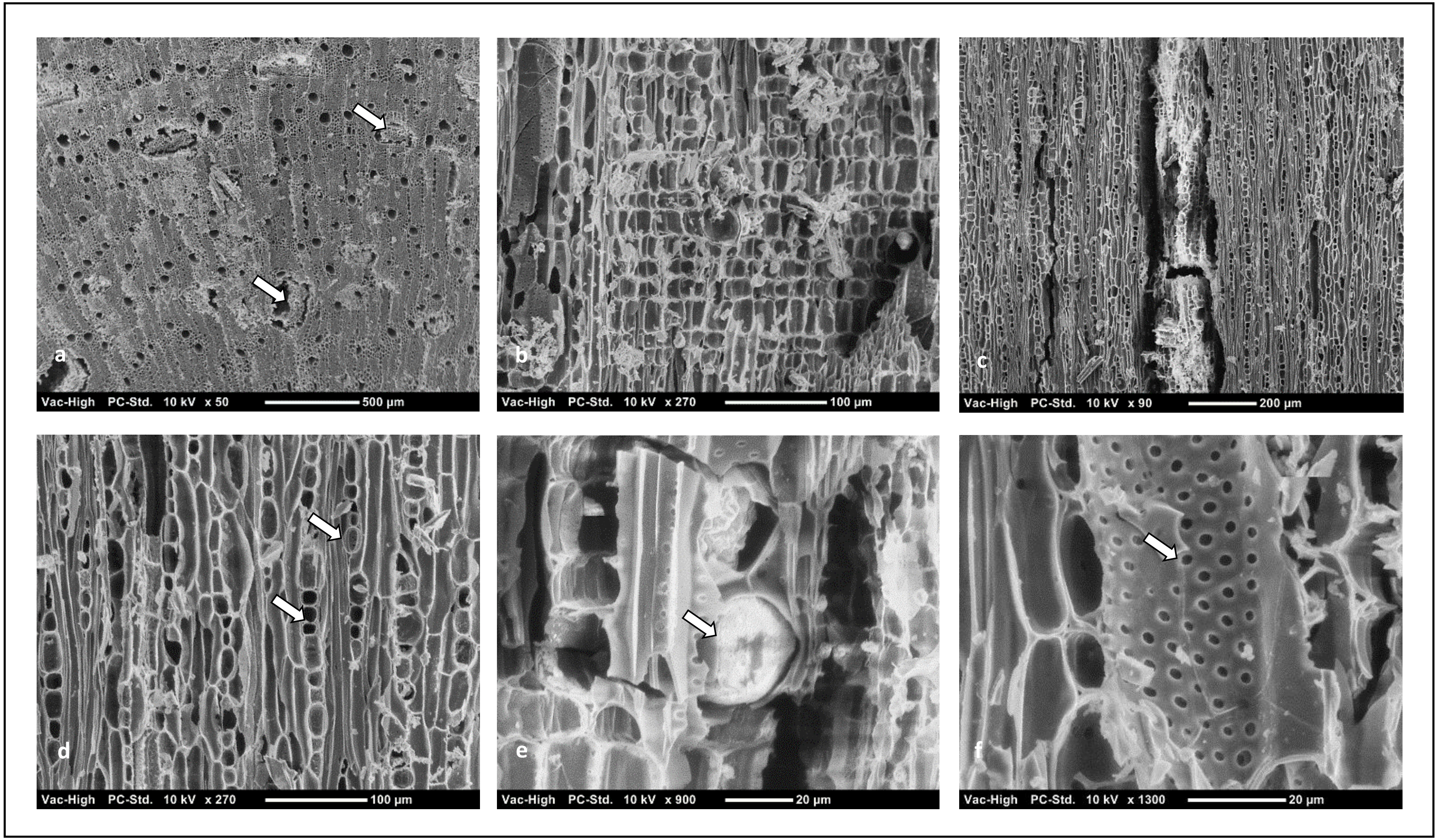


a and d: transversal, b and e: radial, c and f: tangential

Leopard Cave: COMBRETACEAE - *Combretum molle*

IAWA Feature Code: 2,5,9,13,22,24,41,48,65,75,83,96,102,106,115,136,181

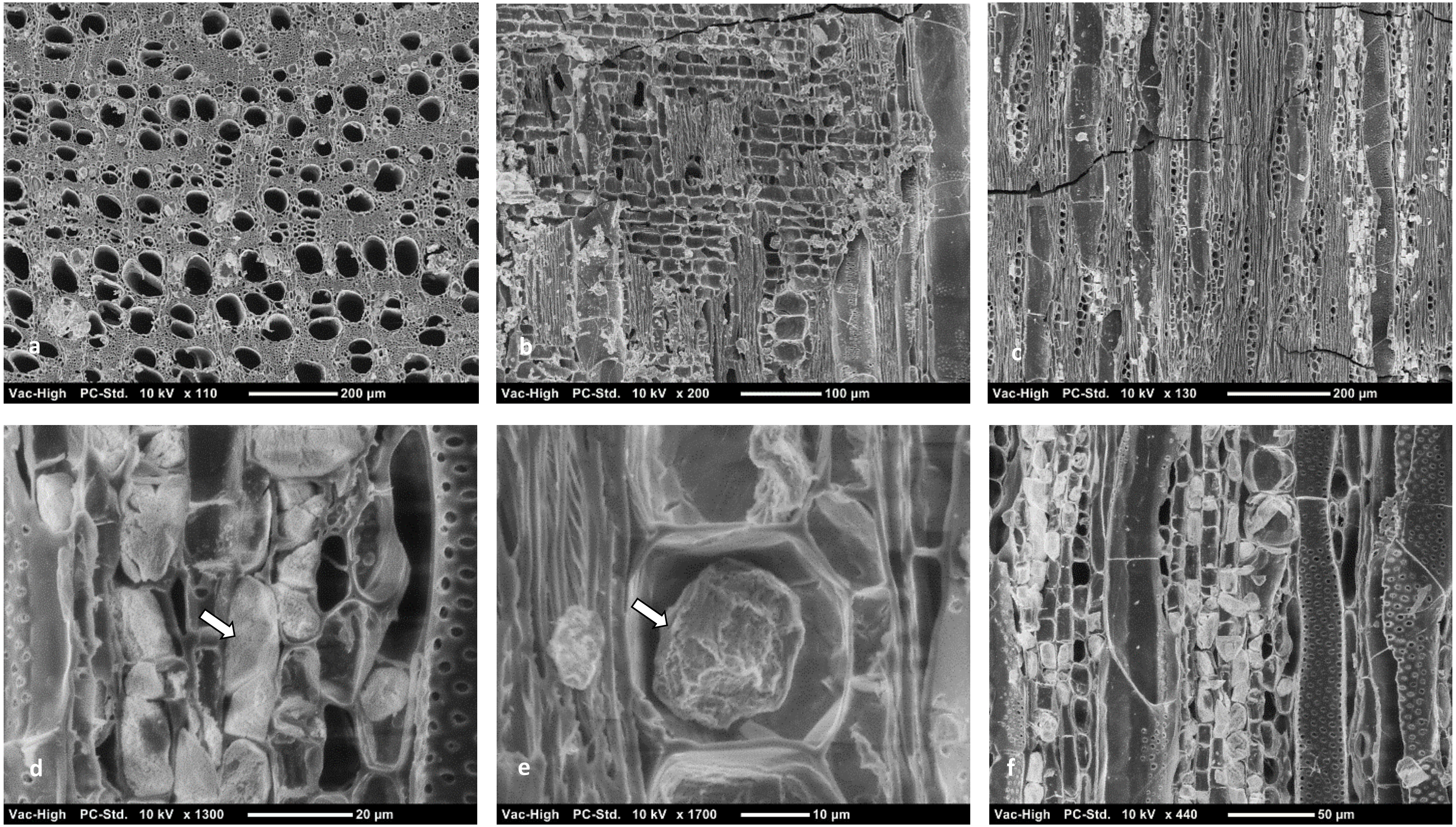
- Growth ring boundaries indistinct or absent
- Wood diffuse-porous
- Vessels mostly solitary (more than 90%)
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting (f)
- Minute intervessel pits: <= 4µm
- Mean tangential diameter of vessel lumina: 50-100µm
- 20-40 vessels per square millimetre
- Septate fibres present
- Fibres thin-to thick- walled
- Paratracheal axial parenchyma present
- Axial parenchyma confluent
- 5-8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4µm
- Rays exclusively uniseriate
- Cupresoid shaped ray cell (d)
- Ray height: >1mm
- Body ray cells procumbent with one row upright and/or square marginal cells
- 4-12/ rays per millimeter
- Crystal idioblasts and silica body present in vessel-ray cells (e)
- Diffuse included phloem present (a)
- Druses in axial parenchyma cells



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,10,13,22,24,41,49,65,75,78,83,96,97,102,106,115, 136,156,181

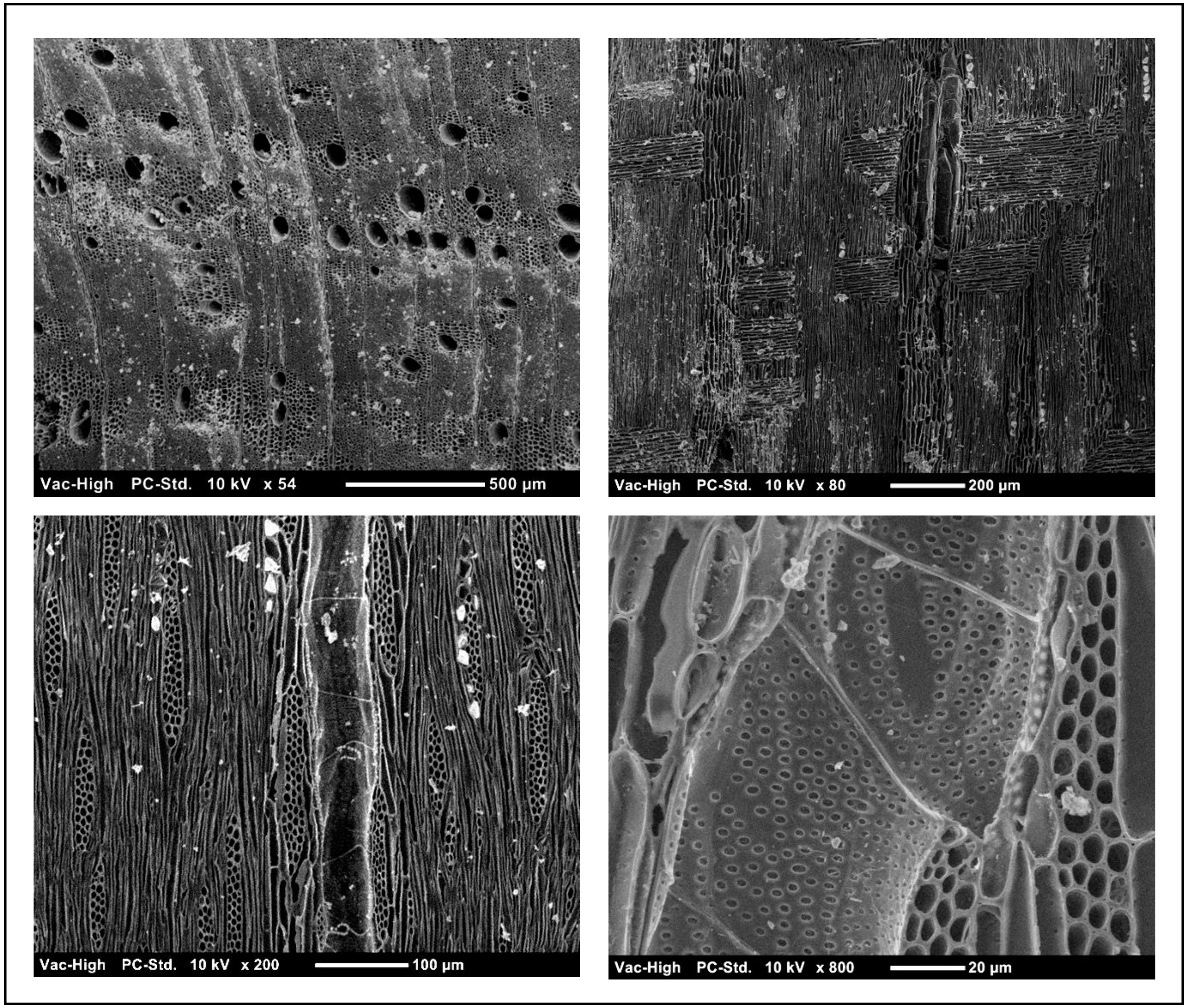
- Growth ring boundaries dindistinct or absent
- Wood diffuse-porous
- Vessels mostly solitary (more than 90%) and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4μm
- Vestured pits
- Vessels of two distinct diameter classes present
- Mean tangential diameter of vessel lumina: 50-100μm
- Tyloses present
- Vasicentric tracheids present
- 40-100 vessels per square millimetre
- Septate fibres present
- Fibres thin-to thick- walled
- Axial parenchyma scanty paratracheal
- Diffuse and banded axial parenchyma also present
- 5-8 cells per parenchyma strand
- Minute alternate pitting in parenchyma cells: <= 4μm
- Rays Rays 1-2 cells wide
- Ray height: >1mm
- Body ray cells procumbent with one row upright and/or square marginal cells
- 4-12/ rays per millimeter
- Crystal idioblasts present in vessel-ray cells
- Prismatic crystals in chambered axial parenchyma cells
- Prismatic crystals in enlarged ray cells
- Styloids/Elongated crystals (c)
- Silica bodies present (d)



a and d: transversal, b and e: radial, c and f: tangential

IAWA Feature Code: 2,5,9,13,22,24,42,47,75,79,83,96,98,102,104,115,136,156,181

- Growth ring boundaries indistinct or absent
- Wood semi-ring-porous
- Vessels exclusively solitary (90% or more)
- Simple perforation plates
- Alternate intervessel pits
- Large intervessel pits - >=10 µm
- Mean tangential diameter of vessel lumina: 50 - 100 µm
- 20 - 40 vessels per square millimeter
- Vascular / vasicentric tracheids present
- Fibres with simple to minutely bordered pits
- Septate fibres present
- Axial parenchyma vasicentric
- Axial parenchyma bands more than three cells wide
- Ray width 1 to 3 cells
- Ray height > 1 mm
- All ray cells procumbent
- >= 12 /mm
- Prismatic crystals present, in ray cells and in fibre cells
- Crystals in enlarged cells
- Southern Africa (south of the Tropic of Capricorn) (Brazier and Franklin region 79)


Vac-High PC-Std. 10 kV x 54 500 µm
Vac-High PC-Std. 10 kV x 80 200 µm
Vac-High PC-Std. 10 kV x 200 100 µm
Vac-High PC-Std. 10 kV x 800 20 µm

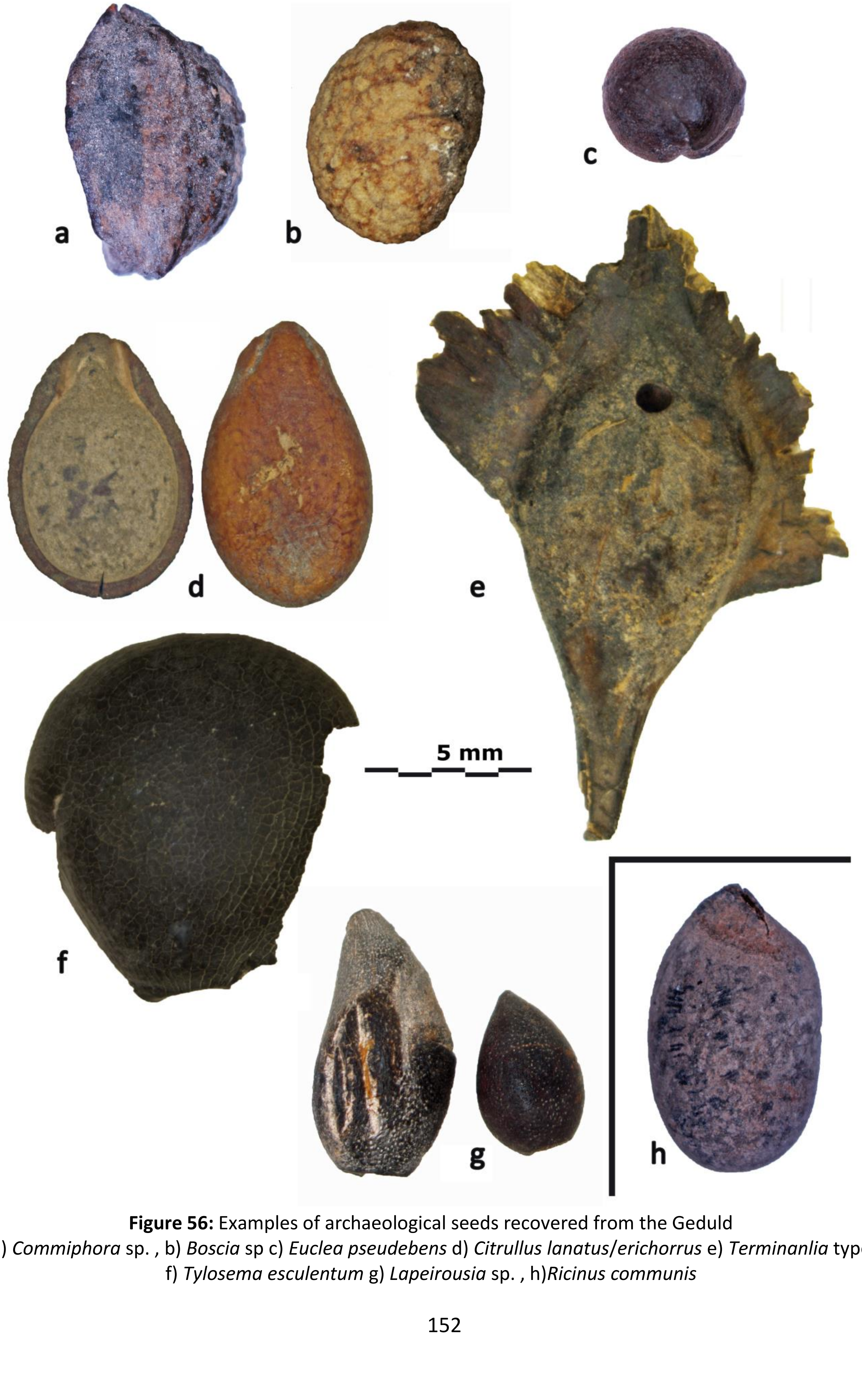


Figure 56: Examples of archaeological seeds recovered from the Geduld
a) *Commiphora* sp. , b) *Boscia* sp c) *Euclea pseudebens* d) *Citrullus lanatus/erichorrus* e) *Terminanlia* type
f) *Tylosema esculentum* g) *Lapeirousia* sp. , h)*Ricinus communis*

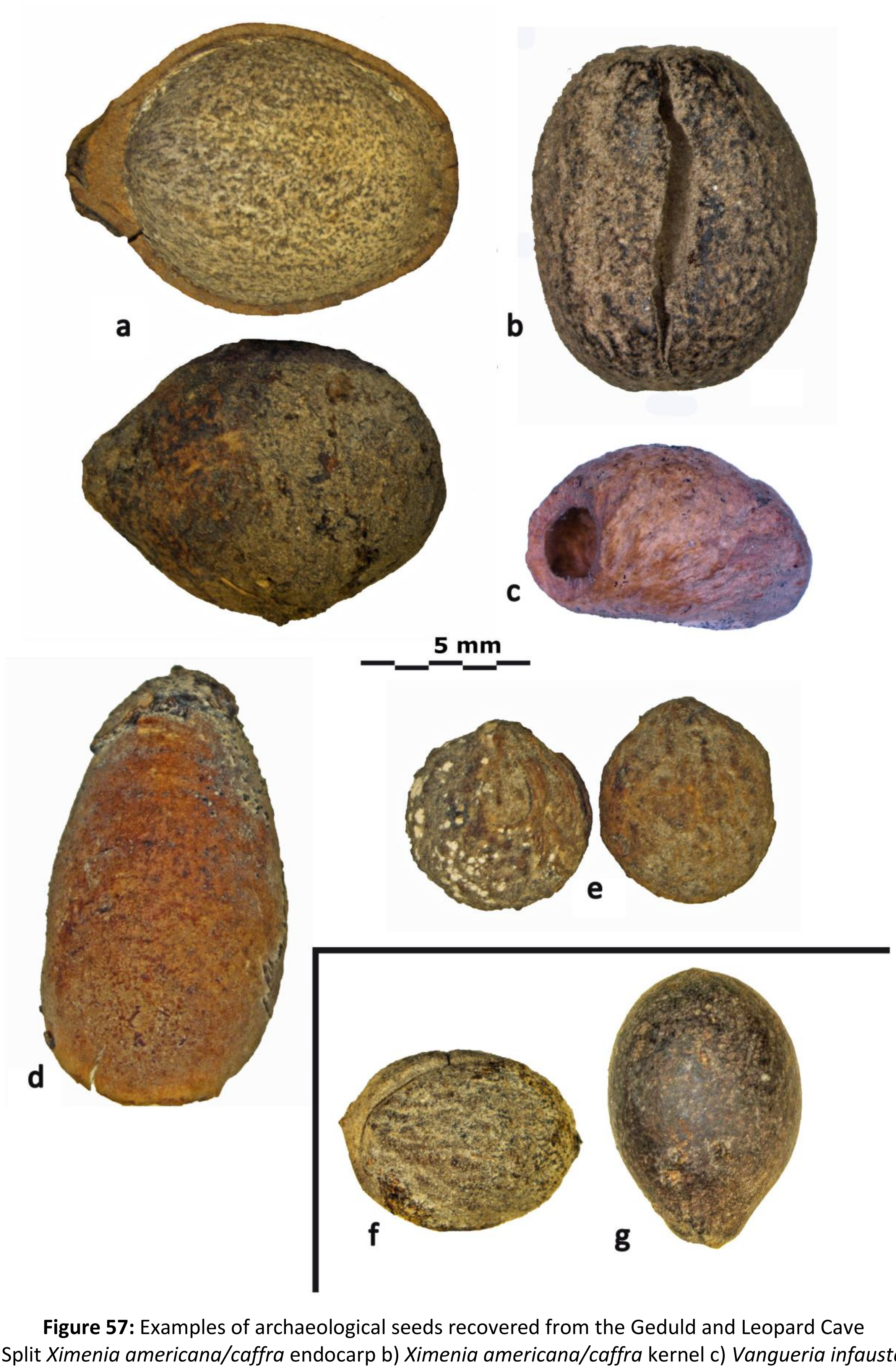


Figure 57: Examples of archaeological seeds recovered from the Geduld and Leopard Cave
a) Split *Ximenia americana/caffra* endocarp b) *Ximenia americana/caffra* kernel c) *Vangueria infausta* d) *Berchemia discolour,* e) *Grewia spp.* f) *Ziziphus mucronata* g) whole *Ximenia americana/caffra* endocarp

2. Leopard Cave

2.1. Results of the anthracological study

The analysis of a total of 1955 charcoal fragments selected from 19 samples collected during the exacavation at Leopard Cave in 2012-15 (see Materials and methods) has allowed the identification of ten botanical taxa belonging to four different plant families: Anacardiaceae, Capparaceae, Combretaceae and Fabaceae (Table 18, Table 19). The analysed fragments belong to two chronological phases identified on the basis of the stratigraphy and C14 dating of the excavated levels. The earlier Phase 1 (3700±150 - 3200±150 cal BP) has yielded less charcoal pieces (N=637) than the later Phase 2 (2600±150 -2100±100 cal BP) (N=1318). This difference in numbers is mainly due to the availability of more samples from the upper levels. Together the two phases cover a timespan of a little more than 1500 years.

All through the occupational sequence wood from acacia-trees (*Acacia* spp.) dominates the charcoal record. Several species from this genus may be present but it has not been possible to distinguish particular species for reasons that are explained in Chapter III. Besides representing the largest proportions of the identified charcoal fragments (43,3% in Phase 1, 49,6% in Phase 2), acacia wood is present in all the studied samples and seems thus to have constituted a common fuel at the Late Stone Age cave-site. In some cases, it was not possible to make a clear distinction between acacia-wood and that of *Dichrostachys,* another taxa from the Fabaceae family. If we consider the acacias and the category called *Acacia/Dichrostachys* together, species from the Fabaceae family correspond to between 63,3% of the total number of identified charcoal fragments in Phase 1 and 67,7% in Phase 2.

The second most frequently encountered group at Leopard Cave are the Combretaceae accounting for 22,9% of the charcoal fragments in Phase 1 and 26,2% in Phase 2. Within this family, species belonging to the *Terminalia* genus (*Terminalia prunioides* sp*. and Terminalia type*) are best represented, followed by those from the *Combretum* genus (*C. apiculatum* and *C. molle*). If considered together *Combretum* and *Terminalia* species are present in almost all of the studied contexts and the wood from the Combretaceae family thus also seems to have been frequently collected, together with *Acacia* during the whole occupation of the site.

The Capparaceae family is represented by two taxa: *Boscia* sp. and *Boscia/Maerua* corresponding to 13,8% and 5,8% of the charcoal pieces in the Phases 1 and 2 respectively. Finally, the Anacardiaceae family is represented by one species, *Sclerocarya birrea,* absent in Phase 1 and attested by a low number of fragments (N=4) from one single layer in Phase 2 (135-140 cm). The presence of this species is intriguing not only because of its rarity in the Leopard Cave assemblage but also due to its complete absence from the surrounding environment today.

Table 18: Absolute numbers and frequencies of the different wood taxa identified from the occupation Phase I at Leopard Cave organised according to their layers and in alphabetical order (family followed by genus)

Phase 1									
	Square	**N7**	**N7**	**N7**	**O8**	**P7**	**P7**		
	Depth (cm)	**186-190**	**190-196**	**196-200**	**206-210**	**Foyer_1-229**	**Foyer_2-259**	**Total N**	**%**
Capparaceae	*Boscia* type	1		4	9	51		65	10,2%
	Maerua/Boscia					11	12	23	3,6%
Combretaceae	*Combretum apiculatum*	5	4	2				11	1,7%
	Combretum molle					5	32	37	5,8%
	Combretum spp.	4		3				7	1,1%
	Terminalia prunioides	4		7		13	7	31	4,9%
	Terminalia type				11	20	29	60	9,4%
Fabaceae	*Acacia* spp.	33	17	27	8	65	126	276	43,3%
	Acacia/Dichrostachys				16	73	38	127	19,9%
	Total	46	21	39	35	176	232	637	100%

Table 19: Absolute numbers and frequencies of the different wood taxa identified from the occupation Pahse IIat Leopard Cave organised according to the depth and in alphabetical order (family followed by genus)

Phase 2																
	Square	**M6, N6, N7, O7**														
	Depth (cm)	**0-10**	**124-130**	**130-135**	**135-140**	**136-146**	**140-145**	**145-150**	**146-156**	**155-160**	**160-165**	**165-170**	**170-182**	**176-186**	**Total N**	**%**
Anacardiaceae	*Sclerocarya birrea*				4										4	0,3%
Capparaceae	*Boscia* type		7		4		3	2	4	1	11	3	3	1	39	3,0%
	Maerua/Boscia				2		11				14		11		38	2,9%
Combretaceae	*Combretum apiculatum*		1	1	1	1	4	4	2	28	3		4	1	50	3,8%
	Combretum molle									6	10	6			22	1,7%
	Combretum spp.	7	1	1	5	5	5	8	12	8	9	1	3		65	4,9%
	Terminalia prunioides	2	22	1	35	15	12	15	4	11	2		3	2	124	9,4%
	Terminalia type		1	7			11	8	4		27	2	24		84	6,4%
Fabaceae	*Acacia* spp.	6	102	73	57	39	43	58	33	74	80	16	46	27	654	49,6%
	Acacia/Dichrostachys		*3*		5	0	*56*	3	15	6	99	2	49		238	18,1%
	Total	15	130	83	103	60	131	96	70	133	230	27	129	30	**1318**	100%

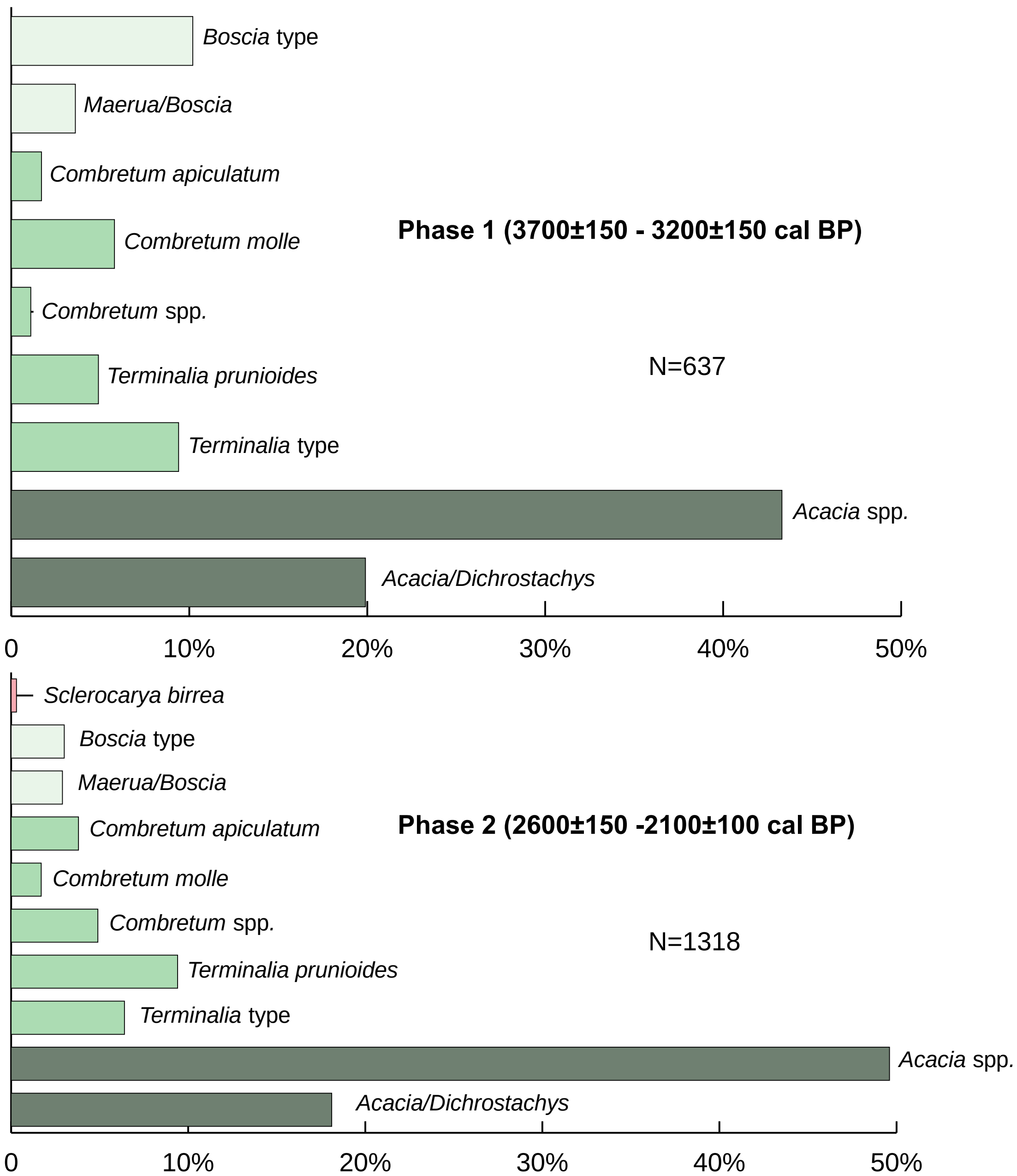


Figure 58: Charcoal diagrams from Leopard Cave showing relative proportions of the identified taxa in Phases 1 & 2

When comparing the representation of the different taxa according to the two phases (Figure 58) the similarities are striking. The same plant groups are dominant throughout the sequence and proportions are not significantly different from one phase to the other, except in the case of *Boscia* for which a certain decrease can be noted, from 10,2% in Phase 1 to 3,0% in Phase 2. We have also noted above that *Sclerocarya birrea* is only present in Phase 2, represented by a low number of fragments (N=4). No major evolution of the vegetation formations around Leopard Cave can thus be detected through our charcoal study. It is possible that a multiplication of the number of charcoal fragments studied from the different layers could introduce some more detail on possible variations through time but it is unlikely that any important change of the surrounding vegetation cover has taken place during the occupation of the cave site.

2.2. Results of the seed analysis

The seed/fruit assemblage from Leopard Cave consisted of both desiccated and carbonised remains of which most belong to woody species with only a few from herbaceous taxa being represented. The remains coming from trees and shrubs consist predominantly of whole or fragmented fruit stones (botanically endocarps) sometimes still enclosing the seed or the seeds, according to the species. Only the later Phase 2 is represented among this category of remains.

The analysis of 233 relatively well preserved items has allowed the identification of 9 different taxa as well as a tenth type that has not yet been identified (Table 20). These taxa represent as many botanical families: Burseraceae, Combretaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Olacaceae, Poaceae, Rubiaceae and Tiliaceae. The genus *Grewia* is largely predominant among these remains, representing 53% of the total number. *Vangueria infausta* (17%) is also common in the samples while other taxa occur less frequently and in lower proportions. A concentration of grass seeds is recorded from the layer excavated at 130-135 cm depth but otherwise seeds from annual plants are rare. The grass remains could not be identified to the genus or species level but could correspond to one of the varieties of grasses found in the surroundings. However, none of those are described as edible contrary to the case of *Sporolobus* cited during our ethnobotanical study conducted among the villagers of Tubusis.

Table 20: Result of the seed/fruit analysis at Leopard Cave

		Phase 2												
	Square	**M6, N6, N7, O7**												
	Depth (cm)	**60-70**	**124-130**	**130-135**	**135-140**	**140-153**	**147-155**	**150-160**	**155-160**	**160-167**	**165-170**	**175-180**	**Total N**	**%**
Burseraceae	*Commiphora* sp.			2		1							3	1,0%
Combretaceae	*Terminalia* sp.				2								2	1,0%
Cucubitaceae	*Citrullus lanatus*						7	1					8	3,0%
Euphorbiaceae	*Ricinus communis*				3			2	3				8	3,0%
Fabaceae	Fabaceae					3					5		8	3,0%
Olacaceae	*Ximenia americana/caffra*		2			1			5				8	3,0%
Poaceae	Poaceae			20					1				21	9,0%
Rubiaceae	*Vangueria infausta*		12		3	1	7	3	13				39	17,0%
Tiliaceae	*Grewia* sp.	20	5	3	41	3	5	26	3	9		8	123	53,0%
	Unidentified				8	4				1			13	6,0%
	Total	20	19	25	57	13	19	32	25	10	5	8	**233**	100%

2.3. First observations on the macrobotanical record at Leopard Cave

An interesting observation that can be made when comparing the charcoal and seed/fruit remains from Leopard Cave is that there is very little taxonomic overlap between the two categories. Indeed, the taxa identified by the anthracological study are generally absent from the seed/fruit assemblage and vice-versa. The only taxa present in both are *Terminalia* sp. (Possibly *T.prunioides*) and Fabaceae, which may include a variety woody trees and shrubs that are presently found in the region**.** However their frequencies are very low, with only 1% and 3% of the total assemblage respectively.

Between 86,2% (Phase 1) and 93,9% (Phase 2) of the charcoal fragments are identified as belonging to the Fabaceae and Combretaceae families that produce few fruits used as human food (cf the ethnobotanical study). Fruit-bearing species are more common in the Capparaceae family but are not attested in the seed record from Leopard Cave. 75% of the taxa identified by the seed/fruit analysis correspond to trees with edible fruit (*Vangueria infausta*, *Ximenia americana/caffra*, *Commiphora* sp., *Grewia* sp.). The Tsamma melon (*Citrullus lanatus*) is a perennial creeper whose flesh and seeds are edible.

3. Geduld

3.1. Results of the anthracological study

The analysis of 691 charcoal fragments contained in nine samples collected during the American excavation of Geduld has allowed the identification of eight taxa belonging to three botanical families: Capparaceae, Combretaceae and Fabaceae (Table 21, Figure 59). No precise chronological phases have been determined and the charcoal results are here considered as a whole even though radiocarbon dates from the site indicate an occupation spanning several centuries in the late 3rd and early 2nd millennia BP (Smith et al. 1995).

Like at Leopard Cave, the majority of the charcoal from Geduld belongs to the Fabaceae family. Fragments identified as *Acacia* spp., probably *Acacia* and *Acacia*/*Dichrostachys* represent almost 80% of the total charcoal record. Two other taxa from the Fabaceae family are also attested: *Colophospermum mopane* and *Peltophorum africanum* occuring in low proportions (0,4% and 0,9% respectively) (.

The Combretaceae family is the second most well represented group, with what to seems to be *Terminalia* according to the anatomical characteristics observed. This genus accounts for 12,4% of the identified charcoal pieces.

The third group present at Geduld are the Capparaceae representing a total of 6,9% divided between *Boscia/Maerua* and *Capparaceae* type.

Table 21: Absolute numbers and frequencies of the different taxa identified at Geduld organised according to their square and level

	Square	B6	B6	B6	B7	B7	B8	B8	B9	C7		
	Level	L7	L6	L5	L7	L5	L4	L3	L3	L13/L11	Total N	%
Capparaceae	*Boscia/Maerua*	5	1		5			2		1	14	2,0%
	Capparaceae type	3	7		5			14	5		34	4,9%
Combretaceae	*Terminalia* type	54	7			4			3	18	86	12,4%
Fabaceae	*Acacia* spp.	9	21	2	3	23	1	4	4	38	105	15,2%
	Acacia/Dichrostachys	225	20		2	49		5	1	19	321	46,5%
	cf *Acacia*	71	3	1	8	7	4	18	7	3	122	17,7%
	Colophospermum mopane	3									3	0,4%
	Peltophorum africanum	4				1				1	6	0,9%
	Total	374	59	3	23	84	5	43	20	80	**691**	100%

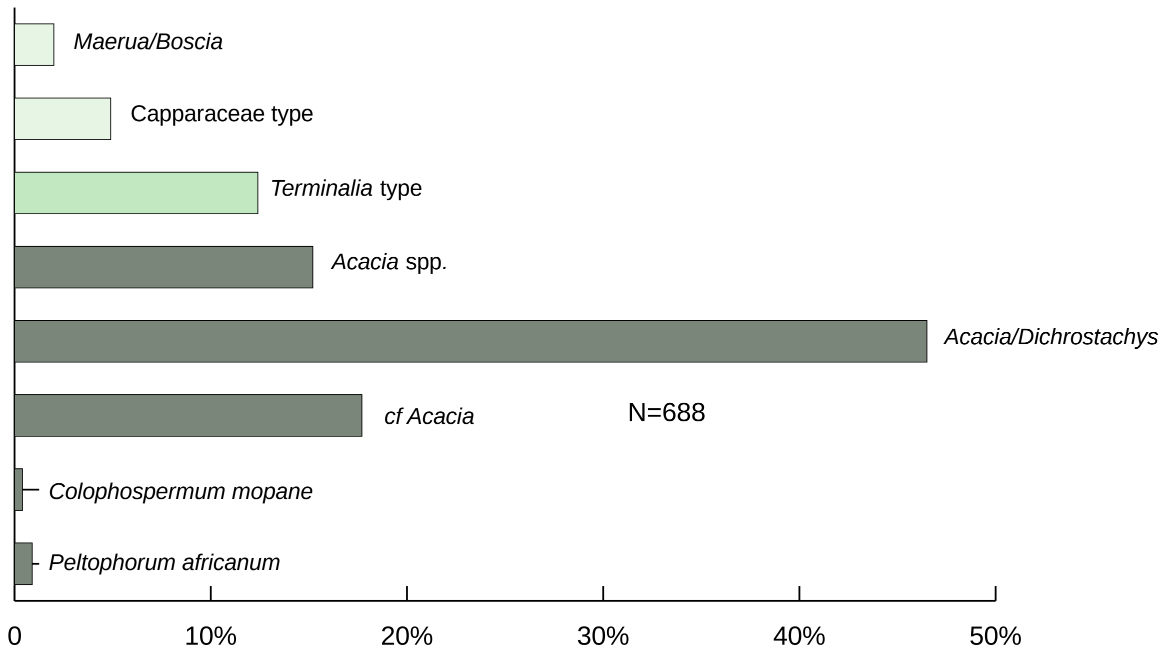


Figure 59: Charcoal diagram from Geduld showing relative proportions of the identified taxa

3.2. Results of the seed analysis

The site of Geduld has delivered a rather large assemblage of seed/fruit remains (N=512) that have been the subject of a first study published in 1995 (Yates et al. 1995). Nevertheless, we have chosen to include this material in our thesis, both in order to confirm and precise previous identifications, add supplementary items and compare the results obtained with those of the charcoal analysis.

The assemblage consists of a mixture of desiccated and carbonised remains, of endocarps (whole and fragmentary), seeds and even bulbs. Their examination has allowed the recognition of sixteen taxa belonging to twelve plant families: Burseraceae, Capparaceae, Combretaceae, Curcubitaceae, Cyperaceae, Ebenaceae, Euphorbiaceae, Fabaceae, Iridaceae, Olacaceae, Rhamnacea and Tiliaceae (

Table 22). Among these taxa we find trees and shrubs but also herbs and creepers, such as Tsamma melon (*Citrullus lanatus*).

Table 22: Result of the seed/fruit analysis at Geduld

	Square	B5-6	B6	B6	B7	B8	B9	C6	C7	C7		
	Level	**L1/4**	**L5**	**L7**	**L6/L7**	**L1/4**	**L1/3**	**L8**	**L8/L10**	**L11/14**	**Total**	**%**
Burseraceae	*Commiphora* spp.			1			1	1	2		**5**	1,0%
Capparaceae	*Boscia albitrunca*				1						**1**	0,1%
	Boscia foetida				83		1				**84**	16,0%
Combretaceae	*Terminalia* sp.			3							**3**	1,0%
Curcubitaceae	*Citrullus lanatus*	14	7	46	8	6	34	1	16	5	**137**	27,0%
Cyperaceae	*Cyperus* sp.			3		4	3		4	4	**18**	4,0%
Ebenaceae	*Euclea pseudebenus*	2		4	2	2	8	1	1		**20**	4,0%
Euphobiaceae	*Ricinus communis*			1							**1**	0,1%
Fabaceae	*Acacia* sp.	2					4				**6**	1,0%
	Tylosema esculentum	1	3	4	2	4	10	12	6		**42**	8,0%
	Elephantorrhiza elephantina								2		**2**	0,4%
Iridaceae	*Lapeirousia* sp.					3	1	1			**5**	1,0%
Olacaceae	*Ximenia americana/caffra*	1	2	9	7	10	5	4	13	5	**56**	11,0%
Rhamnaceae	*Berchemia discolor*	1	1	2		7	10		1		**22**	4,0%
	Ziziphus mucronata	5		2	1	5	14		3	1	**31**	6,0%
Tiliaceae	*Grewia* spp.	11	3	5		7	26	3	2	1	**58**	11,0%
	Unidentified		1			2	16		1	1	**21**	4,0%
	Total	37	17	80	104	50	133	23	51	17	**512**	100%

The latter is present in all of the studied samples and also accounts for the highest number of seeds representing more than 1/4 of the total assemblage. Another species that is ubiquitous is the yellow plum (*Ximenia americana/caffra*) from the Olacaceae family. It is represented by 11% of the identified seeds. A slightly higher number of remains are identified as *Boscia foetida* but they all come from one sample (L6/L7) except for one supplementary seed that was found isolated. Grewia, Tylosema esculentum and Ziziphus mucronata represent 11%, 8% and 6% of the remains respectively. Seeds/fruits from other taxa are less numerous, with a relative numbers varying between 4% and 0,1%. Indeed, several species are present in the form of only one or two remains (*Boscia albitrunca, Ricinus communis, Elephantorrhiza elephantina*). The bulbs belonging to *Lapeirousia* sp. of the Iridaceae family constitute an interesting find that will be discussed further in Chapter VI.

3.3. First observations on the macrobotanical record at Geduld

Several of the ligneous genera identified by charcoal at Geduld are also present in the seed/fruit assemblage (*Boscia*, *Terminalia*). Still, they are not identified with the same level of precision and might not belong to the same species. *Acacia* and *Acacia*-related taxa are predominant in the charcoal record but rare in the seed/fruit assemblage. This is a similar situation to Leopard Cave where no seeds/pods of Acacia have been found.

In general the seed/fruit assemblage at Geduld Cave is diversified with sixteen taxa identified among which ten are identified to the species level. Literature shows that the majority, if not all, of the identified plants are still available in the surroundings of Geduld areas with *Tylosema esculentum* from the Fabaceae family constituting an important part of the diet in many parts of Southern Africa.

4. Toteng

Results of the anthracological study

The analysis of 198 fragments contained in 10 samples collected from the stratigraphic sounding opened at Toteng in 2016 has allowed the identification of four taxa belonging to three different plant families: Capparaceae, Combretaceae and Fabaceae (Table 23). As in the two previously described Namibian sites, at Toteng the predominant taxa in the samples is *Acacia* spp. present in all levels and representing more than 50% of the identified fragments. If we add the charcoal fragments identified either as *Acacia* or *Dichrostachys,* the Mimosoideae subfamily of the Fabaceae represents nearly 70% of the analysed charcoal fragments.

The Combretaceae, represented by *Terminalia prunioides/sirecea,* appears in 60% of the samples and corresponds to 28,3% of the total number of identified charcoal fragments. A fourth taxa identified as belonging to the Capparaceae family appears only in the level between 90 and 100 cm (Figure 60).

Table 23: Absolute numbers and frequencies of the different taxa identified at Toteng organised according to their square and level

	ID_N°	T9_10	T8_9	T7_8	T6_7	T5_6	T4_5	T3_4	T2_3	T1_2	1		
	Depth (cm)	**100-110**	**90-100**	**80-90**	**70-80**	**60-70**	**50-60**	**40-50**	**30-40**	**20-30**	**20**	**Total N**	**%**
Capparaceae	Capparaceae		5									5	2,5%
Combretaceae	*Terminalia prunioides/sirecea*	20		10			7	6	4	9		56	28,3%
Fabaceae	*Acacia* spp.	11	6	5	8	6	9	10	26	17	7	105	53,0%
	Acacia/Dichrostachys		7	6	2	5				12		32	16,2%
	Total	31	18	21	10	11	16	16	30	38	7	**198**	100%

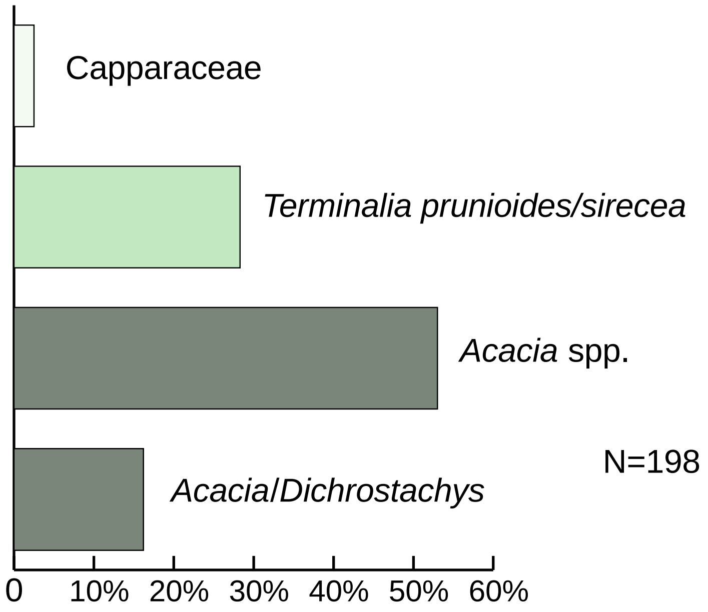


Figure 60: Charcoal diagram from Toteng showing relative proportions of the identified taxa

5. Preliminary conclusions

Despite the geographical disparity of the three sites, and the unavailability of carpological material from the site of Toteng, the results from both the charcoal and the seeds analysis show a uniform pattern with the dominace of woody taxa especially from the Fabaceae, Combretaceae and Capparaceae families and notably *Acacia, Terminalia, Boscia* and *Combretum*. There is also a substantial amount of edible fruit, some belonging to taxa attested both in the form of charcoal and seeds. Both from Leopard Cave and Geduld, the charcoal and seed assemblages show different taxa that are exclusive to each and only a few appearing in both.

CHAPTER VI - DISCUSSION

1. Palaeoenvironmental reconstruction

1.1. Leopard Cave

1.1.1. Arboreal species from charcoal

Leopard Cave is the only one of the three sites with a chronology that can for the moment be divided into two distinct phases: Phase 1 (3700±150-3200±150 BP) and Phase 2 (2600±150-2100±100 BP). Our results do not allow us to detect any change in the vegetation cover between the two occupational phases that show very similar vegetal. There is just a very slight difference by of the reduced presence of *Sclerocarya birrea* in Phase 2. Today this species is a component of the *Mixed bushveld* plant community.

The main vegetation community represented by the taxa identified at Leopard Cave is what Palmer and Staden, (2006) describe as the *Arid Sweet Bushveld* dominated by several *Acacia* species ranging from shrubs to trees growing to up to more than 20 m. These formations also include acacias adapted to riparian[8] woodlands that develop mostly on deep alluvial soils. The predominant species in these formations is *Acacia karoo*. This acacia community is accompanied by dwarf shrubs such as *Boscia foetida, Dichrostachys cinerea* and several shrubs from the genus *Grewia*.. Today in the vicinity of the site, *Acacia mellifera, A. tortilis, A. erubescens, A. robusta* and *Dichrostachys cinerea* grow among other species in the open plains while *A. karoo*, in association with other acacia shrubs, is observed in the valley and along dry streams in the Erongo escarpments well as around the Omaruru river near the town of Omaruru. Wadley (1979) also notes the presence of "giant Acacias" accompanied by tamarisk trees and grasses around the site of Big Elephant as well as in the Erongo region in general.

[8] The interface between land and a river or stream mainly occurring in arid and semiarid regions, the presence of surface water and groundwater fosters the development of distinct riparian zones replete with herbs, shrubs and trees (Lake et al. 2017).

The *Acacia/Dichrostachys* charcoal fragments from the archaeological record are characterised by broad rays (3-5 seriate) and mostly solitary vessels with a relatively large vessel lumina.

Some of the taxa identified from Leopard Cave today belong mainly to the *Mixed bushveld* plant community, composed of woody *Combretum* and *Terminalia* species. This plant community could be further classified as a *Combretum-Terminalia* woodland composed of *Combretum apiculatum* and *Combretum molle* as well as *Boscia albitrunca*. Even though these plant communities are considered as two separate entities, it is difficult to draw a boundary between them as the dominant species in each of them overlap and merge (Thackeray 1979). They are sometimes grouped as bush/shrub and open tree steppe (Wadley 1979).

The wood samples attributed to the Capparaceae family at Leopard Cave present a wide range of characteristics from vessels in radial multiples to thick but short rays (1-2 seriate) in *Boscia/Maerua* species, and a nested vessel pattern with radial canals in uni-biseriate rays in the *Boscia* type. The third type attributed to the Capparaceae family has vessels in radial multiples, with little or no axial parenchyma and differs from the *Boscia/Maerua* group by the absence of prismatic crystals. Today *Boscia albitrunca* occurs extensively in the open plains and on the *kopje* slopes around Leopard Cave and the neighbouring site of Big Elephant. *Boscia foetida* occurs in the open grassland and in the valley but is absent from the mountain slopes.

Concerning the charcoal identified as belonging to the Combretaceae family*, Combretum molle* and the *Terminalia* type both have solitary vessels with very small vessel lumina and narrow rays (1-2 seriate). *Combretum molle* also shows the typical characteristics of the Combretaceae family i.e. included phloem. *Terminalia prunioides* is characterised by vessels arranged in radial multiples with larger vessel lumina than the previous two taxa. All the plants identified as belonging to the Combretaceae family can be seen around the site today even though the only *Terminalia* species present is *T. prunioides*. Ecologically speaking another *Terminalia species*, *T. sericea*, might have grown in the area in the past but if this was the case it seems to have disappeared some while ago as it is not mentioned from the neighbouring sites of Big Elephant and Fäckeltrager nor in the study of plant uses in dry areas of north-western Namibia (Sullivan 1998, 1999).

The Marula tree (*Sclerocarya birrea*) is present in very low numbers (0.3% of the total charcoal assemblage). It also belongs to the woodland plant group but requires a more humid environment than in the present-day arid Erongo (Cheikhyoussef and Embashu 2013). The wood of the species is recognisable by its large vessels and wide 2-4 seriate rays.

1.1.2. Arboreal species from seed analysis

The results of the seed/fruit analysis at Leopard Cave allows us to reconstruct the two same vegetation communities - the Mixed Bushveld (Figure 61) and the Arid Sweet Bushveld (Figure 62) – as those identified by the charcoal analysis. These are dominated by woody taxa such as *Grewia*, *Commiphora* and *Terminalia*. The presence of *Vangueria infaust* suggests further the presence of dry-grasslands (Daemane et al. 2010). This species together with *Commiphora* species is today associated with rocky midslopes and mountain ridges.

Ricinus communis is a soft-woody shrub or small tree that can attain up to 6 m in height. It grows in riparian or stream-bank communities along seasonally dry streams or in open savannahs. The glabrous seeds are about 2 cm long and they have dark and light brown patterns.

The genera *Ximenia* is the last of the woody taxa found at Leopard Cave. It grows presently in association with dry *Acacia* woodlands, wooded grasslands as well as rocky outcrops.

Figure 61: Mixed bushveld (Southeastern Botswana, Photo:M. Mvimi)

Figure 62: Thorny thicket corresponding to the Sweet Arid bushveld (Southeastern Botswana, Photo:M. Mvimi)

The seed assemblage further comprises several annual plants such as *Citrullus lanatus* and *Ricinus communis* as well as undetermined seeds from the Poaceae and Fabaceae families.

Citrullus lanatus is a herbaceous annual plant that grows in the grassland and bushland plant communities of Southern Africa, mostly on sandy soils. *C. ecirrhosus* is restricted to the Kgalagadi desert, the Namib and in the Richtersveld of the Northern Cape. These plants were not observed during the fieldwork periods in July-September as they develop in the summer after the rains and/or are restricted to the more arid Namib to the southwest. The seeds are ovate-elliptic in shape with a smooth endocarp that is sometimes patterned.

The Poaceae fruits could refer a variety of grasses growing throughout the open Savannah to In addition to the woody Fabaceae species, herbaceous species from this family are also present and at while they could not be identified to a precise level several Fabaceae species are present in the above described vegetation units. One among other edible grass taxa consumed in the region today is *Sporolobus* (see Chapter IV). In general, few grass remains are found in Leopard Cave.

1.2. Geduld

1.2.1. Arboreal species from charcoal

Very similar vegetation patterns as those observed for Leopard Cave can also be reconstructed for Geduld. There is only a slight change concerning the Fabaceae family with the presence of two supplementary genera namely *Colophospermum mopane* and *Peltophorum africanum*. The vegetation that we have been able to reconstruct for this site is a mixed bushveld dominated by species from the Combretaceae and Capparaceae families. *Colophospermum mopane* is found in the *Colophospermum mopane* woodland/ *Colophospermum mopane* veld of the Mopane savanna vegetation. It is a tropical plant that falls within the Zambezian Domain of the Sudano-Zambezian Floristic region[9] (Eichhorn and Vogelsang 2011). Today the mopane formations cover large areas of the northern and north-eastern parts of South Africa, Botswana, Zimbabwe, Mozambique and northern Namibia with a total surface estimated to almost 555 000 km^2 (Smit and Rethman 1998). The vessels of *Colophospermum mopane* are arranged in radial multiples, the thin rays are 1-3 seriate. The charcoal may resemble the Acacia type 2 but *C. mopane* has more axial parenchyma than this taxa.

Peltophorum africanum falls within the Mountain bushveld and this is also the case for some *Combretum* and *Terminalia* species. The *P. africanum* archaeological charcoal shows solitary vessels and 1-2 seriate thin rays. *Peltophorum africanum* (weeping wattle) is a plant that is traditionally used to treat a number of ailments including diarrhoea, dysentery, helminthosis and as an immunity booster for both animals and animals (Bizimenyera, 2006). Jacobson et al. (1995) portray the vegetation around the site today as being within the mopane woodland with elements also belonging to the thornveld and mountain savannah. Indeed, except for Mopane the site's woody taxa are very similar to those of Leopard Cave, and likewise very similar to today's vegetation cover around the site. Today *Peltophorum africanum* is observable close to the site of Leopard Cave.

[9] The vast stretches of woodland, savannah and grassland vegetation with occasional dry forests and thickets, and patches of edaphically controlled swampy vegetation, in a wide zone in Sub-saharan Africa around the Guineo-Congolian Region (Weger 1978)

1.2.2. Arboreal species from seed analysis

Woody species of the mixed woodland/shrubland communities composed by *Boscia foetida* and *Grewia* have the highest representations among the identified woody taxa on the basis of seed/fruit remains. A thorny bushveld is also attested through the presence of *Commiphora* and *Acacia* species. Urso et al. (2013) mention a *Ziziphus –Berchemia* association comprising other woody taxa such as *Colophospermum mopane* and the woody *Commiphora* species in northwestern Namibia. A *Berchemia-Ziziphus* vegetation occurs in valley areas as well as well as along drainange lines. The main riparian species found here is *Euclea pseudebenus* that may have grown along the Ugab river.

1.2.3. Annual plants from seeds analysis

Citrullus lanatus is present at Geduld in higher frequencies than at Leopard Cave.

The presence of *Cyperus* seeds suggests once more the proximity of riverine plant communities. Sedges however do not necessarily need a constant mesic environment to thrive. Their presence at the contemporary sites of Big Elephant settlement and some Middle Stone Age sites is for example not associated with perennial streams (Wadley 1979, Sievers et al. 2011). The sedges at these sites are believed to have been used as bedding and the grains and corms are used for human food. The presence of sedges is noted today in most parts of northwestern Namibia including at Big Elephant and they also exist in the dry streams near Leopard Cave. *C. fulgens* is one of the most common in species in the northwestern parts of Southern Africa today.

Lapeirousia is another of the plants where the corms are consumed. It was noted in the archaeological record of Geduld but also grows around the site today as it also does in the Erongo region (Wadley 1979).

The remaining taxa belong to the Fabaceae family (*E. elephantina* and *T. esculentum*) and correspond to herbaceous xeric taxa with foliage that dies off in winter and that resuscitates with the new rains. Together with *C. lanatus* these constitute very important legumes for arid-environment dwellers.

1.3. Toteng

Arboreal species from charcoal

Without doubt the lower quantities of charcoal available from Toteng are responsible for the lesser diversity of taxa obtained through the charcoal analysis. Still the results allow us to suggest that the site was surrounded by Mixed woodlands comprising taxa from the *Capparaceae* and *Combretaceae* families as well as Arid Sweet woodlands with thorny *Acacia* species associated with *Dichrostachys sinerea*. (Figure 63).

Figure 63: Acacia bushveld near the site of Toteng. (Photo: M. Mvimi)

Different phytocenoses of the arid savannahs and other semi-arid regions are controlled by a number of factors especially soil types and annual precipitation (Van Rooyen and van Rooyen 1998, Palmer and Staden 2006). In the context of Southern Africa this type of vegetation occurs in arid but fertile areas. Usually they are characterised by fine-leaved vegetation but the contrast with this postulation is that observably the *Colophospermum mopane* around the study area, i.e northwestern Namibia and the central Kalahari around the Okavango Delta, is rather broad-leaved. To the north of Namibia, the mountainous areas of these savannahs are complemented by *Commiphora* shrub savannahs. Eichhorn and Vogelsang (2011) show that the distribution of mopane is restricted to the limits of the Kgalagadi basin where the sites of Geduld and Leopard Cave are found and also in the central Kgalagadi where the site of Toteng is located.

In conclusion, the macrobotanical remains from the three sites seem to tell similar stories :

1) a story of LSA communities who gathered vegetal resources from similar vegetation communities that moreover have a composition that is comparable to what we find in these areas today. This attestation is solidified by the presence of woody trees that conform to different forms of woodlands and a broader wet and dry open savannah. These woodland taxa include *Combretum apiculatum*, *Combretum molle*, *Terminalia prunioides* and possible *Boscia albitrunca* with a conspicuous dominance of the Arid Sweet woodland that characterised mostly by the genus *Acacia* at the three sites. The exceptional woody taxa are *Colophospermum mopane* and *Peltophorum africanum* that are present in Geduld but not in Toteng and Leopard Cave and also *Sclerocrrya birrea* attested only in Leopard Cave.

These environmental similarities are also observable from woodlands comprising shrub species such as *Grewia* sp., *Boscia foetida* and *Commiphora* and *Acacia* species that are adapted to valleys, mountains and mountain slopes, except in Toteng. Plants that belong to the stream bank communities such as those in the genera *Euclea* and *Cyperus* are found at Geduld. And finally grasslands (Poaceae) and xeric herbaceous species like *C. lanatus,* from both Geduld and Leopard Cave and leguminous perennials like *T. esculentum* and *E. elephantina* both from Geduld.

2) The macrobotanical results show very similar climatic conditions across the Kgalagadi Basin. The results which are in harmony with the semi-arid/savannah Holocene climate of the savannah and Nama karoo biomes discussed in Chapter 1 and 2. The results of our study do not allow to infer that climatic conditions have changed in a decisive way since the study period.

1.4. Making inferences to today's vegetation

The present-day environment of the two Namibian sites shows more similarities. They are both located in the proximity of escarpments and near seasonal streams or; the Ugab river flows near Geduld and a small stream in the valley at the foot of the basalt massif of the Erongo is easily accessible from Leopard Cave. Big Elephant is close to both the Omaruru and Khan rivers to the north. Toteng on the other hand is an open site at the mouth of two rivers within the alluvio-lacustrine soils, very prone to flooding from the Okavango Delta. Moreover the area receives slightly more rainfall than the other two sites. Toteng is found in a region with low open grass shrublands/woodlands and Tall open shrublands/grasslands with riparian reeds and sedges as well as acacia thickets where the sandy substratum influences the vegetation cover (Vanderpost et al. 2015).

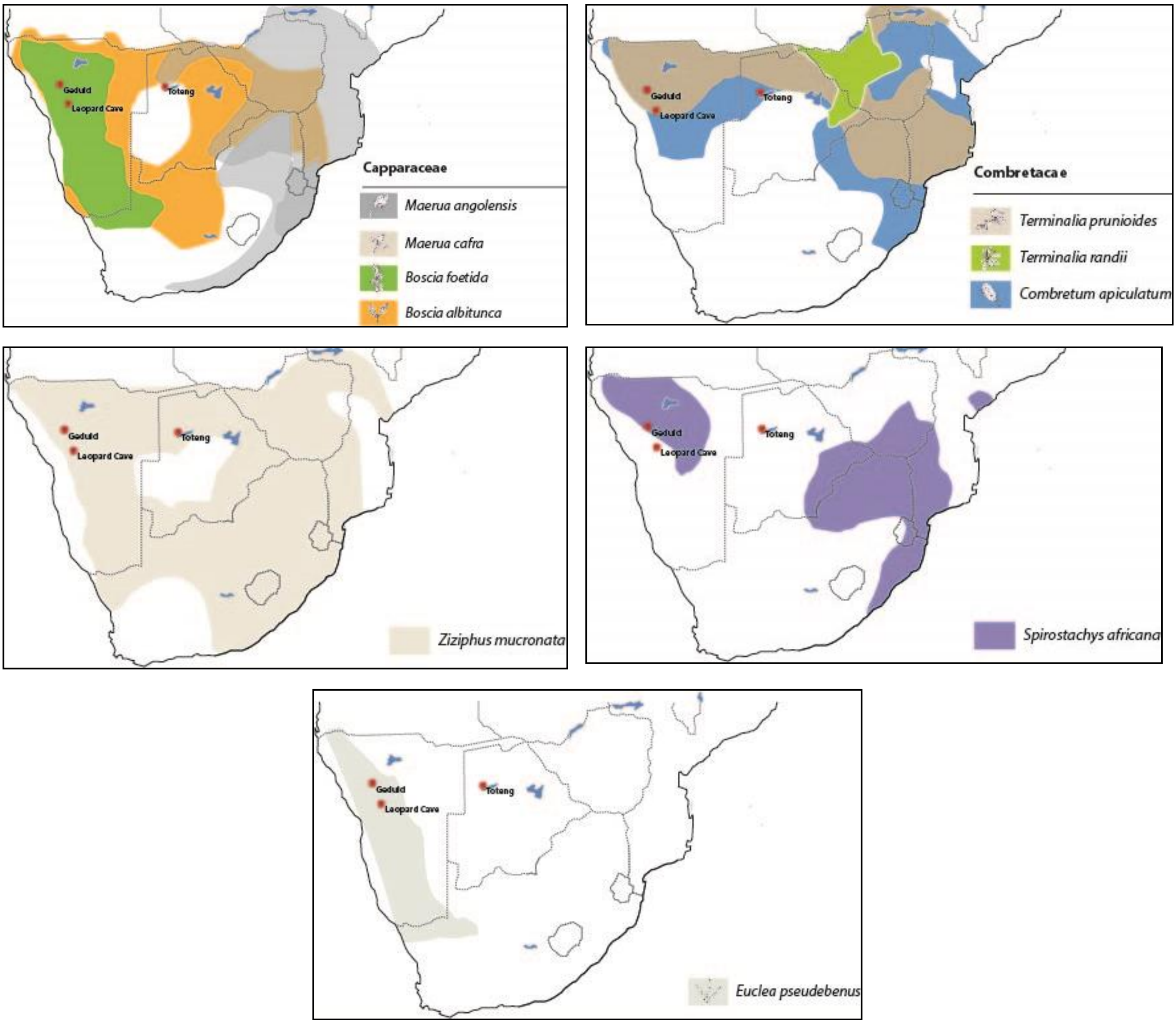


Figure 64: The current distribution of some of the major plant communities

Even though the species growing around the Namibian sites and Toteng are in many cases similar, the impression given by the vegetation at the latter is that of much bigger trees whose growth is probably favoured by better soils and a higher water-table. Plant dimorphism was also observed by Leakey et al. (2005) by comparing the Namibian and South African Marula for possible cultivation where they stated "The fruits of 'Namibian Wonder' Marula were, however, very much heavier".

(See chapters 2 and 4 for detailed descriptions of past and present vegetation in relation to the sites.)

1.5. Wild fauna to complement the environmental setting

The three study sites have delivered well-preserved and diverse faunal remains that in parallel with the plant remains inform us on past environments and subsistence strategies (Thackeray 1979).

At Leopard Cave the mammal record is dominated by small bovines such as impala and klipsringer as well as species adapted to mountain environments such as the rock hyrax (*Procavia capensis*). The reptilian fauna comprises snakes and the monitor lizard. Guinea fowl and ostrich were hunted birds.

At Toteng large bovids like buffalo (*Syncerus caffer*) and red hartebeest (*Alcelaphus buselaphus*) have been identified. Among the smaller bovids appear impalas, grey duiker (*Sylvicapra grimmia*), and steenbok (*Raphicerus campestris*). Wet environment hosted sitatunga (*Tragelaphus spekei*), lechwe (*Kobus* cf. *lechwe*), hippo (*Hippopotamus amphibious*) and crocodile (*Crocodylus niloticus*). Tortoise, snakes and the monitor lizard as well as crab, bullfrog and gastropods are also present. Finally, baboon and the vervet monkey as well as carnivores such as lion complete the rich faunal assemblage at Toteng.

At Geduld finally bovids dominate ranging from small-sized antelopes like the Damara dik-dik (*Madoqua kirkii*) to the common duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestris*) and the larger hartebeest. (*Alcelaphus buselaphus*). Bones from domestic sheep and cattle are attested from ca. 1790 + 50 BP. Other types of fauna consist of birds (guinea-fowl, dove, francolin) and reptiles (*Varanus niloticus,* snakes…). While the bullfrog might have come from the river near the site, the presence of seal phalanges came as a surprise to the archaeozoologists as it must have been brought from the sea.

Other sites such as Big elephant, have provided similar faunal assemblages (Wadley 1979). LSA layers at the site of Apollo 11 have delivered primates such as baboon, bovids like steenbok, springbok and gemsbok as well as carnivores like the jackal and hyena. Wathorg, rabbit and the mountain zebra are equally present. Ostrich, snakes and some unidentified fish are found (Thackery 1979).

Indeed the results from this faunal data from northwestern Namibia and central Kgalagadi are quite similar. Only small variations are perceptible according to the different environmental settings where the sites are found. In general, the wild fauna is composed mainly of grazers such as antelopes, hippo, equids and animals that are both grazers and browsers like the *Procavia*. The spectra from the mountainous Leopard Cave and Geduld areas encompass rocky areas where species like klipspringer and *Procavia* would have lived. Grazers are found at Toteng too but since it is in the proximity of wetlands, Toteng fauna includes hippo, lechwe, sitatunga, shellfish and fish. Together with the sites of Apollo and Big Elephant, the fauna observed here is concomitant with open plains, woody and grassy savannah environments with rocky outcrops.

Moreover, these animals are found around the area today (Figure 65). Ungulate communities in these areas include large browsing fauna like the black rhinoceros, kudu and giraffe, which live in woodland vegetation. Springbok, zebra, gemsbok, impala and ostrich also occur on the open plains. The mountain zebra (*Equus zebra hartmannae*) occurs on the inland mountainous plateaux which run parallel to the South West African coastline, with klipspringer and dassie common on rocky outcrops. The more diverse ungulate faunal community in northern Namibia and north-western Botswana can also be ascribed to the fact that temperature variation there is less extreme than in the southern regions of the country (see Chapter 1 for full southern African fauna).



Figure 65: Vegetation of the Erongo showing Kudu (l) and zebra (c) in the thorny shrubland near Leopard Cave and an ostrich family in northwestern Botswana**.**

These open tree, grassland and shrubland environments, even though relatively arid, then and now, are very imperative as supporters of a rich biological diversity. This shows that the LSA populations living here had a wide range of resources to choose from to sustain their subsistence needs.

2. Subsistence strategies and use of biological resources

2.1. The choice of species

The lack of systematically interpreted archaeobotanical data from various LSA sites creates an imbalance as in the end these LSA communities tend to be portrayed as predominately hunters. This study not only provides information on the environmental conditions but also on the human-vegetation relationship; A relationship from which certain pattern about vegetation choice is evident.

There is a very interesting dynamics between the charcoal and the seed exploitation traits. The two are relatively different with the wood taxa exploited for combustion differing from those exploited for edible fruit trees. The only taxa that are found in both are those from the Capparaceae family, and solely from the site of Geduld. Diagnostic charcoal taxa from these families are either from the genera *Boscia* or *Maerua* while the seeds from the Capparaceae families are exclusively from *Boscia albitrunca* and *Boscia foetida*. Capparaceae (*Boscia and Maerua*) charcoal also exists in Leopard Cave and an unidentifiable type is found in Toteng.

Apart from underlining the vegetation diversity, this insinuates a local and differential sourcing of vegetal resources with a distinction in choice between fruit bearing trees and shrubs and non-edible taxa. Could this reveal a strategy to safeguard fruit trees useful as a food resource by avoiding cutting of their wood? Unfortunately, it is difficult to tell from our charcoal record whether the wood was collected dry or if trees were actually cut down for the purpose of combustion. Another possible factor that could influence the choice of species is that of taboos that prohibit the use of certain taxa considered sacred, poisonous or in general improper for certain uses. Could we even speculate that similarities and differences in the spectra of chosen species could be linked to cultural groups (as it is the case among present-day communities; see chapter IV)?

2.2. Two exceptional species of *Colophospermum mopane* and *Sclerocarya birrea*

The presence of *Colophospermum mopane* in Geduld in very small quantities in a mopane savanna is not surprising. What is unexpected is its frequency in the archaeological record for a plant with the provenance of the Mopane woodland. It is possible that it could have been "preserved" the same way fruit trees have been. *C. mopane* is a highly resourceful plant and much appreciated for its many uses. The strong wood is used for making poles, stools, wood carvings and kitchen utensils. The firewood is long-lasting, the gum can be melted and used as glue, the cambium weaved into rope or used as tannin. The inner cambium is also known to have medicinal properties. The tree is also a host for edible caterpillars (*Gonimbrasia belina*) commonly referred to as mopane worms. Mopane is not used just because it is the dominant species, but because for many of the uses it is a highly preferred resource (Kennedy and Potgieter, 2003; Coates Palgrave, 2002).

Sclerocarya birrea appears at Leopard Cave but, as we have seen, in very small quantities. This is a tree that thrives in different woodland conditions, on variable types of soils, especially when well drained and with an annual rainfall ranging from 200-1500 mm (Cheikhyoussef and Embashu 2013). Therefore the possibility of its existing in this mixed woodland at 2600±150-2100±100 BP cannot be excluded. But it is its quantity and non-existence in the previous phase (3700±150-3200±150 BP) that is not explicable. Like mopane, *S. birrea* is a plant of many uses, even termed a 'power' plant (Eloff 2001). The fruit of *S. birrea* is a part of many rural diets but also of great economic value. The fruit is used to make jam, a traditional brew and could be eaten fresh (Emanuel et al. 2005). The leaves are eaten as relish by the Pedi tribe in South Africa, the kernels are eaten raw and oil is extracted from them, branches are used as firewood and the bark has antibacterial properties (used to treat stomach ulcers and fevers stomach problems) and over the years has been relied on by a variety of southern African traditional healers The bark also contains tannin and tanning material (Eloff 2001). Namibian fruits were significantly larger than those from South Africa (Cheikhyoussef and Embashu, 2013).

The single occurrence of marula charcoal together with the absence of its fruits may suggest that the plant did not grow in the area during the LSA period. In the reconstruction of the vegetation cover in the adjacent Kunene region of north-western Namibia, conducted by (Eichhorn & Vogelsang 2011), this species is also absent from the charcoal record. It is thus possible that it the plant was brought to the site from elsewhere.

Long-distance transport of certain commodities is further attested by the presence of several phalanges from seal in the faunal assemblage at Geduld, located at a distance of 270 km from the nearest coast.

Two other plants, namely *Tylosema esculentum* and *Citrullus lanatus,* are not rare in the archaeological record but they are worth noting as they have played a major role in the survival of arid environment dwellers over the years including today. The large tubers of *Tylosema esculentum* are roasted and eaten and they or eaten raw, for example by the Himba people. They are used as a thirst quencher when raw. The beans which contain around 30% of protein and leaves are eaten. The leaves are eaten raw and the seeds and roots are roasted and eaten by the San people and the seeds are consumed by Tswana-speaking people of south-east Botswana (Sullivan, 1998). *T.esculentum* seeds and leaves can also be fed to livestock.

Tsamma melon contains less than 7% sugar and also has low concentrations of minerals and vitamins (B and C). The protein-rich seeds also contain edible oil and are commonly roasted. Tsamma melons are eaten as fresh fruit or can be boiled or steamed as a vegetable. The Tsamma is not valuable for its nutritional value, but as a source of water in mid to late summer in dry areas (Mujaji, 2009). The tender young leaves of *Citrullus lanatus* as well as the fruits are cooked like spinach or green vegetables, while the fruit flesh may be cooked as porridge accompanied by a starchy side.

Human remains are rare on Late Stone Age sites in Southern Africa and it is thus difficult to draw conclusions concerning the population structure and various aspects of health, diet and daily life that can usually be read from bone remains. It is generally admitted though that these groups were of reduced size and that they were mobile(Palmer & Staden, 2006). The role of domestic livestock during the LSA has been much debated (see Chapter II) and the rarity of faunal remains formally identified as belonging to cattle or caprines has been explained in various ways.

According to the study of charcoal and seeds the vegetation communities around the sites did not change much through time. Moreover they seem to have been very similar to the present. Thus it is possible that the presence of LSA communities, even in a rather fragile environment, did not have a large impact on the local plant communities. It is not until recently that human-induced changes have altered vegetation patterns and composition mostly due to farming and herding practices (Carrión 2000). Even in Toteng and Geduld where the presence of domesticated animals has been certified the impact of grazing is not visible in the anthracological record. This might imply that livestock was of minor importance or simply not really "herdered" in these areas, an assumption that would also explain the small amount of bone remains from domestic fauna at the sites and the persistence of hunting and catching of a large array of wild prey.

2.3. Seasonality of fruit collecting possible processing

The fruit was necessarily collected when available (Table 24) and thus settlement of the cave may have been influenced by the seasonal changes. The plant remains offer information on pharmacopoeia and seasonal food availability (See Ethnography chapter for more detail). Jacobson et al. (1995), schematised the fruiting seasons of the plant spectra at Geduld in order to understand their exploitation throughout the year (See Chapter II for more detail). Here a similar model was adapted for the general seed/fruit corpus of this study to discern the relationship between the fruiting season, fruit harvesting and site occupation. This is a summer rainfall area and most of the fruit ripens between the summer and autumn except for *Boscia albitrunca* which bears fruit in the spring. This is the time to harvest fresh fruit but evidence of possibly processed fruit is present. Therefore it is plausible to be in agreement with Jacobson et al. (1995) that there were phases of seasonal occupation at the site, probably between the autumn and winter. There is also evidence that seed processing for example, those of like those *Ximenia* and melons (*Citrullus* spp.) was also done at the sites of Geduld and Leopard Cave. Systematically broken endocarps as well as whole fruit with dry skin are present. These fruit take preparation like drying of fresh fruit and breaking of the endocarp to access the kernels that contain the oil. Therefore the communities in this area may have used the caves as food processing stations or just processed the fruit during their period of stay (Urso 2013). Further comparison between the two sites as being used for similar purposes is impossible as Leopard has evidence of continuous occupation over the years while further excavation needs to be done at Geduld to establish a continuous sequence.

Table 24. Seasonality of fruit trees reflecting the macrobotanical spectra

	Season	Summer			Autum			Winter			Spring			
	Fruiting period (month)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anacardiaceae	*Sclerocarya birrea*			*	*	*	*	*						
Burseraceae	*Commiphora*		*	*	*	*	*							
	Boscia albitrunca											*	*	*
Capparaceae	*Boscia foetida*			*	*	*								
	Terminalia sericea			*	*	*	*	*	*	*				
Combretaceae	*Terminalia prunioides*			*	*	*	*	*	*					
Ebanaceae	*Euclea pseudebenus*			*	*	*	*	*						
	Ximenia americana	*	*	*										
Olacaceae	*Ximenia caffra*	*	*											
	Berchemia discolor		*	*	*	*	*	*	*					
Rhamnaceae	*Ziziphus mucronata*				*	*	*	*	*	*	*			
Rubiaceae	*Vangueria infausta*		*	*	*	*								
	Grewia flava		*	*	*	*								
Tiliaceae	*Grewia flavescens*		*	*	*	*								
Curcubitaceae	*Citrullus lanatus(ecirrhosus)*			*	*	*	*							
Cyperaceae	*Cyperus* sp.													
Euphorbiaceae	*Ricinus communis*						*	*	*					
	Elephantorrhiza elephantina	*	*	*	*									
Fabaceae	*Tylosema esculentum*			*	*	*	*	*						

The *Ximenia* ripe fruit (Figure 66, Figure 67) has a vitamin C content of 27%, is high in potassium and contains protein. The seed has a 65% oil content. Fruits have a refreshing sour taste, best eaten when over-ripe, but can also be used for making jam, dessert and jelly or an alcoholic beverage. They can be added to porridge. Oil from the seed is used to human skins and for working animal hides. It is also used for lamps. The nuts are also eaten. Oil from the seed is sometimes used by Himba and Tjimba of Kaokoveld as a substitute for animal fat which is normally applied to the body (Sullivan, 1998).

Another notable aspect at these sites is the impeccable nature of preservation of the botanical material whether they are carbonised or just desiccated.

Figure 66: An example of *Ximenia* for oil extraction in Angola and a fresh *Ximenia* fruit. (Urso et al. 2006, http://www.africanplants.senckenberg.de)

Figure 67: shorter and wider *Ximenia* endocarp as compared to the elongated narrower version could be criteria to distinguish different the different species.
Note the smooth surface which may mean methodical breaking of the fruit.

CONCLUSION

Chances of finding preserved botanical material from archaeological sites are not always with assurance, but exceptions are usually available depending on the taphonomical nature of the site. Firstly the chances of carbonised wood to survive in an archaeological site is very high. The inert nature of the charcoal allows it to survive this (Esterhuysen & Mitchell, 1996). Seeds/grains alike can be preserved by carbonisation, but also by desiccation or mineralisation.

The flawlessly preserved nature of the macrobotanical remains at the sites of Leopard Cave, Geduld and Toteng have allowed for their assessment. The analysis from these charcoal and seeds/grains have allowed for the understanding of socio-environmental and possibly sociocultural behaviours pertaining to the relationship between LSA communities and their environment circa 2000 BP. While the study shed light on paleoecological and paleobotanical changes, a number of questions were also raised concerning both the environment and subsistence practices.

This thesis sought to understand the nature of the environment when this assumed period of the first herders arrived in the southern African region around 2000 years ago. Equally interesting was to understand how these communities exploited the environment or rather did the environment influence their food procuring habits.

The macrobotanical assemblage from Leopard Cave and Geduld gave a very clear variety between the charcoal and seed taxa, but a rather similar intra-site spectrum of the charcoal. Toteng even though less diversified, shows taxa similar to that of Leopard Cave and Geduld. Therefore the following information could be extrapolated; the peripheries of the Kgalagadi basin in northwestern Namibia was comprised of woodlands, shrubs and open grasslands dominated mainly by Acacia, Combretaceae and Capparaceae species. Also deducible is the fact that the Central Kgalagadi seems to have similar environmental conditions since the Toteng area also comprises woody taxa comprising of Acacias, but also taxa of Capparaceae and Combretum families.

This brings us to postulate that the communities living in these environs' vegetal food resource procuring ensued in their immediate environs. Fruit and wood may have been collected in the local area but with a clear selective approach. A comparison between the charcoal and seeds assemblages from Leopard Cave and Geduld show that those species that were used for combustion were not the same species that bore edible fruit except for a few *Boscia* species. The possible introduction of some species like the Marula in the phase between 3700±150 - 3200±150 cal BP.

Archaeobotany does not only stop at plant identification but also goes on to look at the people as the actors in their own environments. But working in an area where very few detailed paleobotanical research (Namibia) or none has been done at all (Botswana), seeking for relevant sources to infer to was indispensable.

First, an ethnographic approach had to be included for the main reason that often times it is very difficult for us as archaeobotanists to interpret plant use in the archaeological contexts, especially for earlier periods such as this one where people gathered resources rather than cultivating and storing them.

Secondly, ethnography is also important to make deductions especially for the vegetal connotations that are associated with intangible aspects such as taboos. The ethnographic study between the San and Damara communities found in the Erongo today aided with such. The San communities are more centred around "rules" concerning general plant use and are more selective than the Damara. The Damara, on the other hand, exploit almost all the plants in their environment and they mentioned fewer restrictions.

Conducting research in areas where previous investigations are void was not without its challenges. For that, this thesis included the construction of a detailed basic reference collection to facilitate identification. The processed wood and seeds were collected around the study sites and a catalogue was compiled.

Archaeobotany and ethnobotany alone cannot give a full picture of the LSA in Southern Africa but, this study has managed to show not only the fact that the late Holocene environmental conditions in the Erongo were similar around 3500 years ago to what they are today but also the fact that the local communities exploited their environment and they selected between their fruit and combustion material.

The similarity of the environment from then and now is supported by the zooarchaeological record from the same sites (Pleurdeau et al., 2012; Jacobson, 1987; Jacobson et al., 1995) and those from the environs (Thackeray, 1979; Wadley, 1979). The archaeological fauna found in these sites includes mainly small and large grazers. The majority if not all can be found in the area today. This faunal information together with the botanical information shows that the area was very rich in food and other biological resources that these people exploited. Some of the plants and animals may have been brought to the site and an example is *Sclerocarya birrea* in Leopard Cave and the seal bone in Geduld.

For a period spanning the last 2000 years where the environments in Southern Africa are supposed to be marked by cultural events that might have had an impact on the environment, but this is not the case in the study area. Questions arise though about this lack of impact by "herding" on the environment. Did people keep very small stock? Finally, there is a lack of representation of starchy foods or grasses in the assemblages creates an imbalance.

The Archareobotanical approach employed in this study has proved to be able to make an extraordinarily significant input to the understanding of the LSA people and environmental circumstances at the period, therefore, an extension of the work is indispensable. The study corpus must be expanded especially for the sites of Geduld and Toteng where the assemblages are not very large. Resemblances between the study sites and other sites in the region have been established so such a study should be extended to include these sites for comparison purposes and to gain a profound picture of LSA communities and their vegetal surroundings.

Furthermore, fruit and wood exploitation practices were recognized but the absence of the use of grasses (Poaceae) at the three sites is intriguing. This absence of grasses raises questions on the broader dietary habits that include the carbohydrates acquisition and intake. The inclusion of neighbouring sites can be useful to question whether grasses occur there but starch analysis approaches need to be employed.

Finally, a botanical reference collection was built for this study, a preliminary catalogue compiled and it has been very useful for identification purposes. An expansion of the reference is needed in order to further assemble a reference database for the southern African arid and semi-arid milieus.

APPENDICES

Appendix 1: Wood anatomy for identification purposes

The identification process in this chapter is exclusively based on hardwoods/angiosperms as they are the only type available in the charcoal assemblage.

In botanical terms, angiosperms are vascular, flowering plants that make over 80% of all living plants. Angiosperms comprise a large variety, among other shrubs, aquatic plants, bulbs, herbs, epiphytes and trees. A living, growing tree has two main domains, the outer shoot and the underground roots.

One of the components of the shoot is the stem, which comprises a variety of layers (Figure 68) the outer bark, which is the protective layer of the tree also helps reduce the loss of water by evaporation, the phloem, moves sucrose sugars and proteins, from the leaves where they are produced by photosynthesis to the roots and the rest of the plant. The vascular cambium which is situated between the wood and the bark, is where cell division occurs, the cells either become wood or bark cells. The sapwood is responsible for the storage and synthesis of biochemicals as well as the conduction of sap. At a given moment, the need for the conduction of sap to the leaves by some parts of the trunk ceases. At this stage, the vessels in the centre of the plant fill with extractives and minerals resulting in the heartwood and the pith.

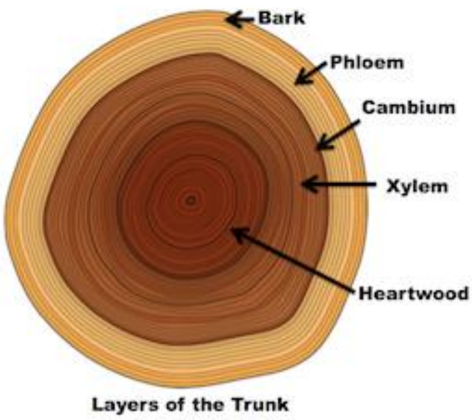
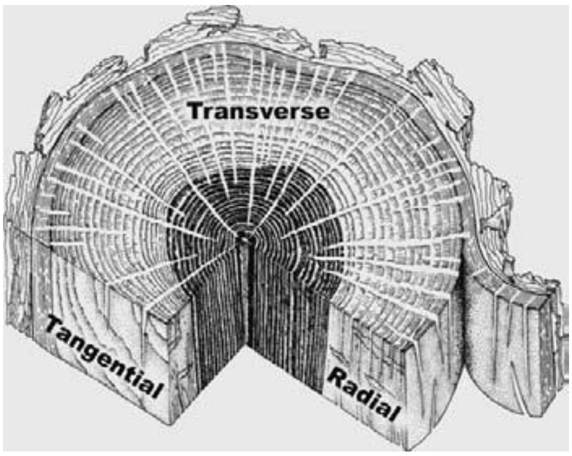


Figure 68: Cross-sections of a tree showing the anatomical features

For all wood identification criteria, identification of charcoal from archaeological contexts requires careful attention. This is due to the fact that even though the inert structure of the charcoal is mainly conserved after carbonization, fire and other post-depositional factors including pest-activity, may possibly interfere with the wood structure, and different species are subject to react to these factors in different ways. Therefore, it is possible to convey information on collection strategies, preferred parts of the wood and wood defense mechanisms (e.g. reaction to insect attack) as well as different taxonomic information. Furthermore, identification is based on xylem which contains the characteristics described below. Notably, there are several other characteristics applicable to different other species but may not be evoked here as they are not pertinent to the corpus at hand. (Prychid et al.,2004; Dabney et al., 2016)

As is the case with any discipline that deals with wood studies and identification, identification of charcoal from archaeological contexts, requires careful attention. This is due to the fact that even though the inert structure of the charcoal is mainly conserved after carbonization, fire and other taphonomical processes including pest-activity may possibly interfere with the wood structure, and different species are subject to react to these factors in different ways. Therefore, it is possible to convey information on collection strategies, preferred parts of the wood and wood defense mechanisms.

Furthermore, the xylem contains the following characteristics. Notably there are many others that are applicable to different other species but may not be evoked here as they are not pertinent to the corpus at hand (Figure 69).



(Caguiatet al.,, 2018)

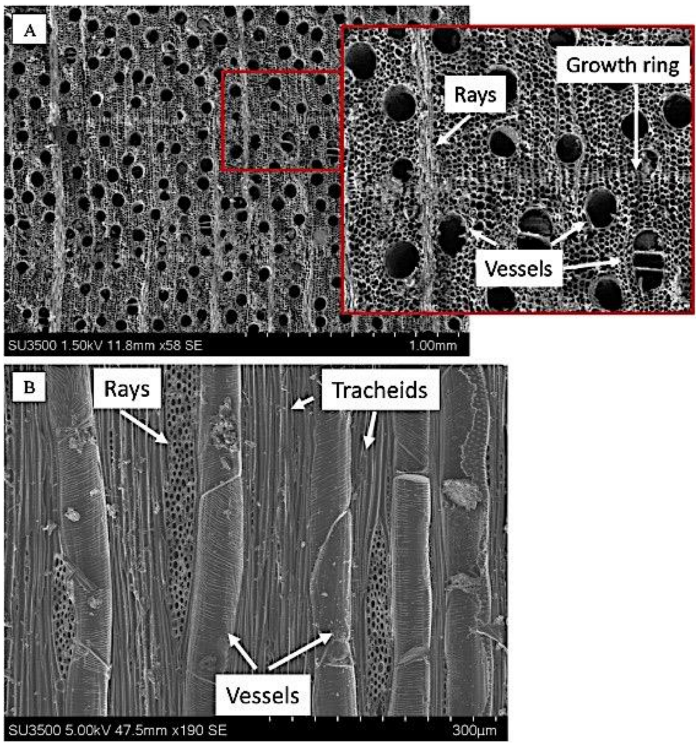


Figure 69: wood phases and wood charcoal showing the below discussed features

Below are the wood anatomical features and their functions according to the International Association for Wood Anatomists:

- **Rays**: Transport water and other dissolved nutrients across the stem.
- **Parenchyma**: Thin-walled cells responsible for the storage and distribution of food. In hardwood, parenchyma cells are brick-shaped and found around gum canals and ray cells.
- **Fibres**: Thick-walled cells that mainly serve to support and strengthen the trunk
- **Tracheids**: they serve both the mechanical and conductive needs of softwoods. They make 90% of the volume of the wood.
- **Xylem** consists of narrow tracheids and wider vessel members that form vessels
- **Tyloses**: In some instances, vasicentric balloons into the interior of adjacent vessel elements. The tyloses efficiently block the unused vessel as passage ways for like insects and fungi.
- **Perforation plates**: Found at the ends of the vessels and they allow for the efficient transport of fluids. Vessel are formed by vessel elements piling one on top of the other, and the perforation plates are the areas where the vessel elements overlap. They could be reticulate, scalariform, simple etc.
- **Vessel**: made up of a raw of meristematic cells of procambium or vascular cambium which remain attached end on end in a longitudinal series.
  The vessel patterns (presentation, porosity, groupings and arrangements) are used to distinguish the wood for identification purposes.
- **Intervessel pits**: The connections between adjacent vessel members.
  They could appear opposite, alternate or scalariform. Their shape also matters as a distinctive feature. Their size(µm) can also be used as a determining factor.
- **Vessel ray** pitting: the connection between vessel elements and adjacent ray parenchyma cells. The size and border shapes are considered.
- **Helical thickenings/Spiral thickenings**: Helical thickening in the secondary xylem appears as a ridge of cell-wall material, usually deposited on the lumen side of the xylem in the tracheids of certain conifers, and in angiosperm fibres and vessels.
- **Phloem**: Inner bark. The function is to distribute manufactured foodstuff.
- **Tangential diameter of vessel lumina**: On the transversal section, vessels appear as open pores. Their diameters may vary from small (<30 µm) to large (>300 µm), but normally range between 50 and 200 µm.
- **Fibre wall thickness**: IAWA, The fibre lumina size in comparison with the surrounding double wall thickness. The thickness of the fiber cell wall is the main determinant of density and strength.

Plant species with thin-walled fibers have a low density and strength, while species with thick-walled fibers have a high density and strength. Wiedenhoeft and Miller 2005.

- **Sheath cells**: Cells found on the limits of broad rays. They are usually larger than the central ray cells.
- **Radial canals**: Pockets filled with resin. They could be thick or thin walled. The walls are not those of the canals themselves they are those of the cells surrounding them. The canals themselves are not cells but cavities.
- **Prismatic crystals**: Mineral remnants of plant metabolism and chemical processes containing calcium oxalate.
- **Druses**: A form of crystals that have a star shape. They could be found in parenchyma and ray cells.
- **Silica bodies**: The plant takes in soluble monosilicic acid from the soil. The Silicon build up in the silica cells become the mineral structures of amorphous hydrated silica with various shapes and properties. They may be found in any part of the plant but they are mainly located in the ray or axial parenchyma cells.

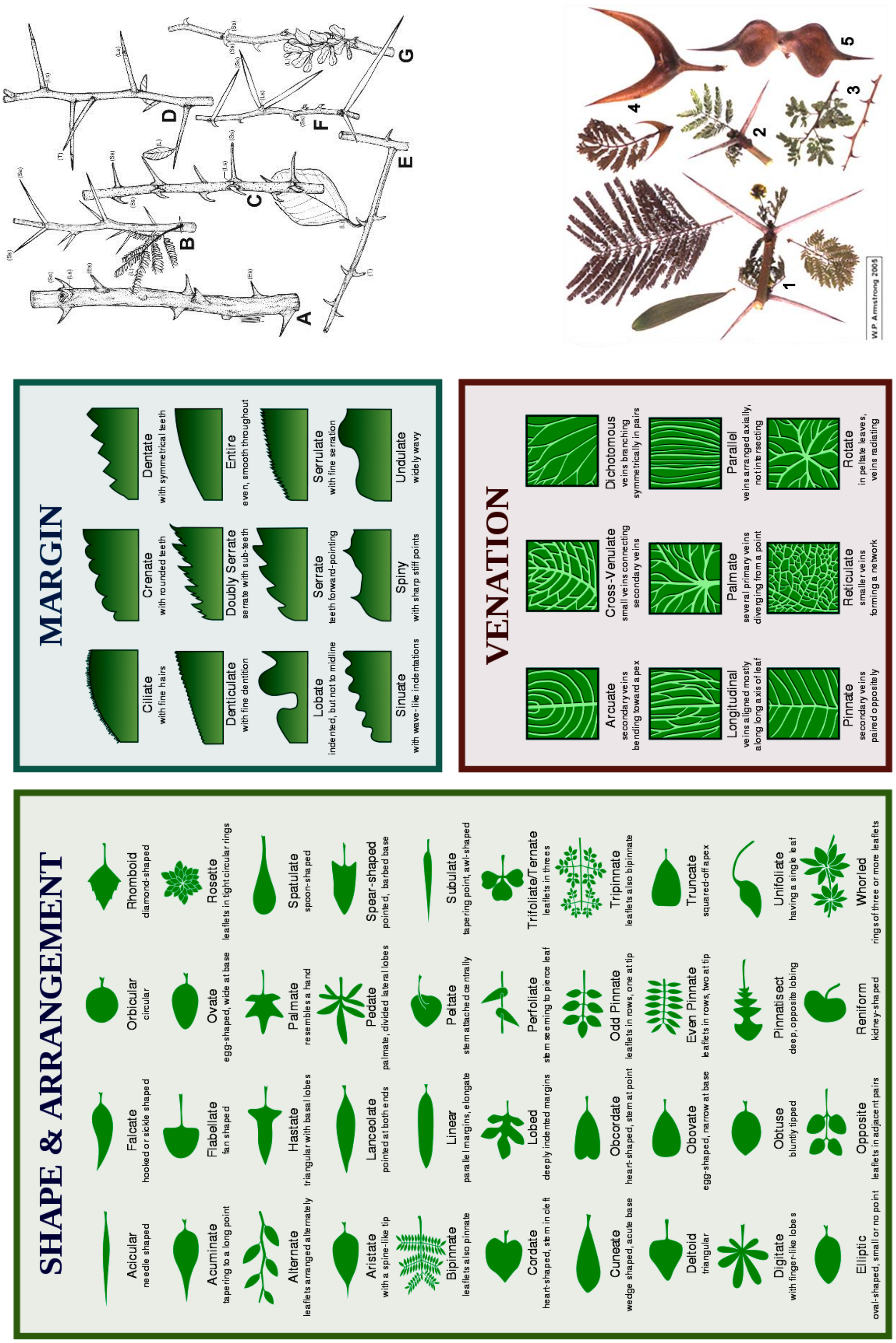


Figure 70 : A description of the thorn and leaf morphology for tree identification and differentiation Types of spines. (A) Prickles: (2 and B) Straight stipular spines: (C) Straight stipular spines and stipular hooks: (1 and D) Straight thorns (E and 3) Hook thorns: (F) Straight stipular spines and stipular hooks:(4 and G) Stipular hooks: Pictures adapted from: left: sciencedendrologyproject.weebly.com, Top-right: Charles-Dominique et al. 2016, bottom right; Armstrong 2005

Appendix 2: List of identified families featuring in wood atlas

Anacardiaceae

They are also known as the mango family. They are mostly trees or shrubs with compound leaves. Theoretically they are expected to contain resinous latex. They have separate female and male species. Species include evergreen and plants like *Loxostylis alata*(Tearwood) or the *Harpephyllum caffrum* (Wild-plum) or deciduous species like the *Lannea discolor* (Live-long tree) and the *Sclerocarya birrea* (Marula).

Burseraceae

Also known as the myrrh family, it is the family only represented by the corkwoods or *Commiphora* species with diverse leaf and bark morphology. The corkwoods are shrubs and trees characterized by their distinctive papery peeling bark and milky or watery sap some of which is aromatic. They are deciduous plants that range in size. Their fruit are spherical fleshy drupes with a hard, sometimes colourful stone that fall away when ripe. Their leaves are simple, compound uni-trifoliate, spirally arranged, grouped at the end of the branchlets and they produce a pungent smell when they are pressed. Species include the Purplestem corkwood *Commiphora multijuga*), Poison-grub corkwood (*Commiphora Africana*), Greenstem corkwood (*Commiphora neglecta*), Glossyleaf corkwood (Commiphora Schimperi), Paperbark corkwood (*Commiphora marlothii*) etc.

Capparaceae

The plants in the caper family all contain mustard oil. Their flowers have four free sepals or petals and numerous stamens with elongated filaments. In Southern Africa, the Capparacae grow in areas of evergreen forest, open woodland, bush, scrub or sand forest. In this family, the ovary is borne on the gynophores, thus the fruit is marked by two sections separated by a scar left both on the receptable and the perianth. The leaves in the Boscia species are in fascicles (tight clusters) along the branch and they are composed of digitately compound leaves with 3-5 leaflets. The Southern African genera found in this group include *Boscia* (Sherpherds tree) *Maerua* (Spider bushes and beadbean trees) *Thilachium* (Cucumber-bush), *Cadaba* (Wormbushes), *Capparis* (Caperbush), *Ritchiea* (Ritcheas), *Bachmannia* (Fingerbush) and *Cladostemom* (Fingerbush).

Combretaceae

The family is made up of the genera *Terminalia* (Clusterleaf) and *Combretum (*Bushwillow), both with winged fruit. The former have leaves in a spiral pattern, often in clusters and the fruit is surrounded by a single wing. They also have branches that deviate from the main shoot. The latter is characterized by opposite leaves and the fruit is usually four-winged. Combretums are the largest members of this family in numbers and they are key components in the bushveld vegetation of Southern Africa. And they are able to survive in poor sandy soils. The genera in this group include the Purple pod Terminalia (*Terminalia prunioides*), the Silver Terminalia (*Terminanlia sericea*), Large fruit bushwillow (*Combretum zeyheri*), Combretum apiculatum, *Combretum imberbe*, *Combretum molle*.

Cucurbitaceae

The gourd or the cucurbits family are mostly climbing or trailing plants with fistular, sometimes woody stems and they have tendrils that aid them in climbing. Their have simple alternate, undivided leaves. These annual or perennial herbaceous plants consist around 975 species and 95 genera. Their root system is sometimes characterised by large tuberous roots. They have unisexual flowers. Seeds are often numerous, often compressed, smooth or variously pitted. Most of the Cucurbitaceae are cultivated and commercial plants but many wil species also occur. The wild species include the genera Cucumis and Citrullus and the most common is the Citrullus ecirrhosus (Tsamma/Kgalagadi melon).

Ebanaceae

Also known as the ebony family, the *Euclea* (Guarri trees) and *Diospyros* (Jackalberries) species in this family usually have opposite leaves that are whorled or sometimes spirally arranged with no stipules. The fruit are tough-skinned berries with a seed that is divided into 3 parts divided by a curved grove in Euclea and ellipsoid shaped with 2 lines joining at the apex in *Diospyros*. Present species include *Euclea pseudebenus* (Ebony tree), *Euclea undulata* (Common guarri) etc. *Diospyros* l*ycioides* (Star-apple), *Diospyros acocksii* (Namaqua Jackal-berry, etc.

Euphorbiaceae

The euphorbia family's main characteristic is the production of milky to watery latex. The' other distinguishing characteristic is the 3 lobed fruit that is crowned by 3 persistent stigmas that can either be dehiscent or indehiscent and fleshy. The genera include among others, different types of *Euphorbia, Spirostachys* and *Croton* species that are found around the study sites.

Fabaceae/Caesalpinaceae

This group is also a legume of pod-bearing nature. They are recognizable by their butterfly-like leaves. They incluse the bauhinia group where we find, the Red bauhinia (*Bauhinia galpinii*), Yellow bauhinia (*Bauhinia tomentosa*), Butteflyleaf (*Adenolobus garipensis*) the Camelsfoot (*Piliostigma thonningii*) etc., the Mopane group that is characterized by the Mopane(*Colophospermum mopane*), Large copalwood (*Guibourtia coleosperma*).

Fabaceae/Mimosoideae

Tree species in this group range from annual and perennial legumes to trees more than 16 metres high. They consist of different groups that are concormitant with the foliage of individual plants. The groups includes, among others the "hook thorn group" with slightly curved spines and twice divided leaves. This group includes the Common hook thorn (*Acacia caffra*), Umbrella thorn (*Acacia tortilis*) , the Flamethorn (*Acacia ataxacantha*) or the Black thorn (*Acacia mellifera*). The "sweet thorn group" on the other hand consist of trees with straight thorns mostly occurring in pairs at each node but can occurring singly. The thorns are usually white and are placed at the base of the leaf. They include the Ana tree (Faidherbia albida), the Sweet thorn (*Acacia Karoo*), the Sicklebush (*Dicrostachys cinerea*) and the Camel thorn (*Acacia erioloba*). The third group is the "False thorn group" which like the previous groups have twice-divided leaves but lacking thorns. Some of the species in this group possess large leaflets with a not so obviously bipinnate. Those in the Mimosoideae group include the Flatcrown (*Albizia adianthifolia*) and the Paperbark albizia (*Albizia tanganyicensis*). Those in the Caesalpinoideae group include the Wild Syringa (*Burkea africana*) and the African wattle (*Peltophorum africanum*). The tree species occur vastly in the savanna and arid northwestern, central and eastern southern Africa.

Olacaceae

The sourplum family presents narrow-winged leaves of the *Olax* and the thorny-branched *Ximenia* groups. They are trees and shrubs that grow from 3 to 7m high. Both genera have simple leaves arranged in the Ximenia group but they are alternate in *Olax*. The fruit in this group is a drupe ranging from 8 mm-2.5 cm depending on the *Olax* species and yellowish/reddish, ellipsoid and measuring 2.5cm for the *Ximenia* species.

Poaceae

Also called the Graminae, this is the grass or the bamboo family of that fall into the class Liliopsida (monocotyledons). These flowering plants' have stems that are hollow except at the nodes, where the leaves attach, and long narrow alternate leaves. The leaves are characterised by parallel veins and comprise a cylindrical sheath that wraps around the stem with the leaf-blade situated above it. The flowers are generally small, and the sepals or petals are not so evident. Of all the worldwide 10 000 species, about 1000 of them have been identified in southern Africa with 300 of them being endemic. The rest have been introduced. A large number of grasses are found in Southern Africa. Even though the majority is found in grasslands, the Poaceae also occur in wetlands, forests and tundra environments. Domesticated poaceae cereals found in Southern Africa include maize, sorghum, millet and sweet reeds and sugarcane. Wild grass uses include building material, food, as well as animal feed.

Rhamnaceae

The Buffalo thorn or jujube group consists of shrubs and trees with glossy leaves and grow up to more than 20m high. The genera in this family include the thorny *Ziziphus* species eg Z. *mucronata* (buffalo thorn) and different *Berchemia* species *eg B.bicolour(*Bird-plum). The fruit are a drupe.

Rubiaceae

The coffee and gardenia family is the largest family of trees in Southern Africa, with more than 10 000 species worldwide. The trees present leaves that are simple and sometimes opposite with entire margins. The leaves are rarely coiled or crisped. The stipules cover the growing tip and are usually interpetiolar. The genera include among others the most recognisable members of this group, i.e the wild medlar group (*Vangueria*) and the genera *Gardenia*.

Tiliaceae

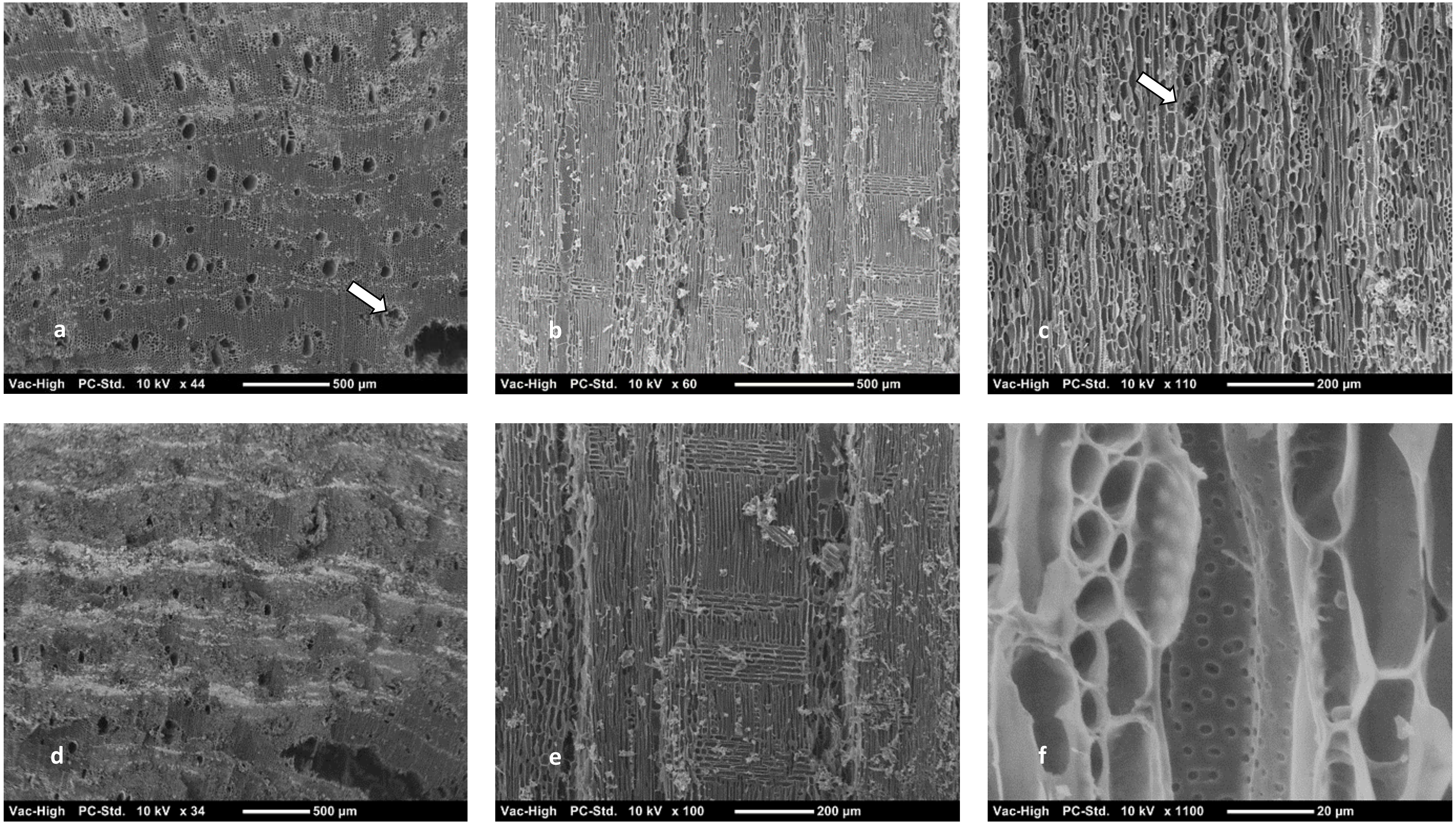
This is the jute and linden family of shrubs and trees that includes several species from the "raisin bush group" notably *Grewia*. The leaves have several veins usually starting from the base, usually hairy and the edible fruit are drupes ranging from thin-fleshed to woody with longitudinal ridges. Species found in the region include Carpodiptera (*Carpodiptera africana*), Glyphaea (*Glyphaea tormentosa*), the Cape stock-rose (*Sparrmannia africana*) and the raisin bushes (*Grewia flava, G. flavescens* , *G.bicolor* etc.)

1 - FABACEAE - *Acacia millifera subsp. detinens*, Swarthaak (Erongo, Namibia)

IAWA Feature Code: 2,4,22,24,41,60,65,79,85,79,85,97,104,112,131,134,136,144,306

***Acacia millifera* tree. Photo: M. Mvimi**

- Growth rings absent
- Wood semi-ring porous
- Simple plate perforations
- Alternate intervessel pits
- Intervessel pit sizes : 4µm
- Simple vessel-ray pits
- Mean tangential diameter vessel lumina: 83µm
- Vascular tracheids
- Paratracheal vasicentric parenchyma
- Banded/Confluent parenchyma(aliform in some areas)
- 1-2 seriate wide
- All rays procumbent(e)
- Slightly simply perforated ray cells
- Intercellular canal(mostly present in the cross section)
- Possible included phloem
- Resin canals also present
- Prismatic crystals in ray, fibre and parenchyma cells
- Druses present
- Crustal diameter: 14µm
- Crystal height:20µm
- Crystals are present in long horizontal chains associated with parenchyma in the transversal
- Crystals also in radial multiples in the tangential side
- Septate fibres present
- Lowest ray cells at 4 cells high
- Highest cells at 14 cells high
- Included phloem



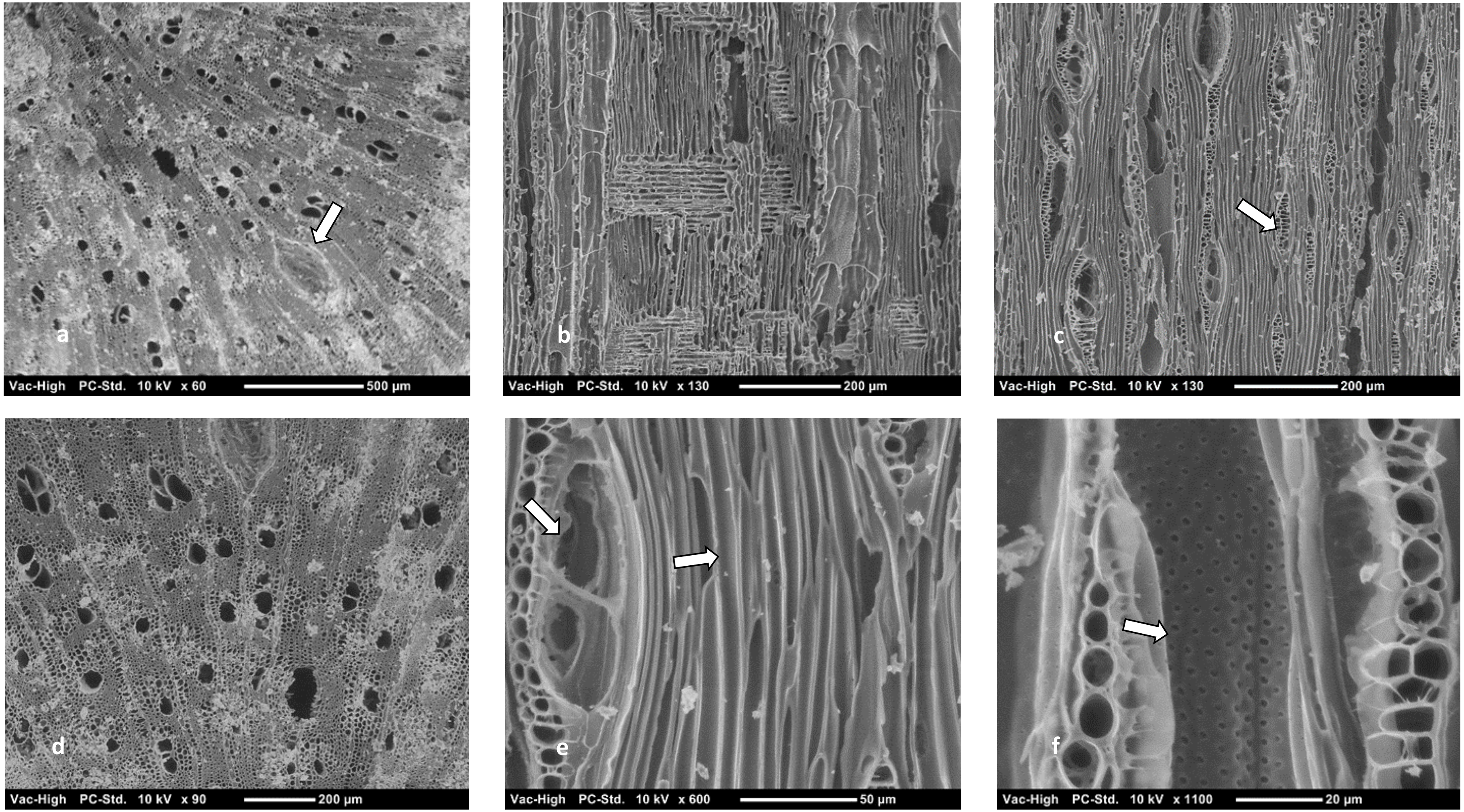
a and d: transversal, b and e: radial, c and f: tangential

2 - FABACEAE - *Acacia robusta* (Burch) (Southeastern Botswana)

IAWA Feature Code: 2,4,9,24,13,30,36,40,66,69,83,97,130,106

- Wood semi-ring porous
- Vessels solitary, in pairs or in aggregates of 3
- Simple plate perforations
- Alternate intervessel pits(f)
- Vessel ray pits similar to intervessel pitting
- Helical thickenings present
- Mean tangential diameter vessel lumina: 50µm
- Intervessel pit size= 2µm
- Non –septate fibres present
- Medium fibre walls
- Paratracheal confluent axial parenchyma
- 1-3 seriate
- Rays with scalariform pattern in tangential section
- Rays up to 60 cells high
- Shorter rays 6 cells high
- Resin canals present(round shape appearance)(e)
- Body rays cells procumbent with one row of upright cells

***Acacia robusta* tree. Photo: http://powo.science.kew.org**

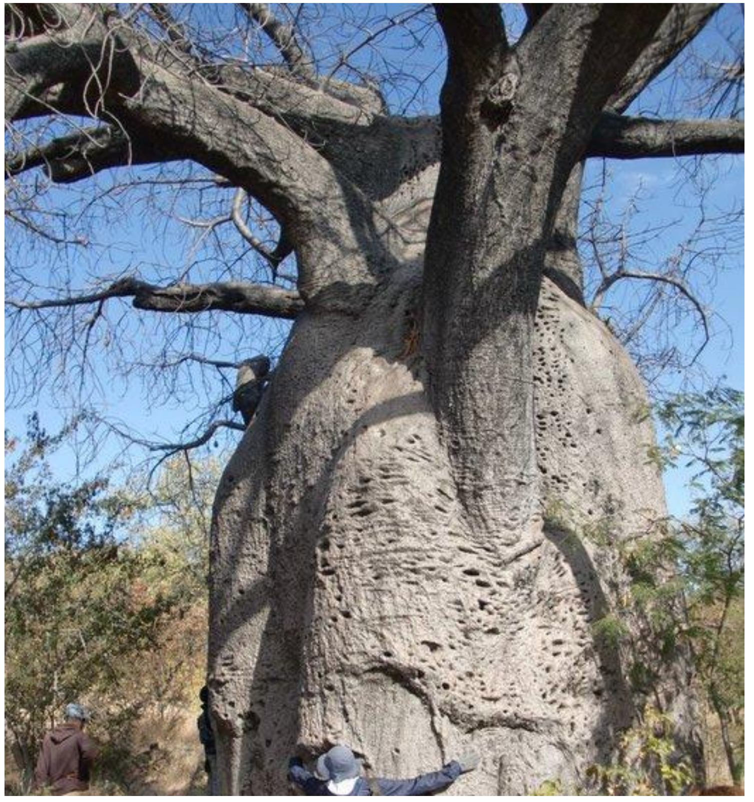


a and d: transversal, b and e: radial, c and f: tangential

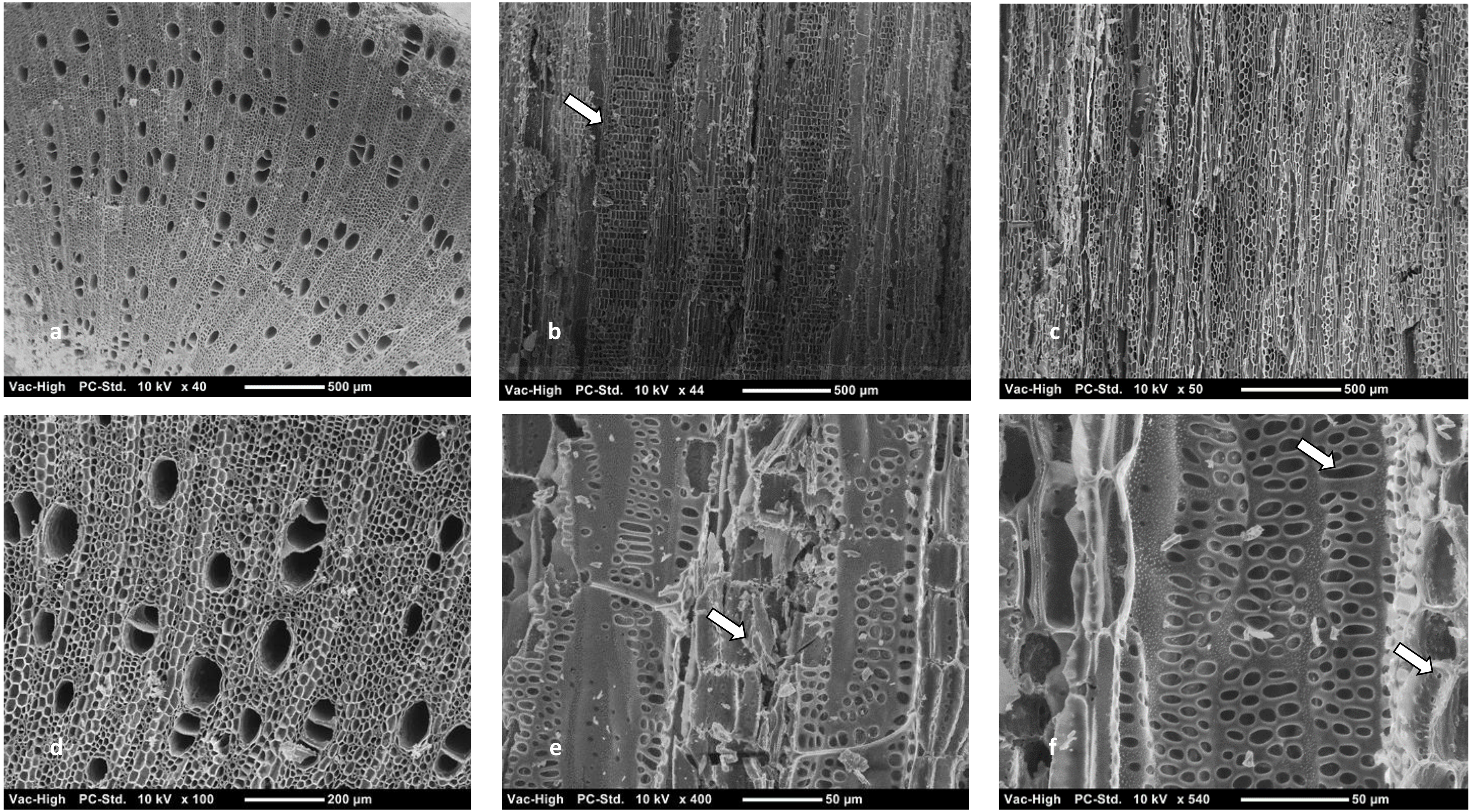
3 - BOMBACACEAE - *Adansonia digitata* L. (Northwestern Botswana)

IAWA Feature Code: 4,9,22,27,41,56,60,65,69,77,112,105,65

- Wood semi ring porous
- Vessels solitary or in multiples of up to 4
- Simple plate perforations
- Alternate intervessel pitting of 2 sizes
- Intervessel pitting large and round to oval(17µm)
- Intervessel pitting almost scalariform
- Large - >= 10 µm intervessel pits (f)
- Mean tangential diameter vessel lumina: 67µm
- Vascular tracheids present
- Fibres thin to thick walled
- Tyloses common(e)
- Apotracheal parenchyma-parenchyma in aggregates
- Simple pitted ray cells
- Rays 1-3 seriate(c)
- All ray cells upright/and or square
- Axial parenchyma quasi-storied
- Septate fibres present



***Adansonia digitata*. Photo: M. Mvimi**



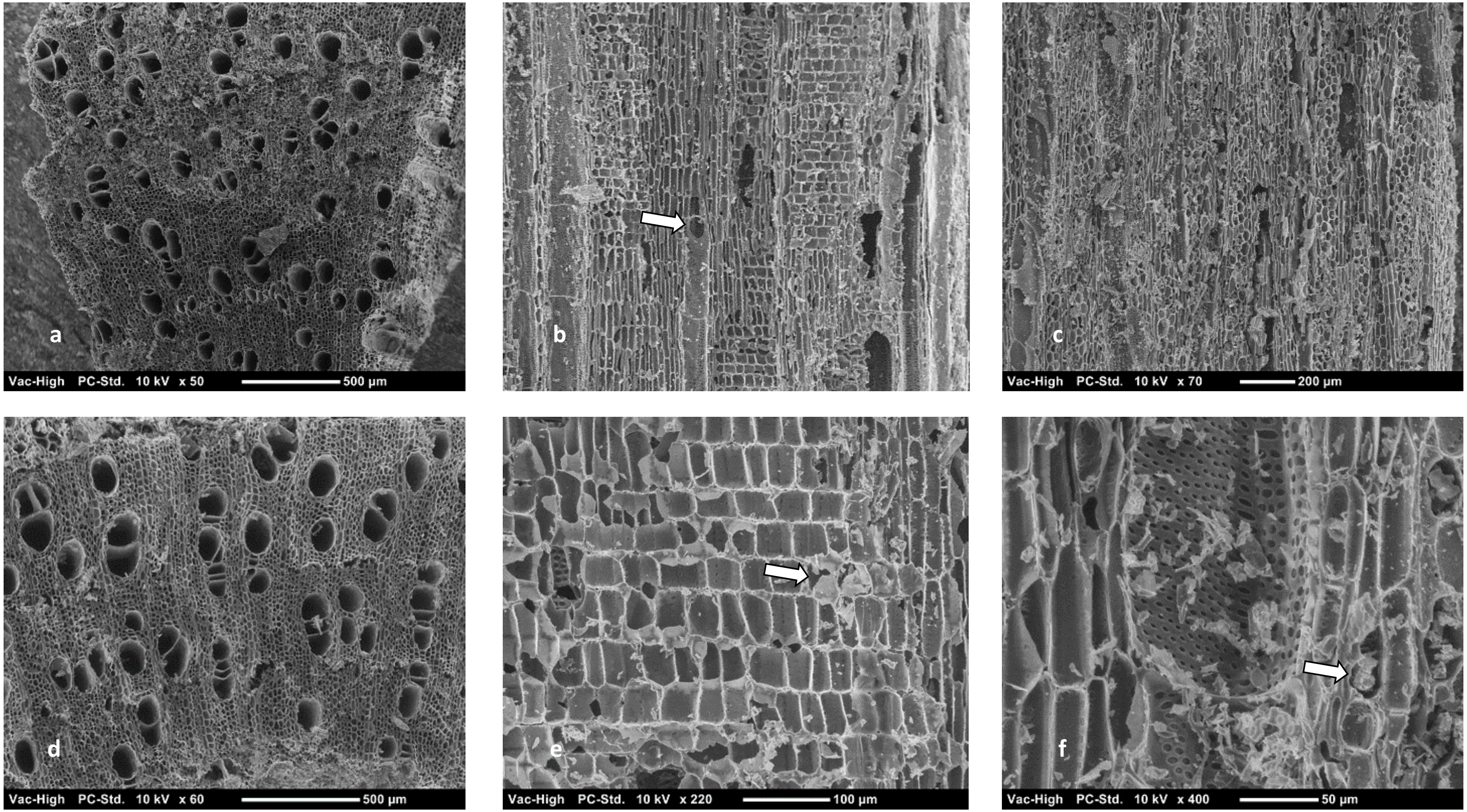
a and d: transversal, b and e: radial, c and f: tangential

4 – MALVACEAE - *Azanza garckeana* (F.Hoffm.) Exell & Hillcoat (Southeastern Botswana)

IAWA Feature Code: 2,5,10,13,22,50,42,60,65,69,76,97,105,112,124

- Growth rings absent
- Wood diffuse porous
- Vessels solitary, in pairs or in radial multiples of 3
- Simple plate perforations(b)
- Intervessel pitting alternate
- Mineral residues in intervessel pits(medium 7-10µm)
- Vessel-ray pits similar to intervessel pitting
- Helical thickenings absent
- Mean tangential diameter vessel lumina: 100-200µm
- Vascicentric tracheids
- Fibres with thick to thin walls
- Septate fibres present (e)
- Diffuse axial parenchyma
- 1-3 seriate
- All ray cells upright and/or square cells
- Perforated ray cells
- Storied axial parenchyma
- Oil and/mucilage cells in intervessel pits

Photo : ***Azanza garckeana*** (Ochokwu and Oshoke, 2015)



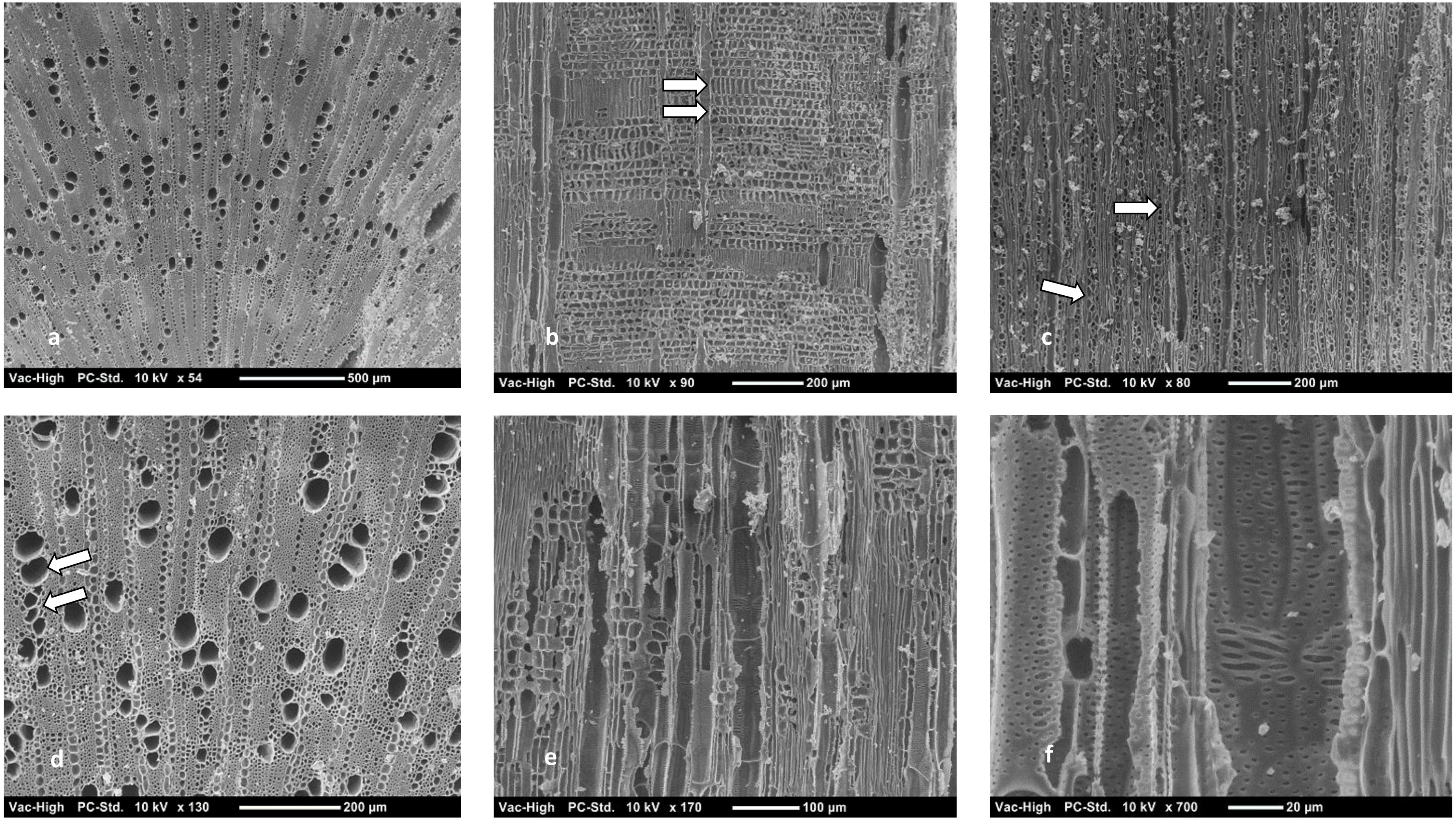
a and d: transversal, b and e: radial, c and f: tangential

5 – FABACEAE - *Adenolobus garipensis* (E.Mey.) Torre & Hillc.
(Erongo, Namibia)

IAWA Feature Code: 1,5,8, 11,13,21,30,40,65,69,78,97,103,109,115,136,144

- Growth rings present
- Wood diffuse porous
- Rays in a dentritic arrangement
- Mean tangential diameter vessel lumina: 50µm
- Vessels solitary and also in short and long radial clusters of 2-5
- Simple plate perforations
- Storied ray structure in transversal side
- Intervessel pits opposite , elongated and quasi-scalariform in some areas (>10µm)
- Intervessel pits of 2 distinct sizes
- Vessel-ray pitting similar to intervessel pitting
- Vessels of 2 distinct diameters (d)
- Fibres medium to thick walled
- Septate fibres present
- Axial parenchyma scanty paratracheal
- 1-2 seriate rays
- A combination of both procumbent and square ray cells
- Rays of two distinct sizes (c)
- Idioblasts present in rays
- Druses in ray cells
- Tyloses in vessels
- Aggregate vessel structures(f)
- Long rays up to 26 cells high
- Shortest rays at ± cells high
- Rays with both uni and bi or tri seriate cells present
- Minutely pitted interray cells

***Adenolobus garipensis*. Photo: M. Mvimi**



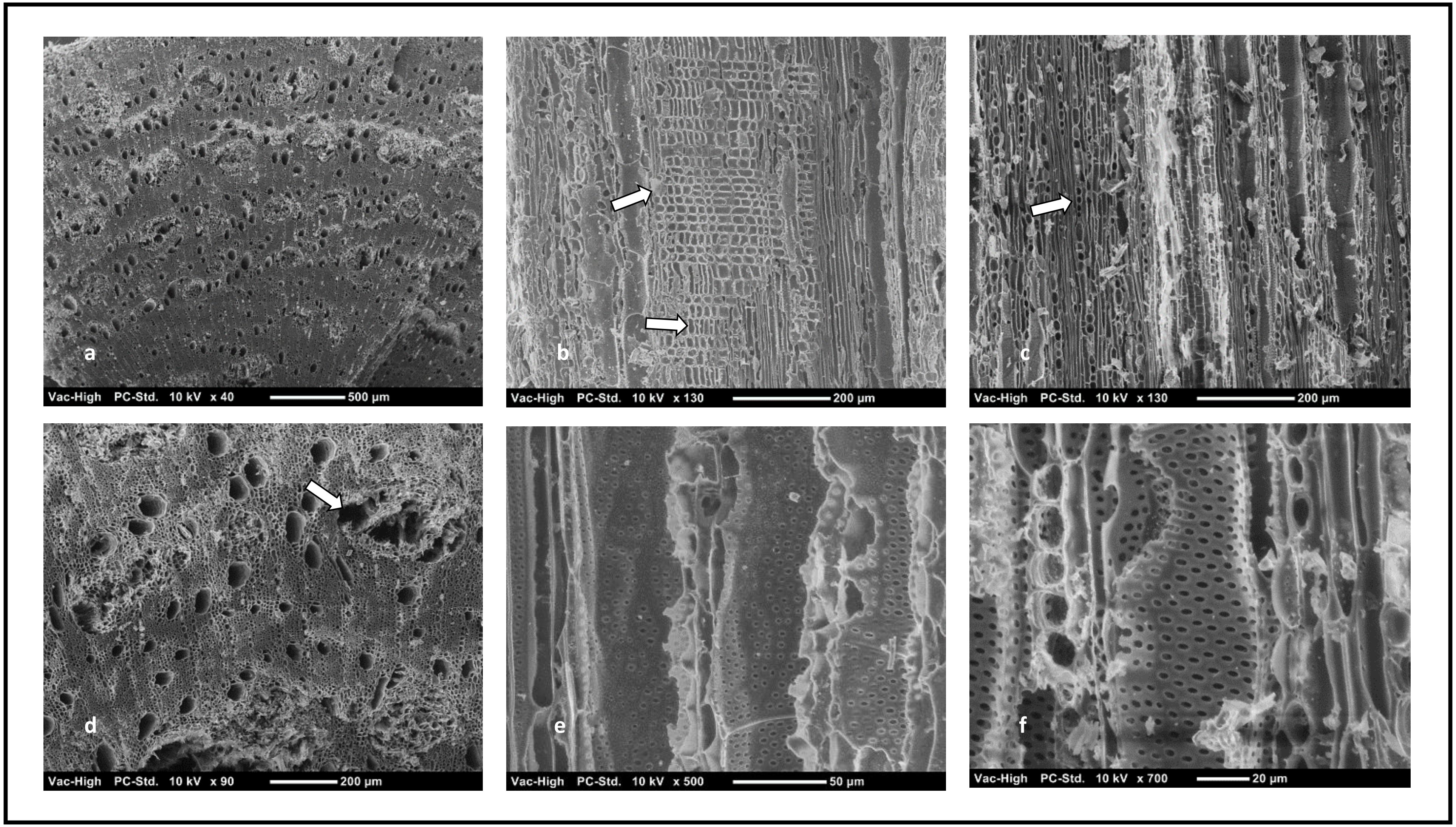
a and d: transversal, b and e: radial, c and f: tangential

6 – COMBRETACEAE - *Combretum apiculatum* subsp. *boreale* Exell (South-eastern Botswana)

IAWA Feature Code: 1,3,8,9,13,22,30,41,79,85,96,133,136

- Growth ring boundaries distinct
- Wood ring porous
- Vessels in dentritic form
- Vessels < 90% solitary
- Both procumbent and upright ray cells
- Simple perforation plates
- Alternate intervessel pitting (oval shaped)
- Spiral thickenings in fibres
- Vessel-ray pitting similar to intervessel pitting
- Mean tangential diameter vessel lumina: 80µm
- Large crystals in fibres and in ray cells
- Idioblasts in fibre cells
- Crystal diameter: 40µm
- Rays exclusively uniseriate
- Included phloem(d)
- Axial parenchyma paratracheal and vascicentric
- Axial parenchyma banded

Combretum apiculatum. **Photo: M. Mvimi**



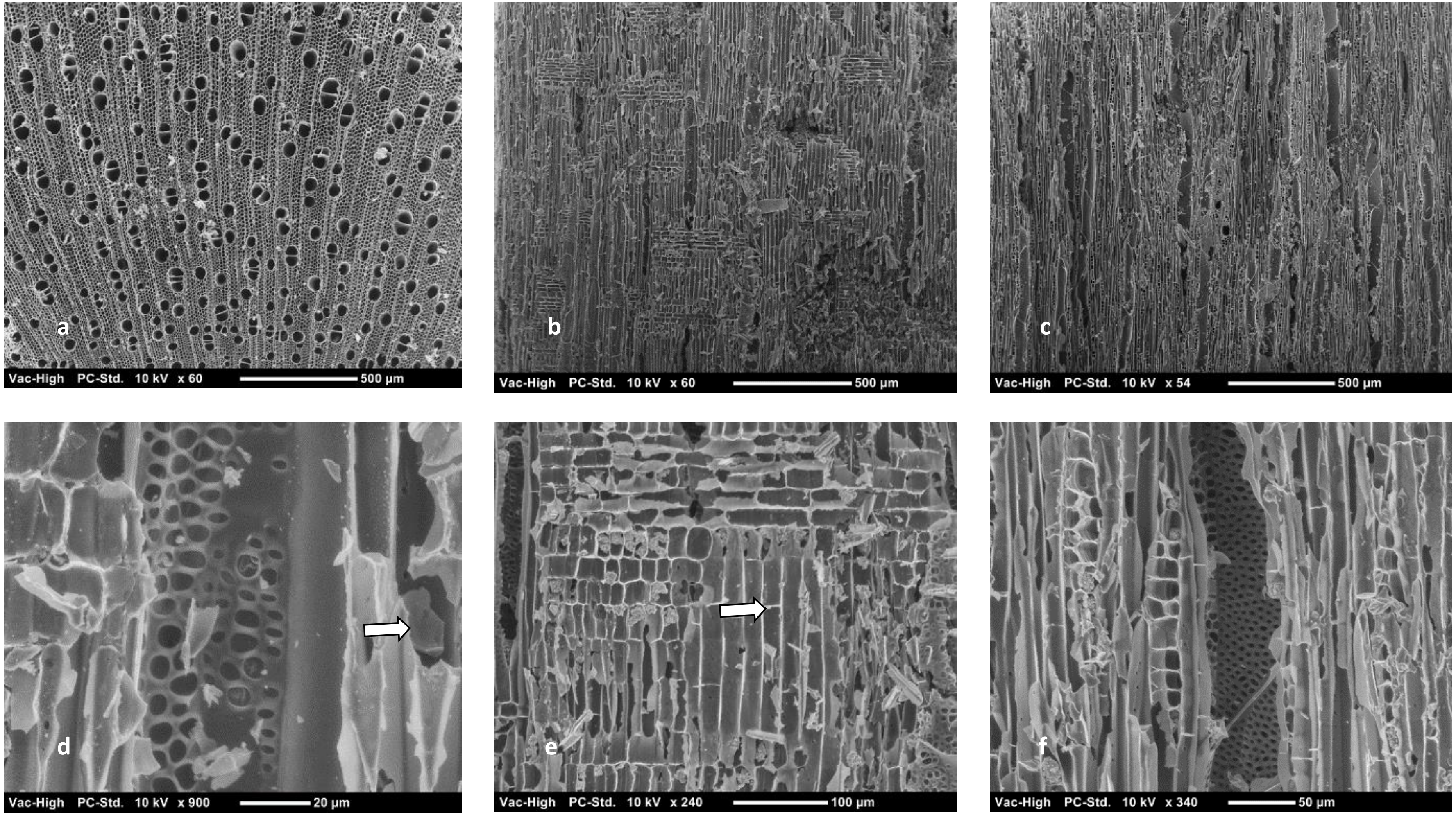
a and d: transversal, b and e: radial, c and f: tangential

7 – BURSERACEAE - *Commiphora glandulosa* Schinz (South-eastern Botswana)

IAWA Feature Code: 2,5,9,13,21,25,26,30,41,65,68,76,99,109,144

- Growth ring boundaries absent
- Wood diffuse porous
- Diffuse axial parenchyma
- Vessels rarely solitary, in pairs, or in small radial groups
- Simple plate perforations
- Opposite intervessel pits
- Small to medium intervessel pits
- Intervessel pits 8µm
- Vessel ray pitting similar to intervessel pitting
- Druses present in rays
- Very thin fibre cells
- Both square and upright ray cells
- Resin canals present
- Rays 1-3 seriate
- Uniseriate rays up to ± 21 rays high
- Shortest rays at 4 cells high
- Minutely pitted parenchyma cells
- Mean tangential diameter vessel lumina: 67µm
- Septate fibres present

Commiphora glandulosa. **Photo M.Mvimi**



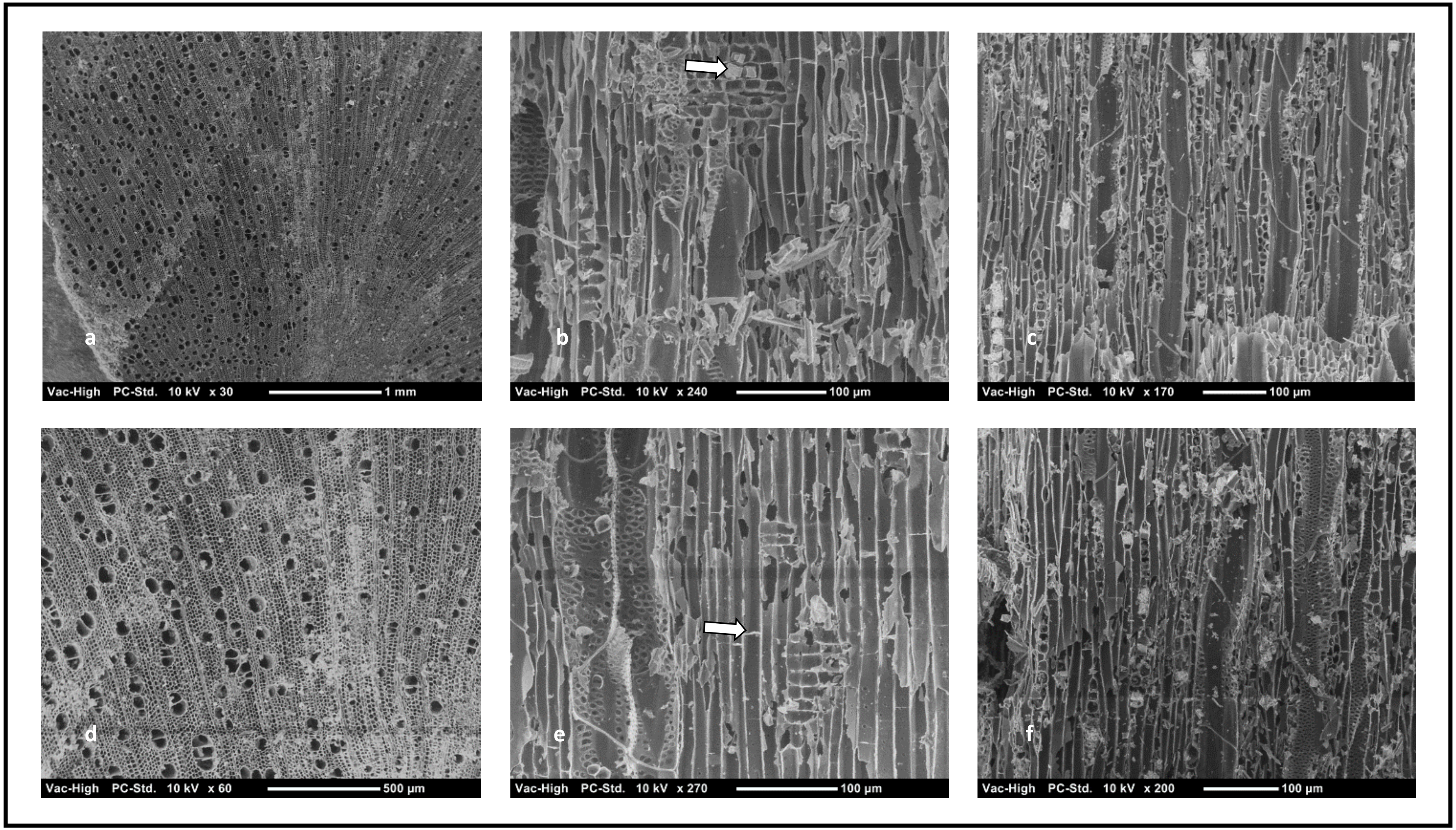
a and d: transversal, b and e: radial, c and f: tangential

8 – BURSERACEAE - *Commiphora mossambicensis* Engl. *(*North-western Botswana)

IAWA Feature Code: 2,5,13,27,36,41,65,68,97,102,109,130,144

- Growth ring boundaries absent
- Wood diffuse porous
- 1-2 seriate
- Simple perforation plates
- Mean tangential diameter vessel lumina: 71µm
- Druses in ray cells
- Crystals present in ray cells
- Large intervessel pits ≤ 11µm
- Highest rays at 13 cells high
- Shortest rays at 3 cells high
- Uniseriate rays generally shorter than multiseriate rays
- Cupresoid shaped intervessel pits
- Very thin fibre cells
- Septate fibres present
- Both upright and procumbent ray cells
- Minutely simple pitted parenchyma ncells
- Resin canals present

Commiphora mossambicensis. **Photo: https://www.zimbabweflora.co.zw**



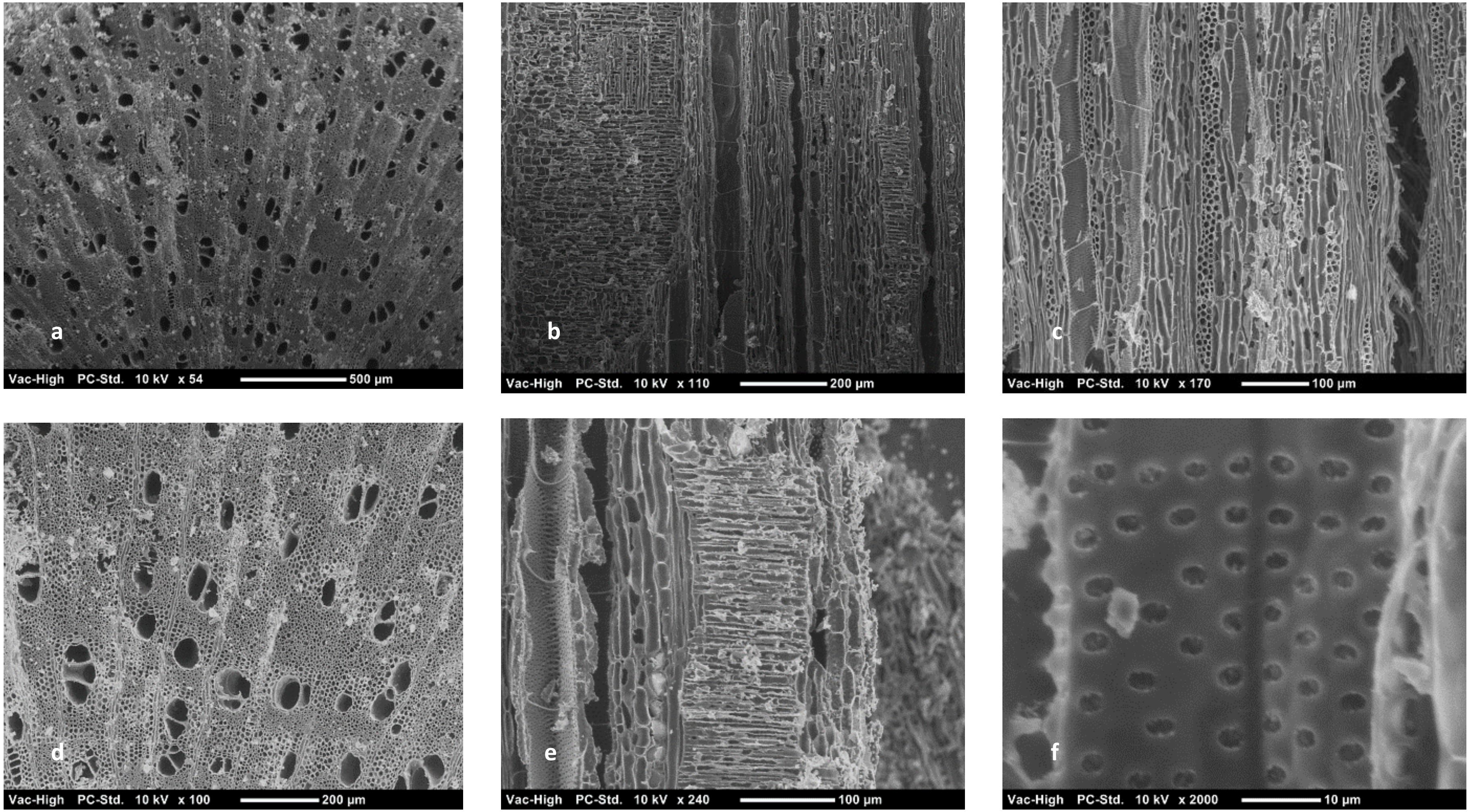
a and d: transversal, b and e: radial, c and f: tangential

9 – FABACEAE - *Dichrostachys cinerea* (L.) Wight & Arn (Erongo, Namibia)

IAWA Feature Code: 2,5,9,10, 13,22,24,41,47,53,56,61,65,79,83,97,102,104,115,136,142

- Growth rings present
- Wood diffuse porous
- Rays in a dentritic arrangement
- Mean tangential diameter vessel lumina: 50µm
- Vessels solitary and also in short and long radial clusters of 2-5
- Simple plate perforations
- Storied ray structure in transversal side
- Intervessel pits opposite , elongated and quasi-scalariform in some areas (>10µm)
- Intervessel pits of 2 distinct sizes
- Vessel-ray pitting similar to intervessel pitting
- Vessels of 2 distinct diameters
- Fibres medium to thick walled
- Septate fibres present
- Axial parenchyma scanty paratracheal
- 1-2 seriate rays
- A combination of both procumbent and square ray cells
- Idioblasts present in rays
- Druses in ray cells
- Tyloses in vessels
- Aggregate vessel structures
- Long rays up to 26 cells high
- Shortest rays at ± cells high
- Rays with both uni and bi or tri seriate cells present
- Minutely pitted interray cells

***Dichrostachys cinerea*. Photo: M. Mvimi**



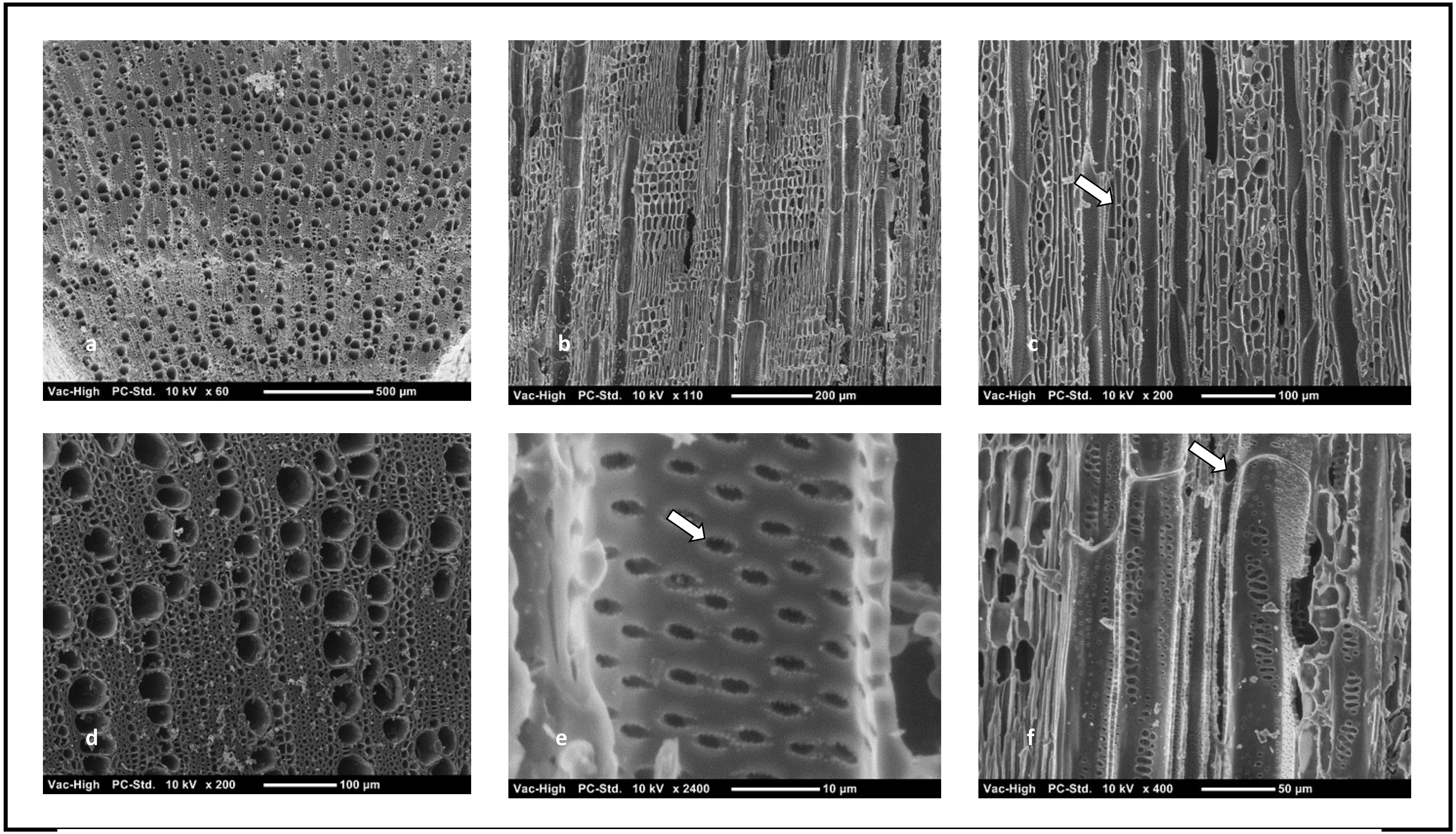
a and d: transversal, b and e: radial, c and f: tangential

10 - STERCULIACEAE - *Dombeya rotundifolia* Planch. (South-eastern Botswana)

IAWA Feature Code: 2,5,8,10,13,26,50,52,65,70,78,97,108,114

- Growth ring boundaries indistinct or absent
- Wood diffuse-porous
- Vessels in dentritic pattern
- Vessels in radial multiples of 4 or more common
- Solitary vessel outline circular
- Mean tangential diameter vessel lumina: <= 50 µm
- Simple plate perforations (f)
- Intervessel pits of 2 distinct sizes: opposite , and quasi-scalariform
- Intervessel pits medium: 7-10µm
- >= 100 vessels per square millimetre
- Mean vessel element length : <= 350 µm
- Septate fibres present
- Fibres very thick-walled
- Axial parenchyma scanty paratracheal
- Ray width 1 to 3 cells
- Ray height > 1 mm
- Body ray cells procumbent with over 4 rows of upright and / or square marginal cells
- <= 4 / mm rays per millimetre

Dombeya rotundifoliai. **Photo: M. Mvimi**



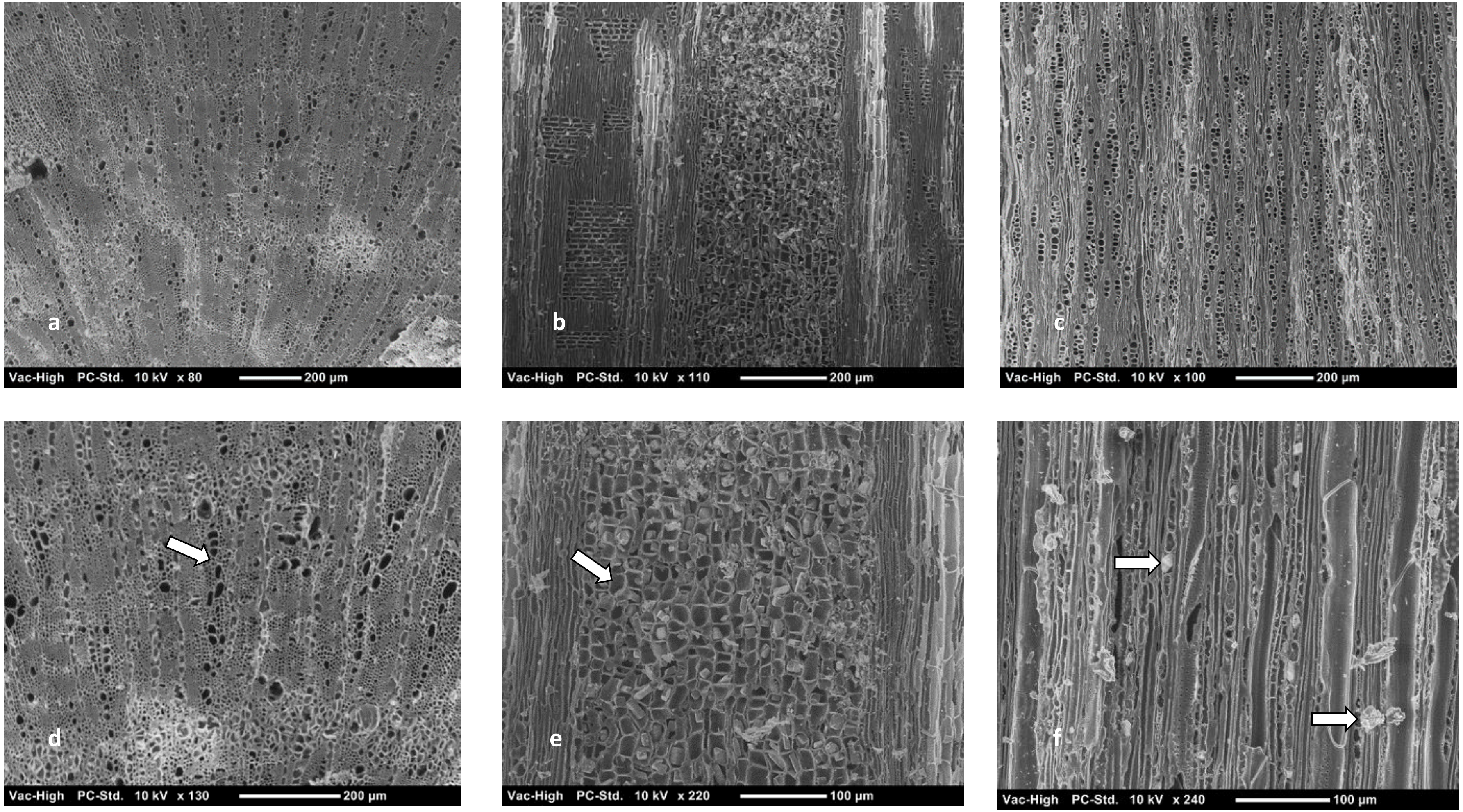
a and d: transversal, b and e: radial, c and f: tangential

11 – CAPPARACEAE - *Boscia foetida* Schinz. (Erongo,Namibia)

IAWA Feature Code: 1,4,10,11,13,22,24,41,50,52,58,61,65,69,85,86,97,102,104,115,137,144

- Growth ring boundaries distinct
- Vessels in dentritic pattern
- Vessel clusters common
- Vessels in radial multiples of 4 or more common
- Simple perforation plates (f)
- Intervessel pits alternate
- Intervessel pits minute: <=4 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- Gums and other deposits in heartwood vessels
- Fibres with simple to minutely bordered pits
- Septate fibres present
- Fibres thin- to thick-walled
- Axial parenchyma bands more than three cells wide
- Axial parenchyma in narrow bands or lines up to three cells wide
- Ray width 1 to 2 cells
- Ray height : >1mm
- All ray cells procumbent
- Rays :4-12 / mm
- >= 100 vessels per square millimetre
- Mean vessel element length : <= 350µm
- Prismatic crystals in upright and / or square ray cells
- Druses present

***Boscia foetida*. Photo: M. Mvimi**



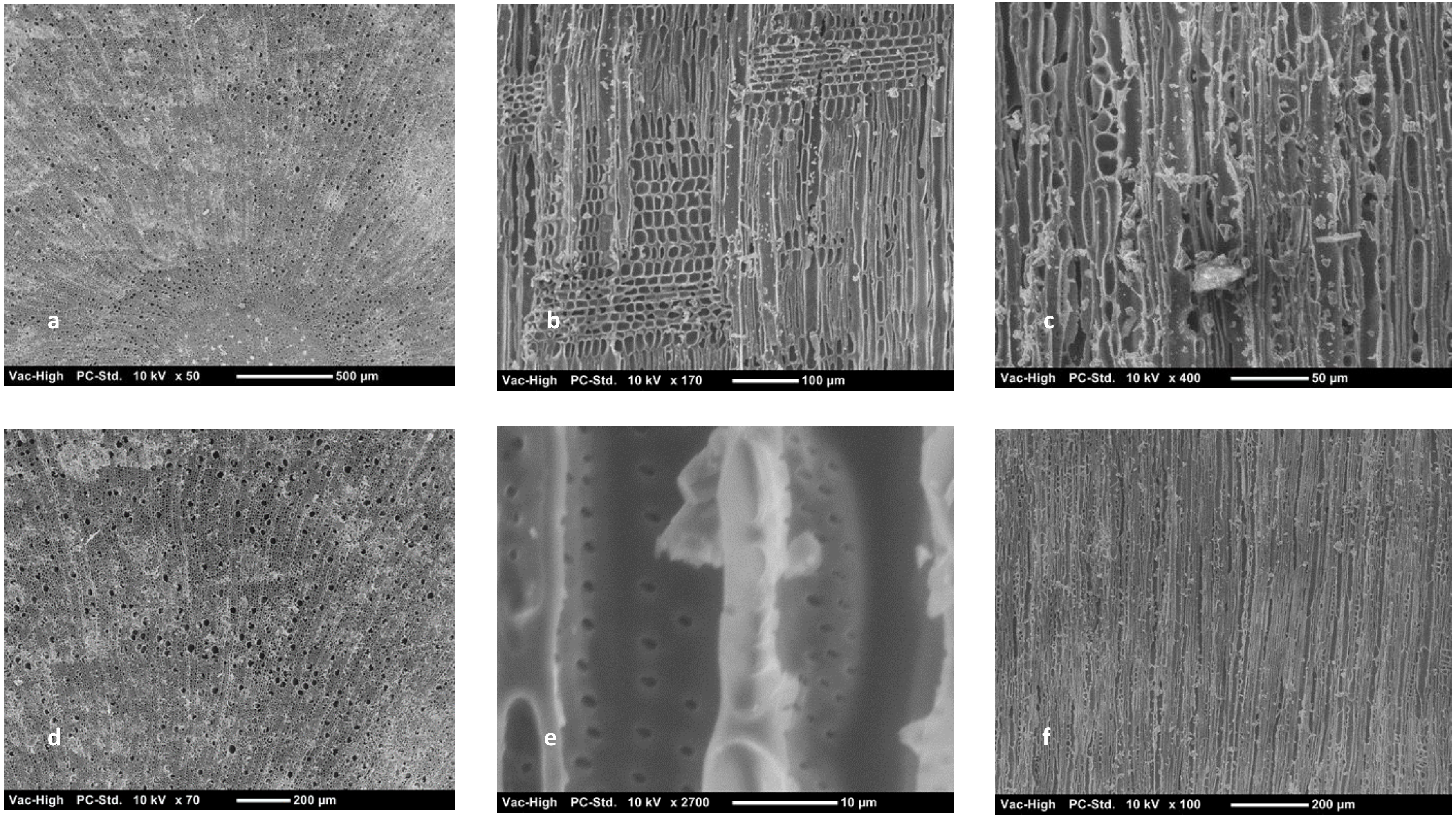
a and d: transversal, b and e: radial, c and f: tangential

12 – RUBIACEAE - *Gardenia volkensii* K.Schum (South-eastern Botswana)

IAWA Feature Code: 2,5,9,13,22,24,41,47,58,61,65,68,96,133,137,144

- Growth ring boundaries indistinct or absent
- Vessels exclusively solitary (90% or more)
- Simple perforation plates (f)
- Intervessel pits alternate
- Intervessel pits minute: <=4 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- Gums and other deposits in vessels and fibres
- Fibres with simple to minutely bordered pits
- Septate fibres absent
- Fibres thin-walled
- Axial parenchyma absent or extremely rare
- Rays exclusively uniseriate
- Ray height : >1mm
- Body ray cells procumbent with over 4 rows of upright and / or square marginal cells
- Rays : <=4-12 / mm
- 5-20 vessels per square millimetre
- Mean vessel element length : <= 350µm
- Prismatic crystals in upright and / or square ray cells
- Druses present
- Included phloem

Gardenia volkensii. **Photo: http://pza.sanbi.org**



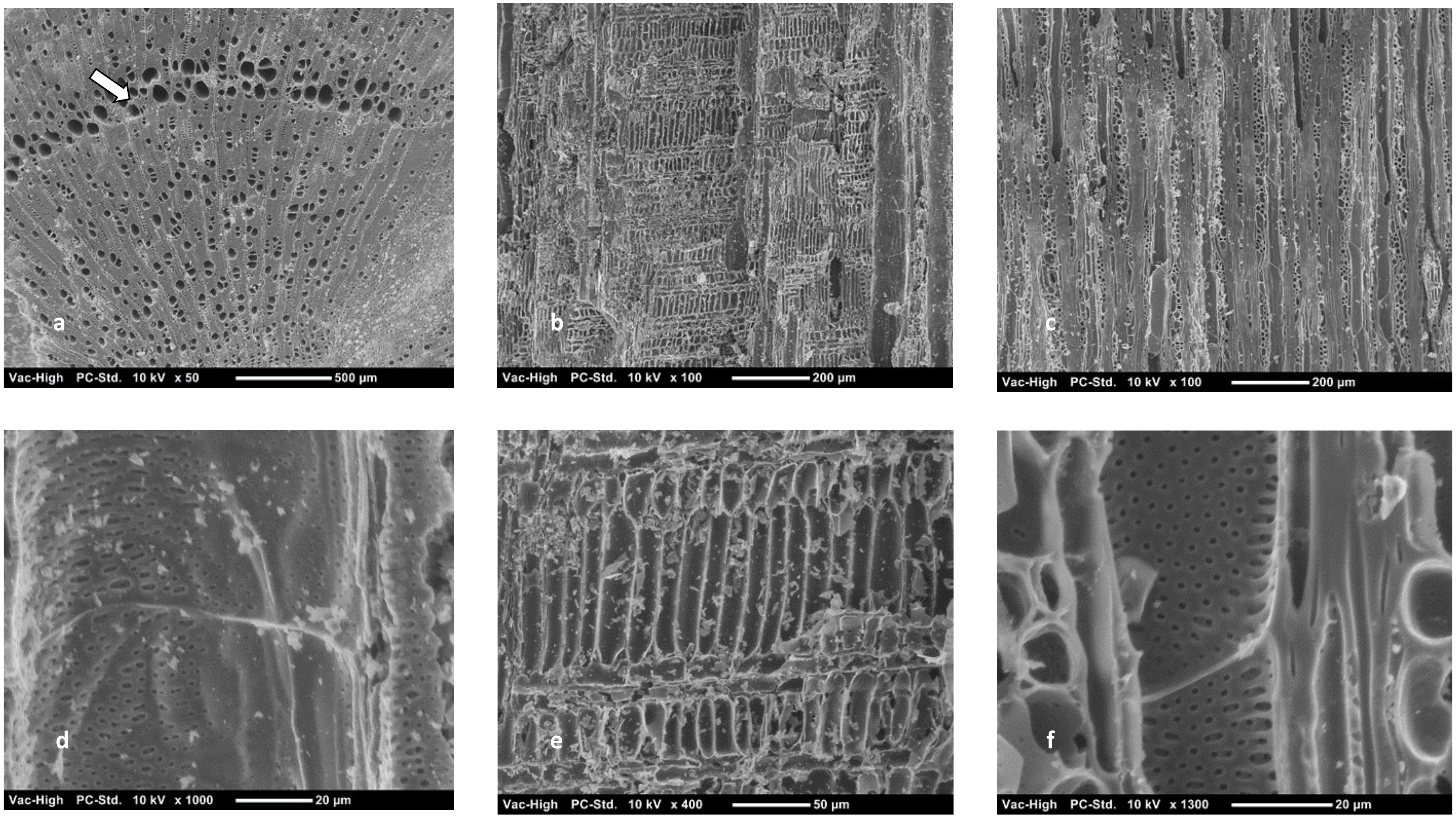
a and d: transversal, b and e: radial, c and f: tangential

13 – TILIACEAE - *Grewia flava* DC. (South-eastern Botswana)

IAWA Feature Code: 1,3,11,13,22,25,41,50,52,58,69,75,97,102,109,115

- Growth ring boundaries distinct (a)
- Vessel clusters common
- Simple perforation plates (f)
- Intervessel pits alternate
- Intervessel pits small - 4 - 7 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- Gums and other deposits in heartwood vessels
- Fibres thin-to thick-walled
- Axial parenchyma absent or extremely rare
- Ray width 1 to 3 cells
- Ray height : >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Rays :4-12 / mm
- >= 100 vessels per square millimetre
- Mean vessel element length : <= 350µm

***Grewia flava*. Photo: M. Mvimi**

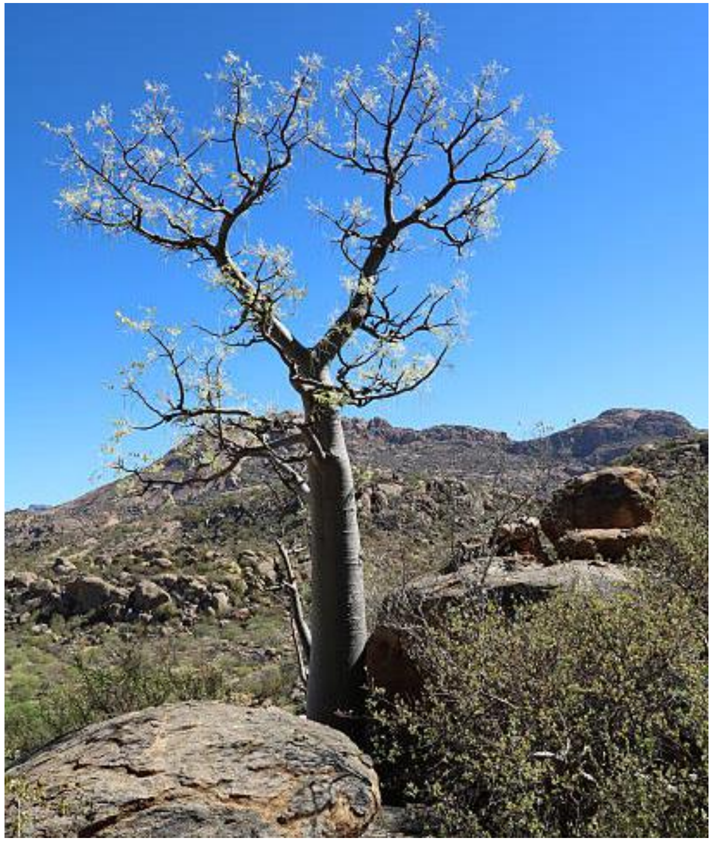


a and d: transversal, b and e: radial, c and f: tangential

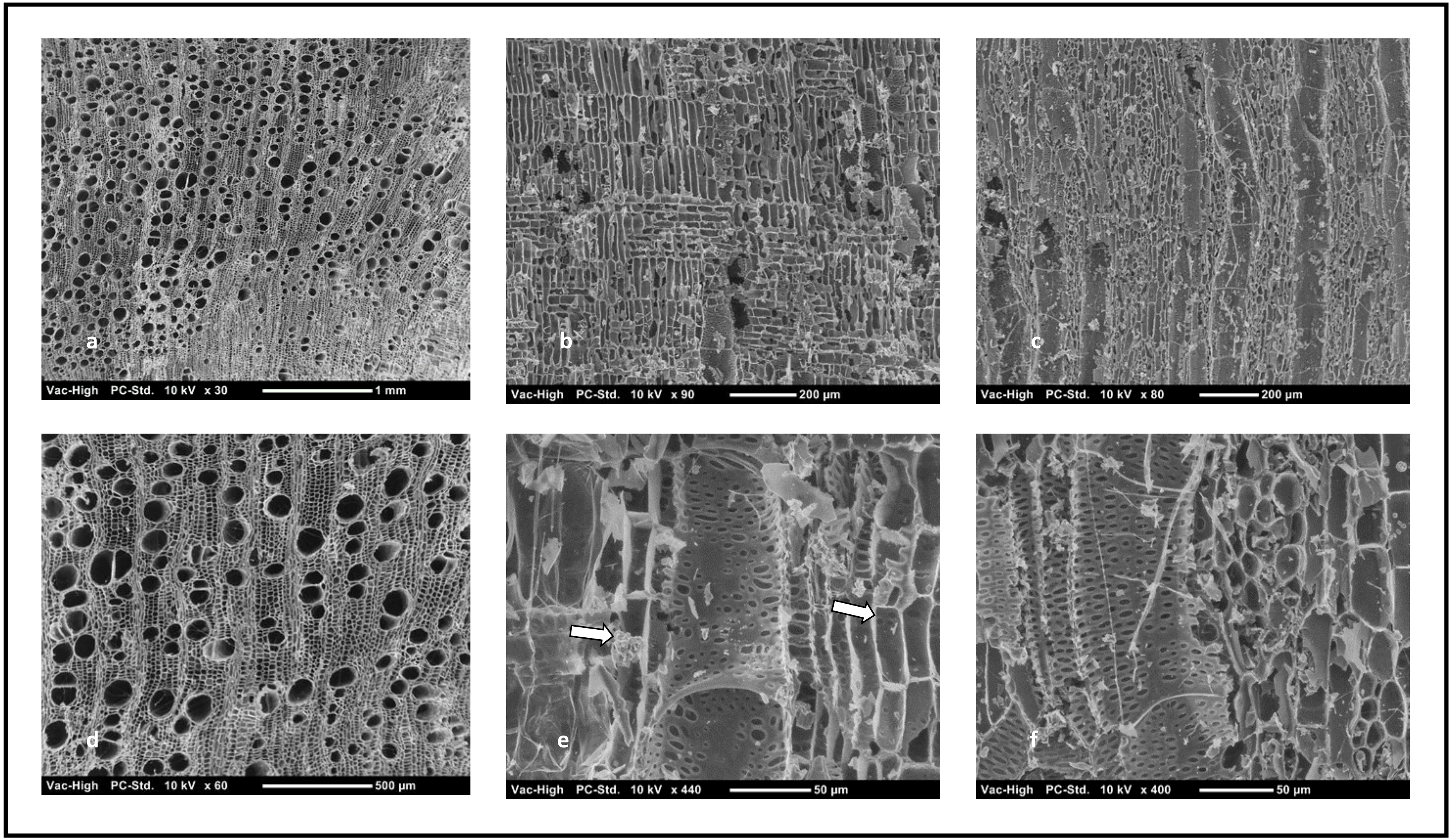
14 – MORINGACEAE - *Moringa ovalifolia* Denter&Berger (Erongo mountains)

IAWA Feature Code: 2,9,13,22,24,41,47,54,58,61,78,96,102,108,115,144

- Growth ring boundaries indistinct or absent
- Vessels exclusively solitary (90% or more)
- Simple perforation plates
- Intervessel pits alternate
- Intervessel pits minute: <=4 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- Gums and other deposits in parenchyma and fibre cells
- Fibres with simple to minutely bordered pits
- Fibres thin-walled
- Axial parenchyma absent or extremely rare
- Rays exclusively uniseriate
- Ray height : >1mm
- Body ray cells procumbent with over 4 rows of upright and / or square marginal cells
- Rays : <=4-12 / mm
- 5-20 vessels per square millimetre
- Mean vessel element length : <= 350µm
- Druses present



***Moringa ovalifolia*. Photo: https://www.istockphoto.com**

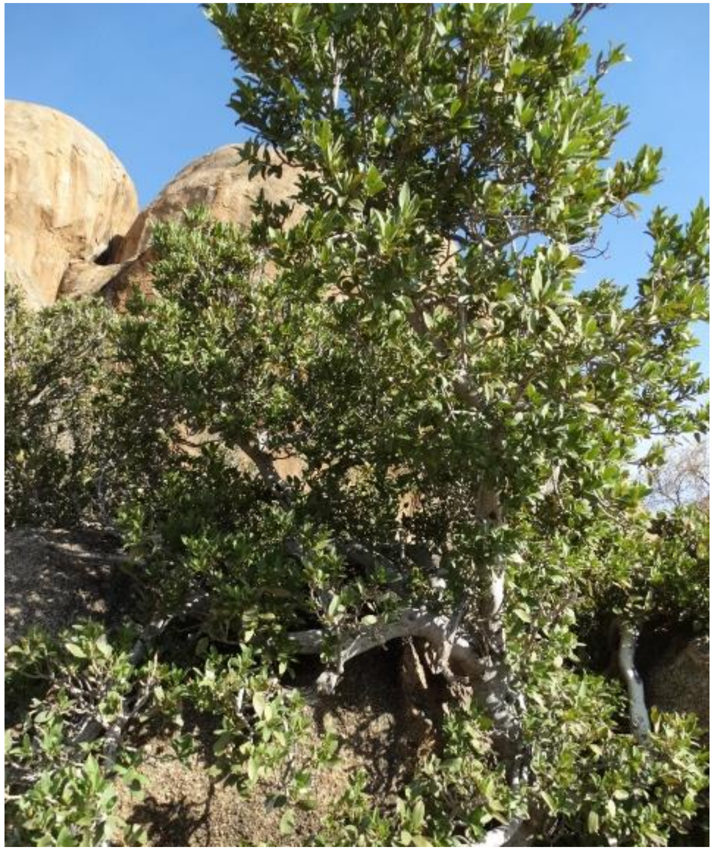


a and d: transversal, b and e: radial, c and f: tangential

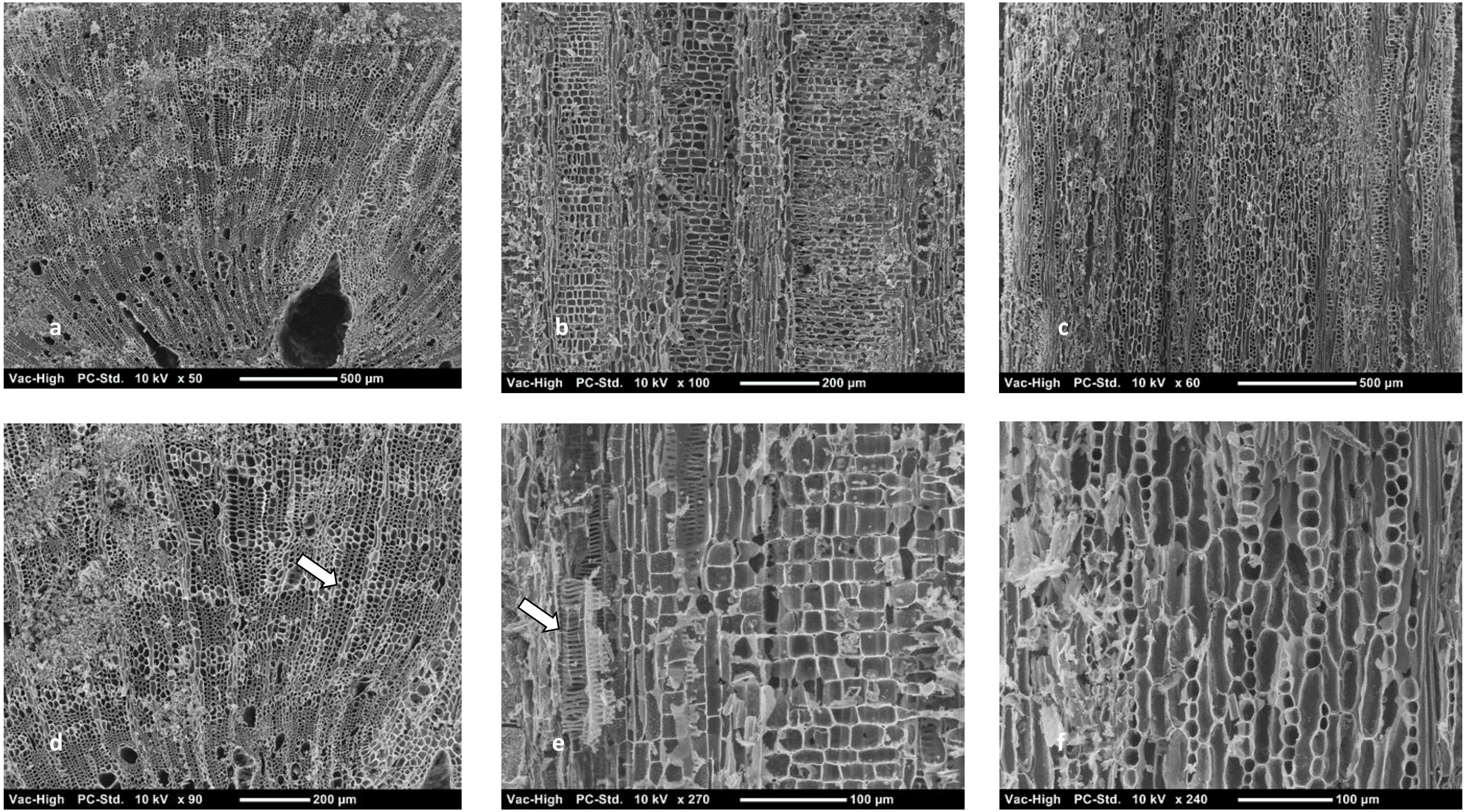
15 – SAPOTACEAE - *Sideroxylon inerme* L. (South-eastern Botswana)

IAWA Feature Code: 2,11,14,41,47,58,65,68,76,85,92,85,92,97,109,115,144

- Growth ring boundaries indistinct or absent
- Nested-vessel pattern
- Vessel clusters common
- Simple perforation plates
- Intervessel pits scalariform
- Mean tangential diameter of vessel lumina: 50-100µm
- Mean tangential diameter of nested vessels: 100µm
- 5-20 vessels per square millimetre
- Fibres thin-walled
- Axial parenchyma diffuse
- Axial parenchyma bands more than three cells wide
- Four (3-4) cells per parenchyma strand
- Banded axial parenchyma present
- Ray width 1 to 3 cells
- Rays of two distinct sizes(c and f)
- Rays with procumbent, square and upright cells mixed throughout the ray
- Rays :4-12 / mm
- Septate fibres absent
- Druses present
- Gums and other deposits in parenchyma and fibre cells



Sideroxylon inerme. **Photo: M. Mvimi**



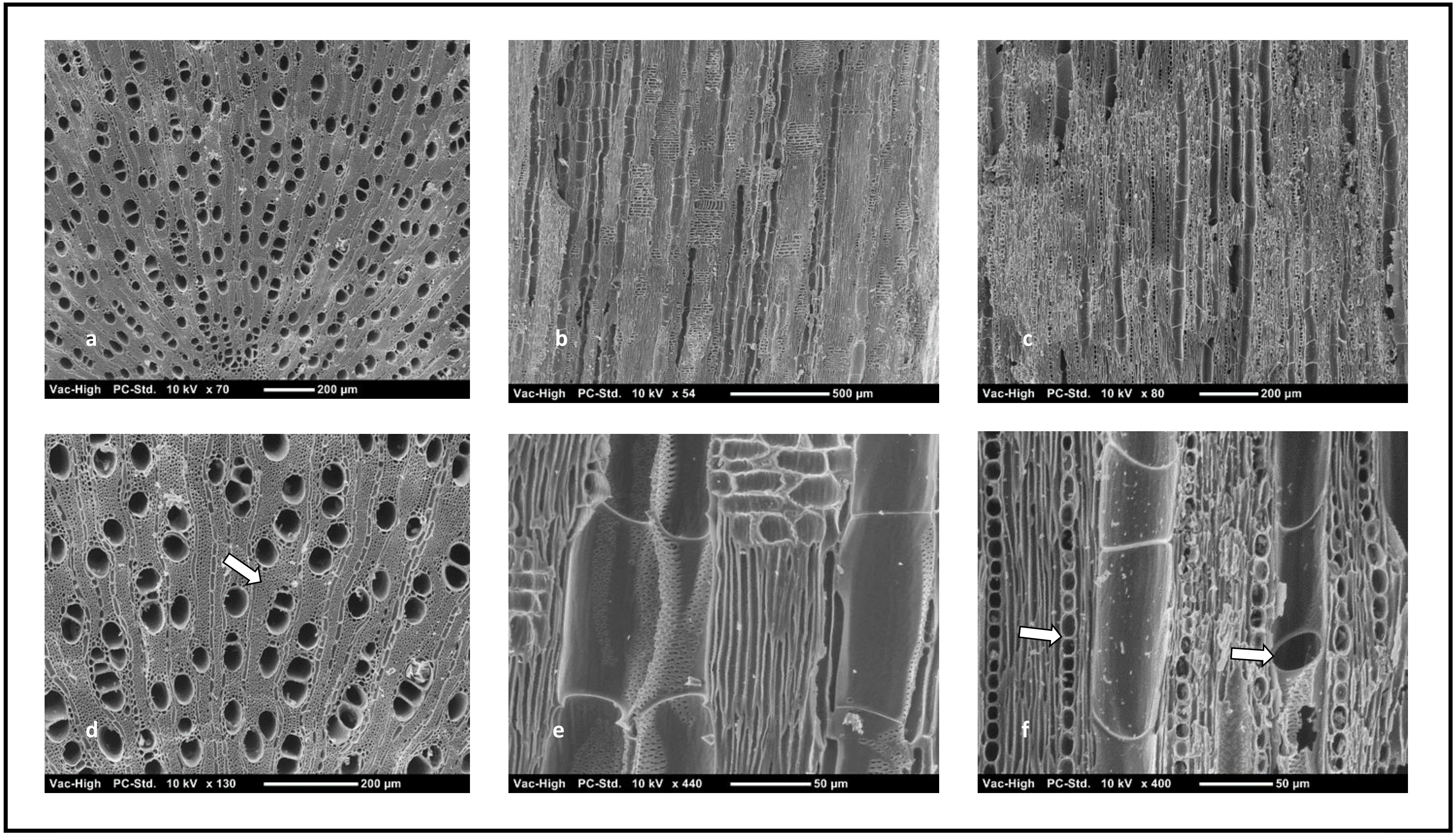
a and d: transversal, b and e: radial, c and f: tangential

16 – CAESALPINIACEAE - *Colophospermum mopane* (J.Kirk ex Benth.) J.Léonard (North-western Botswana)

IAWA Feature Code: 2,5,9,13,22,30,41,48,58, 70,78,96,102,104,112,144

- Growth ring boundaries indistinct or absent
- Wood diffuse porous
- Vessels exclusively solitary (90% or more)
- Solitary vessel outline circular
- Simple perforation plates
- Intervessel pits alternate
- Mean tangential diameter of vessel lumina: 50-100µm
- 20-40 vessels per square millimetre
- Fibres very thick-walled (d)
- Axial parenchyma scanty paratracheal
- Ray exclusively uniseriate
- Ray height : <1mm
- Ray cells procumbent
- Perforated ray cells
- Gums and other deposits in vessel elements
- Rays : <=4-12 / mm
- Septate fibres present
- Druses present

Colophospermum mopane. Photo: D. Pleurdeau



a and d: transversal, b and e: radial, c and f: tangential

17 – VITACEAE - *Cissus cornifolia* Planch. (North-western Botswana)

IAWA Feature Code: 1,3,9,13,22,27,47,68,76,92,97,102,105,112,115,144

- Growth ring boundaries distinct
- Wood ring porous
- Vessels exclusively solitary (90% or more)
- Solitary vessel outline circular
- Simple perforation plates
- Intervessel pits alternate
- Gash-like intervessel pits
- Mean tangential diameter of vessel lumina: 100-200µm
- 5-20 vessels per square millimetre
- Fibres thin-walled
- Axial parenchyma diffuse
- Four (3-4) cells per parenchyma strand
- Ray width 1 to 3 cells
- Ray height : >1mm
- Ray cells upright(e)
- Perforated ray cells
- Rays : 4-12 / mm
- Druses present in fibre cells

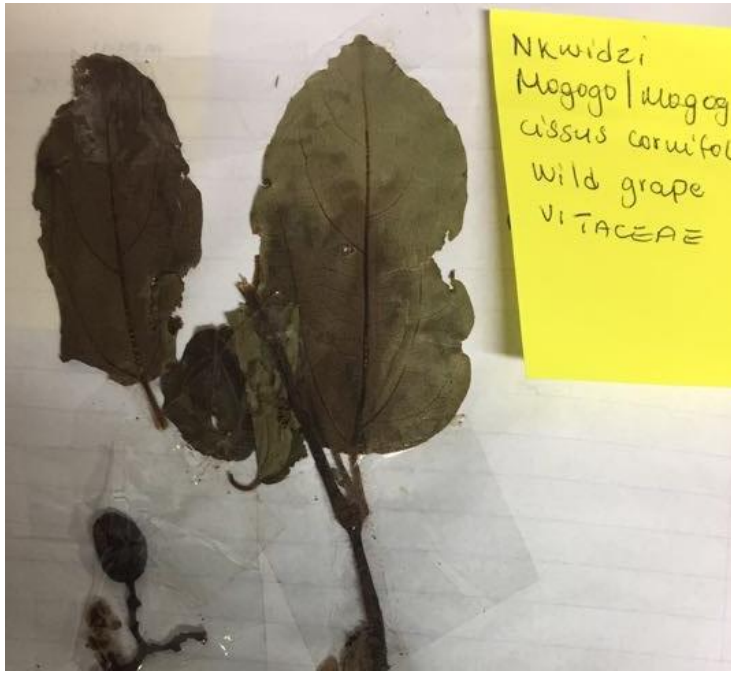
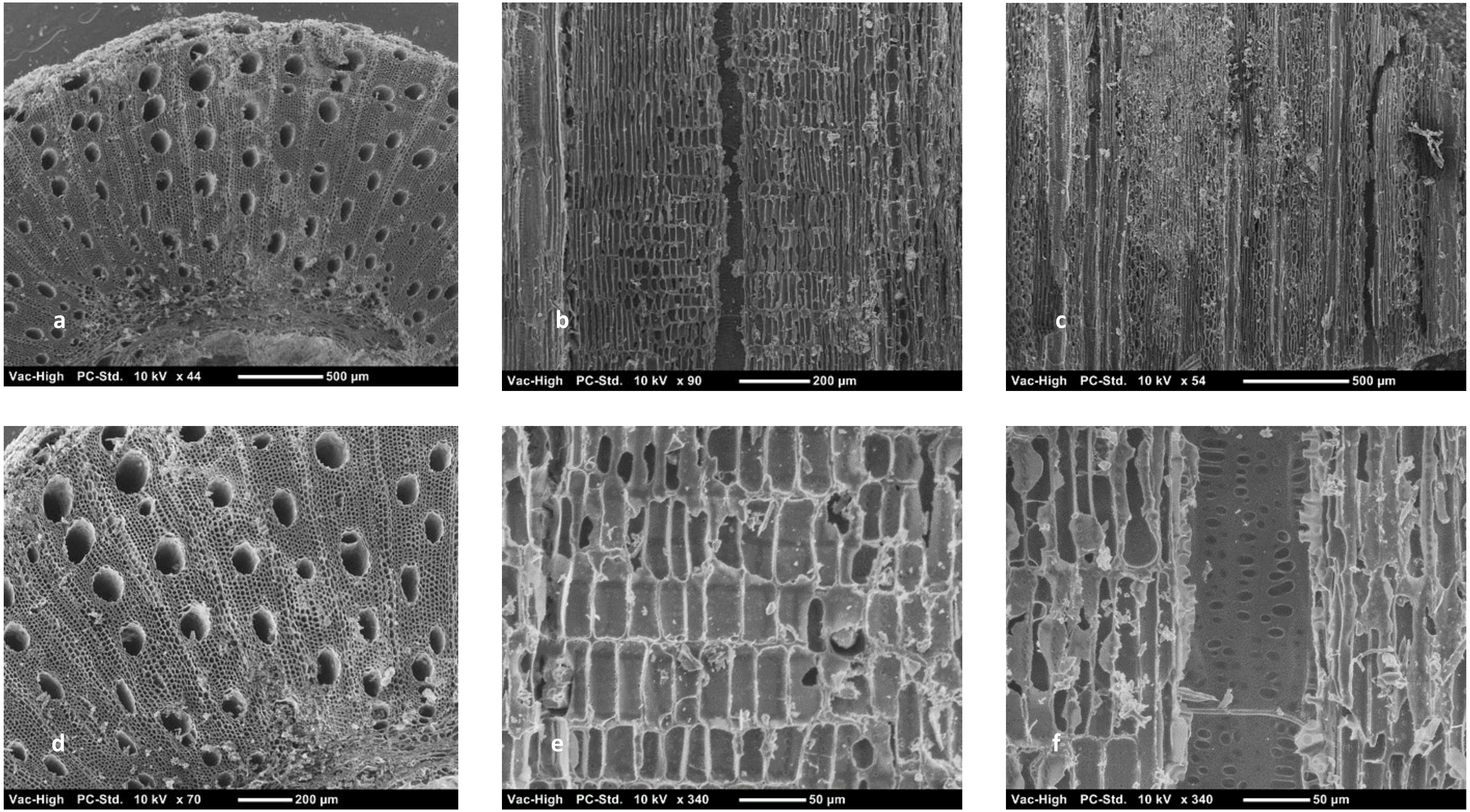


Photo from part of the herbarium. Photo: M. Mvimi



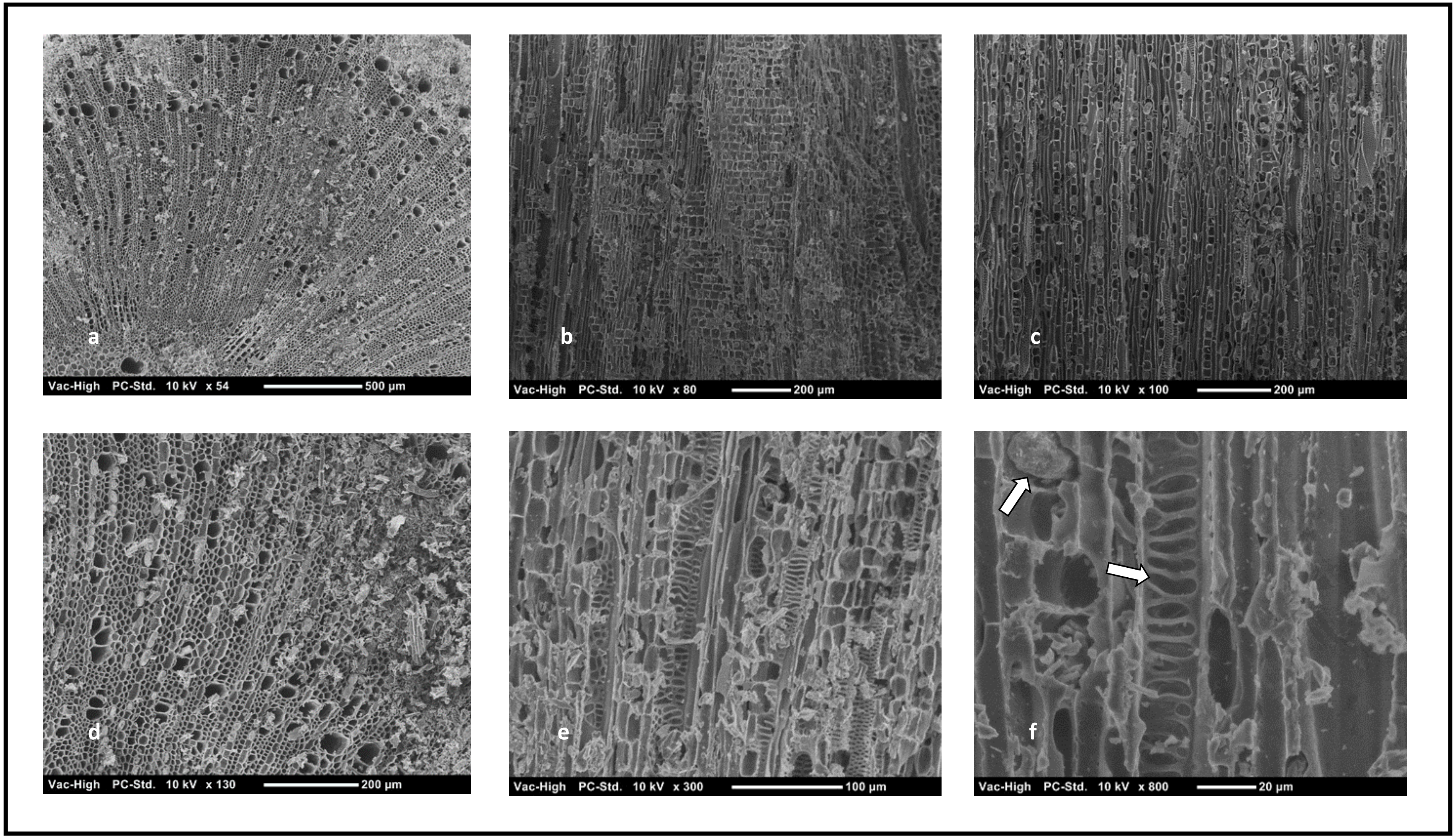
a and d: transversal, b and e: radial, c and f: tangential

18 – ANACARDIACEAE - *Lannea schweinfurthii* Engl*. (* South-eastern Botswana)

IAWA Feature Code: 2,3,9,13,16,22,27,41,47,68,76,92,97,102,109

- Growth ring boundaries distinct
- Wood ring porous
- Vessels exclusively solitary (90% or more)
- Vessel clusters present
- Solitary vessel outline circular
- Perforation plates simple
- Intervessel pits scalariform
- Scalariform perforation plates with 10 - 20 bars
- Mean tangential diameter of vessel lumina: 100-200µm
- 5-20 vessels per square millimetre
- Fibres thin-walled
- Axial parenchyma absent or extremely rare
- Rays exclusively uniseriate
- Ray height : >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Perforated fibre cells
- Rays : <=4-12 / mm
- Prismatic crystals present
- Druses present in fibre cells

Lannea schweinfurthii **.Photo: https://www.botswanaflora.com**



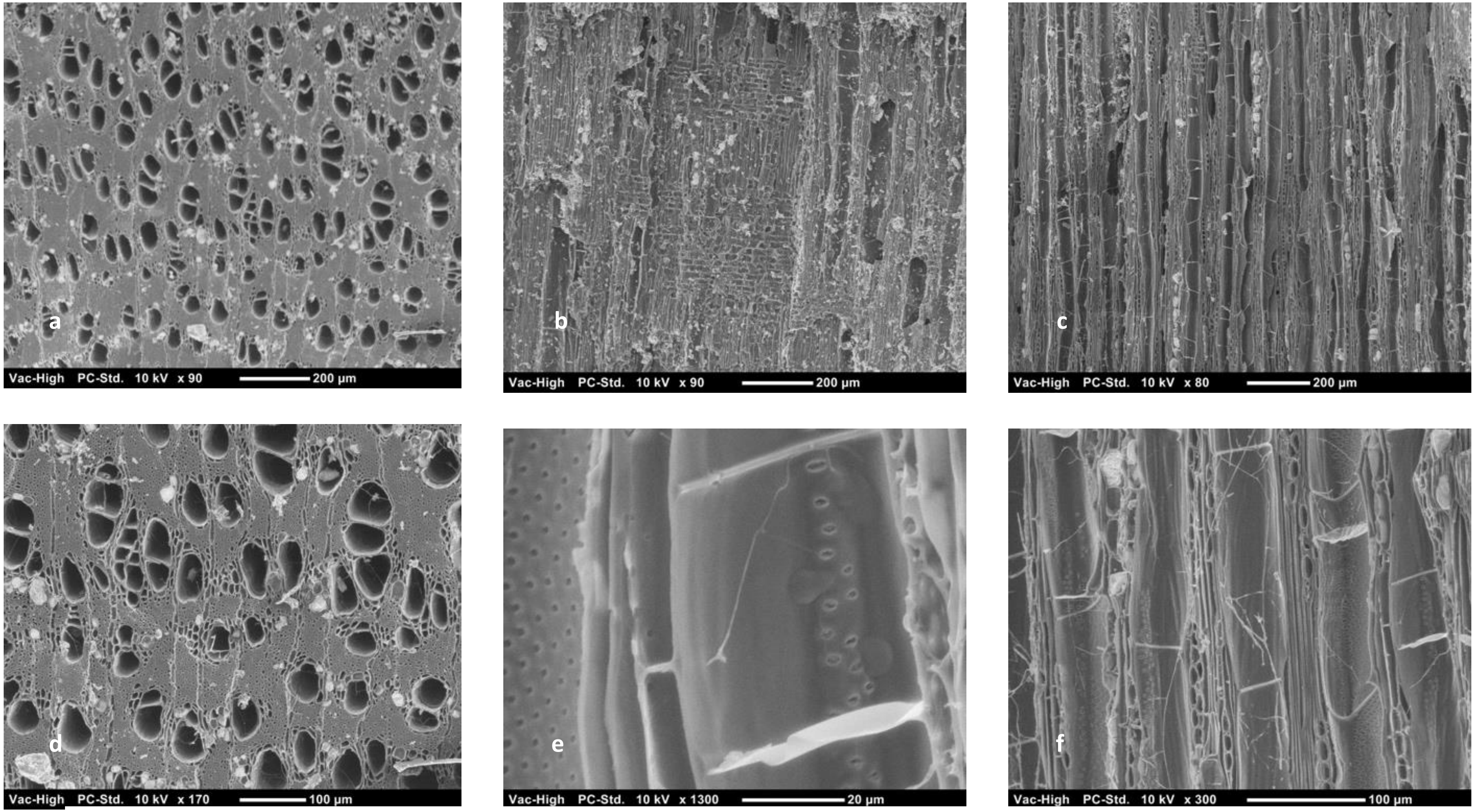
a and d: transversal, b and e: radial, c and f: tangential

19 – COMBRETACEAE - *Terminalia prunoides* M.A Lawson (North-western Botswana)

IAWA Feature Code: 2,5,9,10, 13,22,24,41,47,53,56,61,65,79,83,97,102,104,115,136,142

- Growth ring boundaries indistinct or absent
- Wood semi-ring porous
- Vessels mostly solitary and rarely in pairs or radial multiples
- Solitary vessel outline rounded
- Simple perforation plates
- Alternate intervessel pitting
- Minute intervessel pits: <= 4µm
- Mean tangential diameter of vessel lumina: 50-100µm
- Gums and other deposits in vessels
- >=100 vessels per square millimeter
- Fibres thick-walled
- Axial parenchyma diffuse
- Minute alternate pitting in parenchyma cells: <= 4µm
- Rays 1-2 cells wide (b and c)
- Ray height: >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- 4-12/ rays per millimeter
- Gums and other deposits in ray cells
- Gums and other deposits in vessels (a)
- Druses in ray parenchyma cells
- Crystal idioblasts present in ray-parechyma cells (e)
- Prismatic crystals in chambered axial parenchyma cells

Terminalia prunoides **Photo: M. Mvimi**



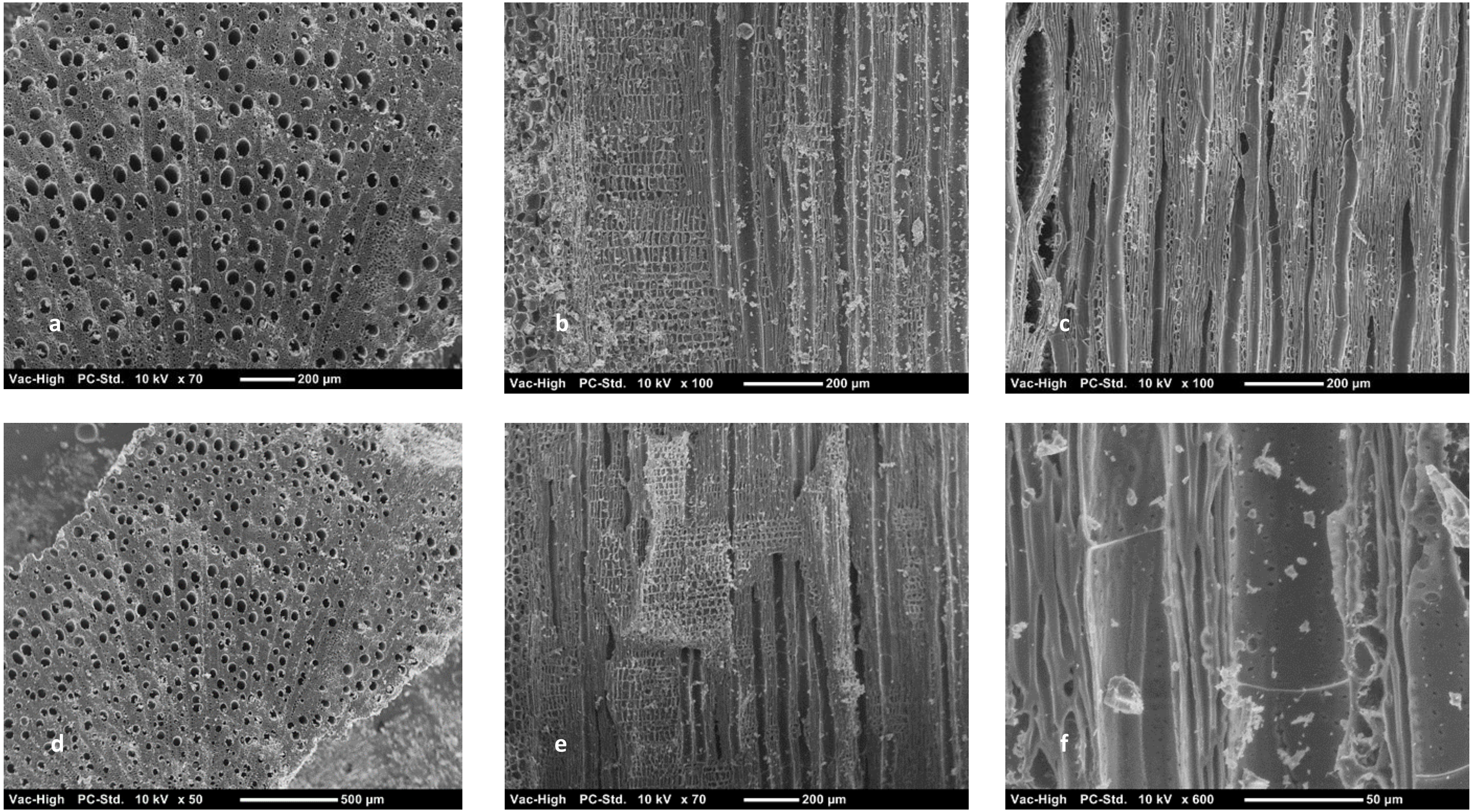
a and d: transversal, b and e: radial, c and f: tangential

20 - OLACACEAE - *Ximenia americana* L. (Erongo, Namibia)

IAWA Feature Code:2,5,9,10, 13,22,24,41,47,53,56,61,65,79,83,97,102,104,115,136,142

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusively solitary (90% or more)
- Solitary vessel outline circular
- Perforation plates simple
- Intervessel pits alternate
- Mean tangential diameter of vessel lumina: 50-100µm
- 20-40 vessels per square millimetre
- Fibres very thick-walled
- Axial parenchyma absent or extremely rare
- Four (3-4) cells per parenchyma strand
- Ray width 1-2 seriate
- Ray height : >1mm
- Radial canals present in rays
- Rays with procumbent, square and upright cells mixed throughout the ray
- Perforated fibre cells
- Rays : <=4-12 / mm
- Prismatic crystals present
- Druses present in fibre cells

Ximenia americana **Photo: M. Nankela**



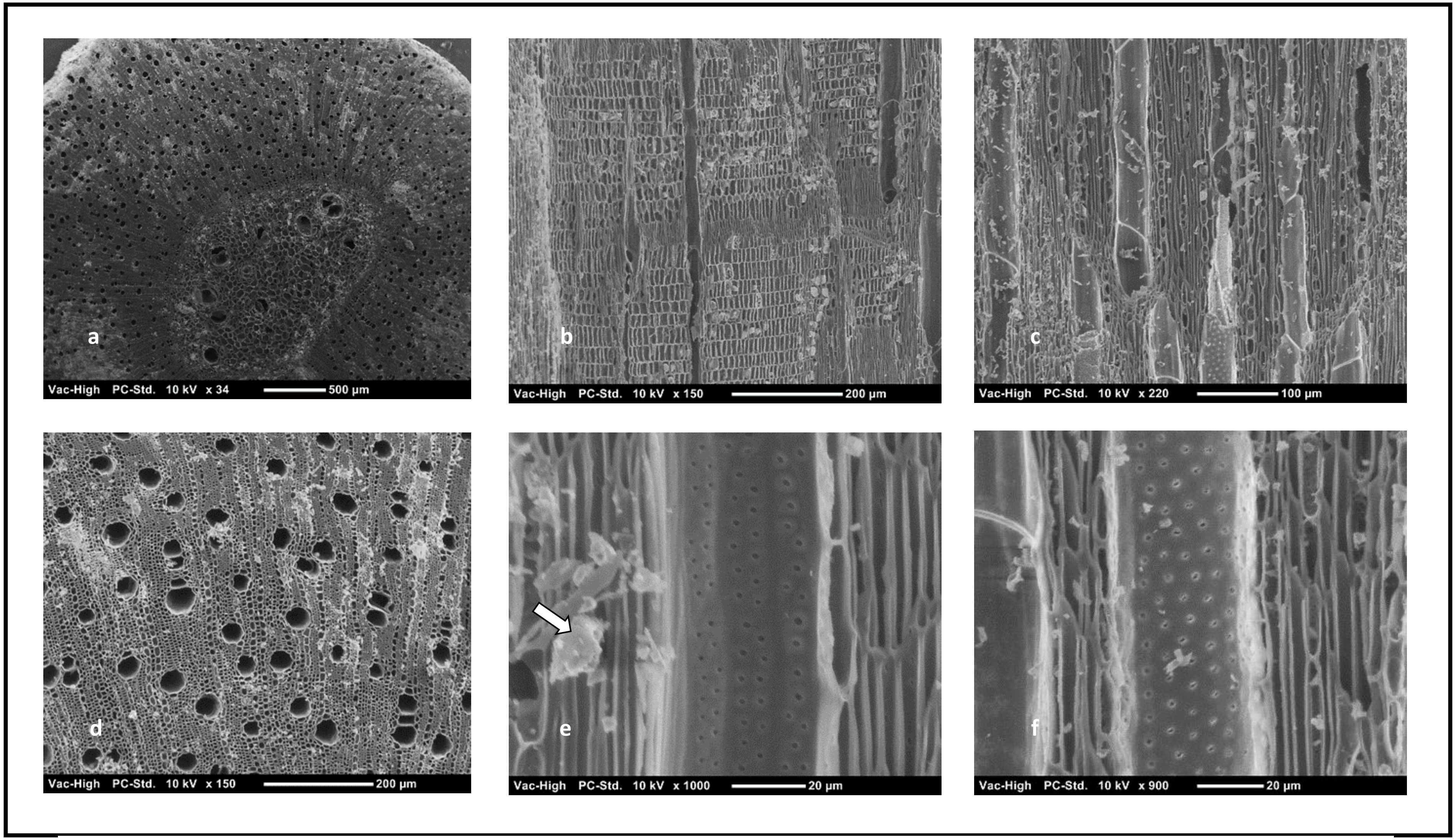
a and d: transversal, b and e: radial, c and f: tangential

21 – RHAMNACEAE - *Ziziphus mucronata* Willd. (Erongo, Namibia)

IAWA Feature Code: 2,5,9,22,24,41,48,49,70,65,92,96,101,105,114,147

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusively solitary (90% or more)
- Small radial multiples present
- Solitary vessel outline angular(d)
- Perforation plates simple
- Intervessel pits alternate
- Intervessel pits :Minute - <= 4 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- 20-40 vessels per square millimetre
- Fibres thin to thick-walled
- Axial parenchyma diffuse
- Four (3-4) cells per parenchyma strand
- Rays exclusively uniseriate
- Ray height : >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Perforated fibre cells
- Rays : <=4-12 / mm
- Septate fibres present
- Prismatic crystals present in ray cells
- Druses present in fibre cells
- Prismatic crystals in chambered upright and / or square ray cells

***Ziziphus mucronata*. Photo: M.Mvimi**



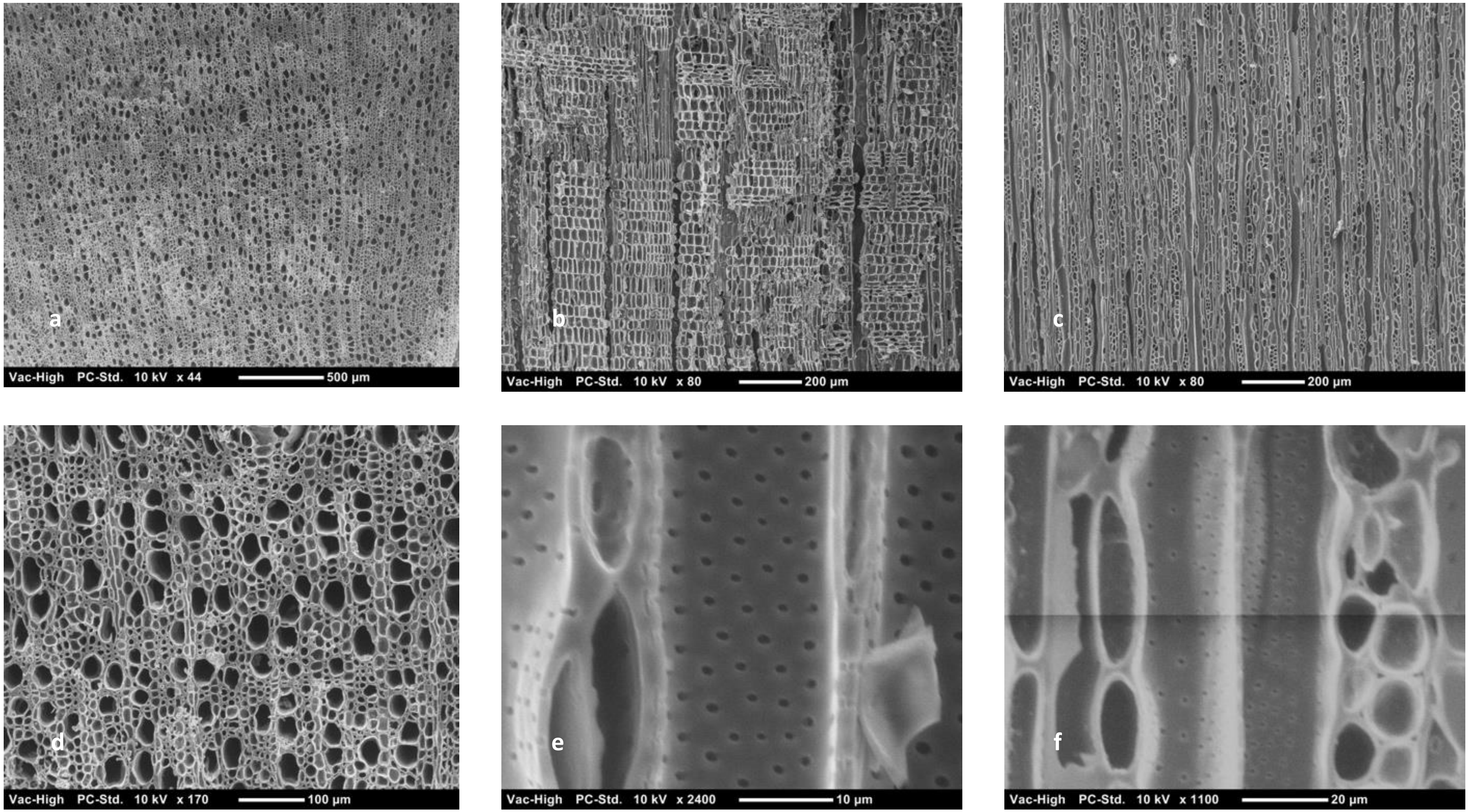
a and d: transversal, b and e: radial, c and f: tangential

22 – RUBIACEAE - *Vangueria infausta* Burch. (Erongo, Namibia)

IAWA Feature Code: 2,5,9,13,22,41,49,65,68,75,97,102,109,115

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusively solitary (90% or more)
- Small pairs or radial multiples are present
- Solitary vessel outline angular
- Perforation plates simple
- Intervessel pits alternate
- Minute - <= 4 µm
- Mean tangential diameter of vessel lumina: 50-100µm
- 40-100 vessels per square millimetre
- Fibres thin-walled
- Septate fibres present
- Axial parenchyma absent or extremely rare
- Four (3-4) cells per parenchyma strand
- Rays width 1-3 cells
- Rays of two distinct sizes
- Ray height : >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Rays : <=4-12 / mm

***Vangueria infausta* .Photo: M.Mvimi**



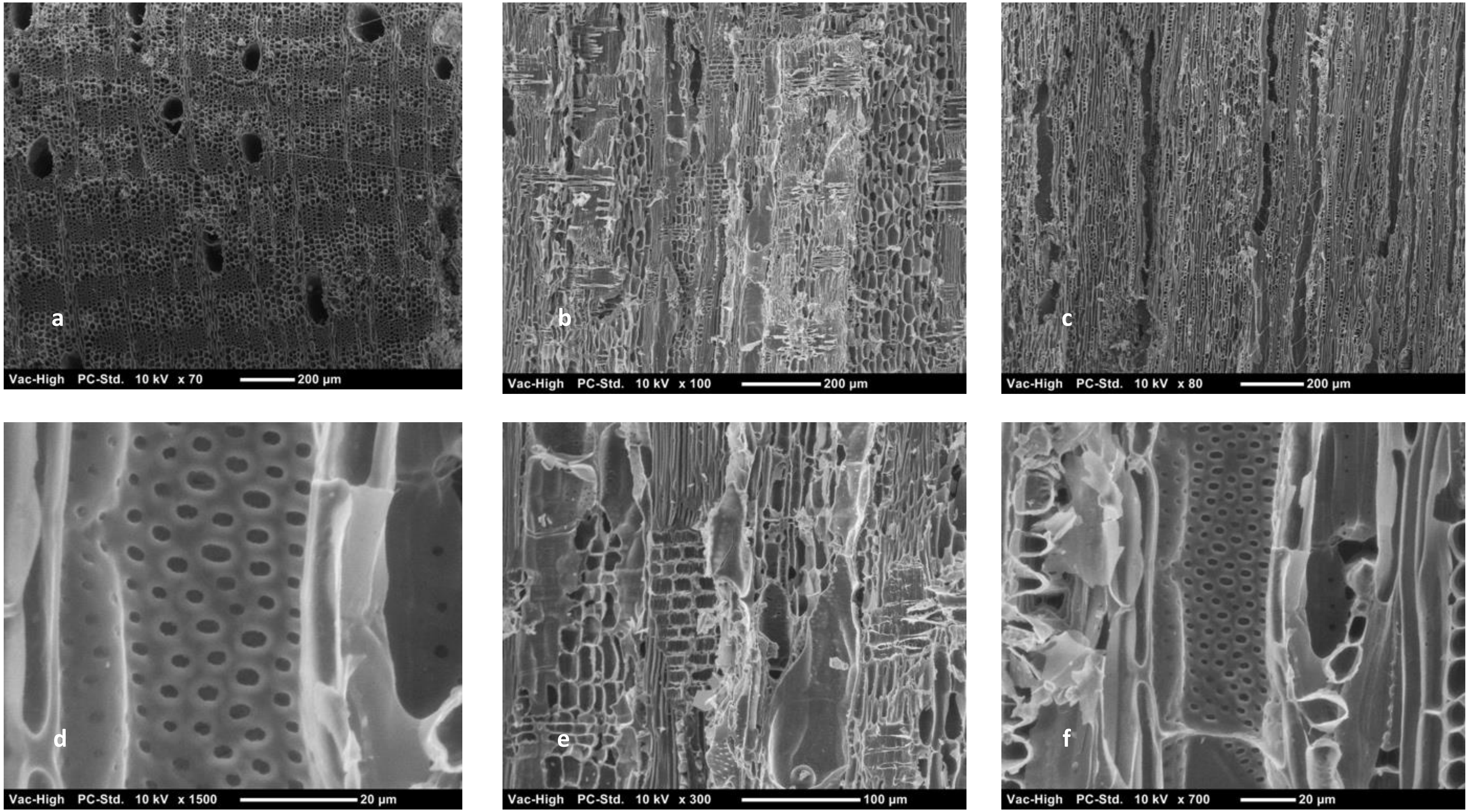
a and d: transversal, b and e: radial, c and f: tangential

23 – FABACEAE - *Cassia abbreviata* Oliv. (Southeastern Botswana)

IAWA Feature Code: 2,5,9,13,22,41,46,65,69,85,93,97,109,116

- Growth ring boundaries absent
- Wood diffuse porous
- Vessels exclusively solitary (90% or more)
- Solitary vessel outline circular
- Perforation plates simple
- Intervessel pits alternate
- Mean tangential diameter of vessel lumina: 50-100µm
- <= 5 vessels per square millimetre
- Fibres thin to thick-walled
- Axial parenchyma bands more than three cells wide
- Eight (5-8) cells per parenchyma strand
- Rays 1 to 2 cells
- Ray height : >1mm
- Rays with procumbent, square and upright cells mixed throughout the ray
- Perforated fibre cells
- Rays : <=4-12 / mm
- Septate fibres present

***Cassia abbreviate*. Photo: http://www.africanplants.senckenberg.de**



a and d: transversal, b and e: radial, c and f: tangential

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