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CHAPTER ONE

Introduction

1 Background

This thesis is a study of the charcoal (anthracology) from Great Zimbabwe and Chigaramboni. Great Zimbabwe is a world heritage site and is one of the earliest expressions of state formation in southern Africa. Great Zimbabwe is thought to have become a state capital after the decline of Mapungubwe in South Africa. It was at its height between 1450 AD and 1550 AD. Chigaramboni, on the other hand, is a specialist metallurgical site that seems to have been in use during the terminal phase of Great Zimbabwe. Great Zimbabwe is located about 300km north of the Zimbabwe-South Africa border, and 27 km south of Masvingo Town (Figure 1) in south eastern Zimbabwe. The area declared a World Heritage Site spreads over 720 hectares, but in the past would have extended its influence beyond that. Great Zimbabwe is a Late Iron Age settlement comprising extensive dry stone walling. It is probably the largest such complex south of the Sahara that is built in stone without mortar. It was built in three phases that are the Hill complex, the Great Enclosure and the Valley Enclosures (Chirikure *et al.* 2013; Collett *et al.* 1992). Settlement commenced on the Hill Complex and then spread to the Great Enclosure and the Valley ruins. Gumanye Tradition (pottery) dated to the 11th or 12th century marked the first permanent settlement on the Hill at Great Zimbabwe (Garlake 1982). The pottery belonging to Gumanye Tradition was very plain and the shapes show that it was clearly part of the main Shona tradition (Garlake *ibid*). The influence of the Great Zimbabwe civilisation spread far beyond the vicinity of the present day Mozambique, Botswana, Zimbabwe and South Africa (Mudenge 1988). Great Zimbabwe is the biggest and best known of a large set of sites that were established between 11th -16th centuries (Sinclair 1987). It is known as one of the most important sites in southern Africa.

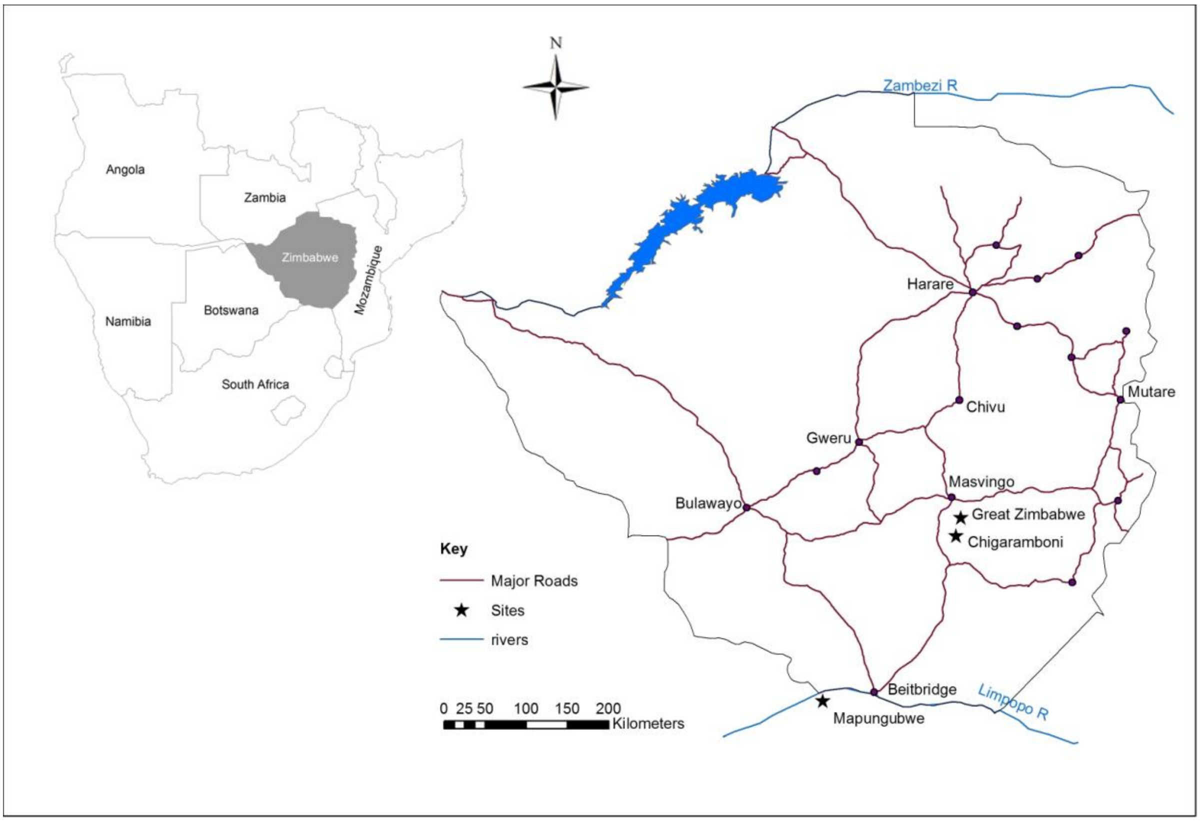


Figure 1: Map of Southern Africa showing Zimbabwe and the location of sites mentioned in the text.

Cities like Mapungubwe and Great Zimbabwe grew with time, each generation adding new structures to accommodate the needs of a growing urban metropolis (Manyanga *et al.* 2010). It is also known that the people of Great Zimbabwe State traded with the east coast as well as with other parts of Zimbabwe (Mudenge 1988). The rise of Great Zimbabwe is explained in terms of religion, control of coastal trade and ecological crisis in the Shashe-Limpopo basin (Huffman 1972, 2007; Manyanga 2007; Pikirayi 2001; Hall 1987).

The Little Ice Age is associated with cooler and drier phases that are thought to have resulted in the general decline of the environment. The declining environment culminated in the abandonment of the Shashe-Limpopo basin (Loubser 1991; Huffman 1996a; Pwiti 1996;

Tyson and Lindesay 1992; Pikirayi 2005; Smith 2005; Holmgren and Oberg 2006). The settlements in the Shashe-Limpopo basin were said to have shifted to the Zimbabwe plateau, eastern and central Botswana and South Africa after AD 1200. According to Hall (1987) the warm and dry environmental conditions weakened Mapungubwe by reducing livestock productivity which was a crucial branch of the economy. The Little Ice Age began AD1450 and did not conclude until around AD 1890. The period had two main cold stages which roughly coincided with the 17^{th} century and 19^{th} century (Tyson *et al.* 2000). Although it is sometimes thought of as a European phenomenon, the Little Ice Age was global but varying in severity.

However, Manyanga (2007) pointed out that the environmental model has been put to question by its proponents who suggest that the abandonment of Mapungubwe around AD 1290 needed to be explained in political terms rather than the environmental collapse model. This is as a result of new data from multistable isotope (carbon, oxygen and nitrogen) study by Smith (2005). Smith's (2005) study seems to suggest that, on the contrary, the climate remained wet until about AD 1400. Furthermore Manyanga (2007) questions the linear link between the collapse of Mapungubwe and subsequent growth of Great Zimbabwe as being unlikely.

Garlake (1978) argued for a more localised stimulus for the rise of Great Zimbabwe, in terms of the elite being able to accumulate and control large herds of cattle. This would ensure access to good pasturage which involved the seasonal movement of cattle between upper lands and the lowlands in summer and winter respectively. Pikirayi (2001) has expressed some doubts about this transhumance hypothesis and questioned whether it was necessary for long and large scale movements of cattle or whether it even took place. The rise of Great Zimbabwe has also been explained partly in terms of trade (Pikirayi 2001; Huffman 1987; Sinclair 1987; Bannerman 1982). Trade at the time of Great Zimbabwe included external and internal trade. Mudenge (1988), however, questions the so called trade stimulus hypothesis for the origin of the putative state around Great Zimbabwe. The role of external trade in causing social differentiation has been questioned (Manyanga 2007) as it has been considered only as a catalyst in the pathway to complexity and demonstrated power and wealth in an already differentiated society (Hall 1987; Connah 2001; Manyanga 2007). Pwiti (1991) argues that the role of external trade as being important without adequately explaining its possible effects or considering the possible local indigenous factors which may have made a contribution to economic growth and in some case which may have been more important in the development of these societies. It is further argued that African societies were already growing prior to the development of external trade. Hall (1987) argues that the suggestion of trade as a causal factor was not completely satisfactory the reason being that simple forms of barter and exchange had probably been part of the economic life of the people. It is further argued that the growing importance of cattle as an economic resource in addition to their cultural significances had already started. The elite possessed the wealth needed to sponsor the exploitation of the products for exchange (Pwiti 1991). According to Mudenge (1988), the Portuguese documents show that the Mutapa rulers used herds of cattle to sponsor gold mining among their dependents and that the metal was then used to acquire exotic goods (Mudenge 1988). The external trade hypothesis is also criticised for not taking into account the relations of production (Hall 1987). The decline of Great Zimbabwe has been explained in terms of factors such as trade, religion, political instability and environmental or ecological degradation. According to Mudenge (1988), decreasing rainfall in the region and siltation of the Save River, said to have been the main trade route used by Great Zimbabwe merchants, resulted in hampered navigability. The environmental hypothesis links the demise and abandonment of Great Zimbabwe with environmental change causing population movement and the breakup of states (Pikirayi 2001; Sinclair 1987; Bannerman 1982; Garlake 1978). On the other hand the decline of Great Zimbabwe is explained in terms of a shortage or depletion of salt (Chigwedere 1980; Abrahams 1959; Beach 1980; Mudenge 1988; Huffman 1972). This is thought to have resulted in people moving out of the Great Zimbabwe region for the areas to the north and west of Zimbabwe leading to the establishment of the Mutapa and the Torwa states respectively (Manyanga *et al.* 2010; Pikirayi 2005; Mudenge 1988). According to Huffman (1972), the references to salt were a social rationalisation of abandoning a settlement. According to Manyanga *et al.* (2010), the salt depletion explanation is linked to both the economic and environmental paradigm. Reference to salt should therefore be viewed as a metaphor referring to the environment.

Urban centres like Great Zimbabwe might have exploited large amounts of natural resources and food to cater to the increasing population. Increased population led to intensive building activities, and the increasing demands for wood fuel and space for agricultural fields. Urbanisation thus became heavily dependent on the immediate and distant surroundings, transforming the physical environment and eventually leading to ecological disasters (Pikirayi 2005). Therefore an environmental degradation hypothesis has been suggested as part of the reason that led to the fall of the Zimbabwe state centred at Great Zimbabwe (Pikirayi 2003, 2000, 1993; Sinclair 1987; Bannerman 1982; Summers 1963). However, it has not been tested or supported by any empirical data, hence in the long term, with further excavations and dating of samples this thesis will provide the means to testing the degradation hypothesis. A population of between 11000 and 18000 people is estimated to have lived at Great Zimbabwe during the time of occupation by its original builders (Ndoro 2001; Huffman 1987; Garlake 1973). That would have resulted in massive demands for building materials and firewood. During prehistoric times firewood was the only major source of energy for cooking, lighting and warming in southern Africa.

1.1 Brief history of archaeological research at Great Zimbabwe

Caton-Thompson (1931) excavated the Maund Ruins, Acropolis Terraces and middens, Rock Shelter, the Conical Tower in the Great Enclosure, the Mauch Ruins and the Ridge Ruins. Caton- Thompson states:

"Without overstating the security of my findings I have stated the results of my excavations: examination of all the existing evidence, gathered from every quarter, still can produce not a single item that is not in accordance with the claim of Bantu origin and medieval date."

Thus she concurred with MacIver's dictum that the stone walls were medieval and post medieval. MacIver (1906) had conducted previous research at Great Zimbabwe and concluded that Great Zimbabwe was of an African origin.

In the 1950s the Southern Rhodesia Public Works Department opened a section of the wall in the Great Enclosure and removed two pieces of *Spirostachys africana* wood. One of the pieces was dated to give the first radiocarbon date for Great Zimbabwe (Summers 1963, 1955). The date of Great Zimbabwe was found to be AD 591 ± 60. Two more tests were done and they were found to have had an average date of AD 591 ± 120. A further date for

Great Zimbabwe was obtained from two more pieces of wood that dated to AD 702 ± 92 (Summers 1963).

In 1958 Robinson dug in the Hill Complex and near No. 1 Ruin. The excavation in the Hill Complex disclosed twelve house floors, several sets of house walls that lay on top of one another, differing pottery types and charcoal samples. Robinson found pottery like that from Class 3 in the Ruin No.1 (Appendix 2). The pottery was earlier than most of that found in the Great Enclosure (Summers 1963). He also placed the Class 1 (Appendix 2) pottery within the Gokomere unit. According to Huffman (1976, 1989, 2007), Gokomere belongs to the Nkope Branch of the Urewe, differing from Nkope and Ziwa in that Gokomere unit has significant proportion of multiple bands in the neck. This discovery confirmed the suspected connection between style P walling and Class 3 pottery. The P-style walling is where irregular blocks were laid with the long axis horizontal to produce a wall with pseudo courses that run for short distances (Whitty 1959; Collett *et al.* 1992; Ndoro 2001). In the same year Summers and Whitty excavated in the Great Enclosure. They did not find many artifacts except for *dhaka* kerbs or hut floors. The pottery they found belonged to Class 4 (the latest) (Summers 1963). Whitty (1959) formulated a comprehensive classification of walling style were the P walling, Q walling, R walling and the PQ walling that provided an architectural sequence for Great Zimbabwe, however, that was later disproved by Huffman and Vogel (1991). The Q-style walls were built in regular and approximately rectangular blocks that were laid in level courses and the PQ style walling constitutes P and Q style elements (Whitty 1959; Huffman 1996; Ndoro 2001). The occupation of Great Zimbabwe was dated by beads and pottery (Classes 3 and 4). They also demonstrated that Great Zimbabwe was abandoned by the 15th century. Summers (1963) concluded that the Great

Enclosure was nothing older than AD 1100. A small piece of glass was also used to give a date of about the AD 14th century (Summers 1963).

Huffman *et al.* (1991) excavated at Great Zimbabwe between 1971 and 1976. They argued that the R-style was contemporaneous with P as well as Q- styles. They further refined the chronology for reinterpreting the sequence at Great Zimbabwe. Thus the Zhizo pottery between period 1 and 2 deposits in the Western Enclosure were dated to the AD 7th – 8th century. The new dates for example for Period 1 eliminated the possibility of the Phoenicians or Sabaeo-Arabians origins of the buildings. Thus it fully supported the African origin hypothesis as had been earlier on proposed MacIver (1906) and Caton-Thompson (1931).

Collett *et al.* (1992) critically examined the structurist model of the social organisation at Great Zimbabwe proposed by Huffman. They used architectural data from the Posselt and Phillips ruins to show the complexity that occurred through time in the social meaning of spatial organisation. They argued that the dates from the Valley Enclosures indicated that they were unlikely to have been occupied by the royal wives. They concluded that the architecture of the valley undermined the spatial model developed by Huffman (1981, 1982, 1984a, 1984b, 1985a, 1985b, 1986, 1987).

Chirikure *et al.* (2013) combined radiocarbon dates with stratigraphic information and datable imports to provide a Bayesian chronology for Great Zimbabwe and its structures. They showed that the age of the Hill Complex was from AD 1000 to AD 1281 and Great

Enclosure was AD 1226 to AD 1383. They also indicated that the Valley Enclosures were the last to be built. The results also indicated that the date of Great Zimbabwe overlapped with that of Mapungubwe, thus making the two sites more of competing peers than successors.

1.2 Chigaramboni

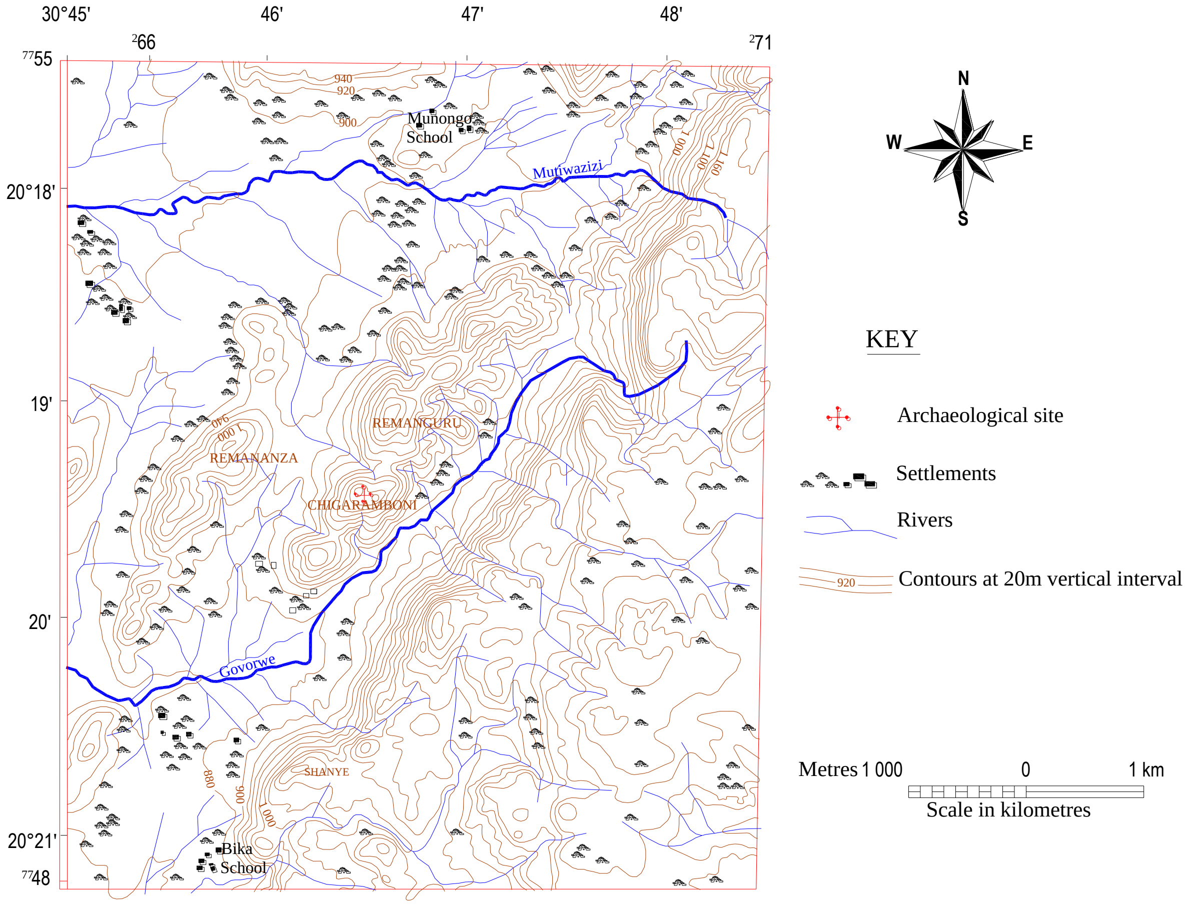


Figure 2: The study area of Chigaramboni

Chigaramboni is a specialist metallurgical site located to south west of Great Zimbabwe at 20° 20’ 27”S, 30° 46’ 35”E. It is situated on Chigaramboni Mountain ridge, a landscape endowed with a wide diversity of archaeological sites. Ndoro (1991) recorded Early Iron

Age sites on the bottom of Chigaramboni range. He also recorded more than nine terminal Zimbabwe tradition sites (refugee period). Chigaramboni itself is an iron working site with several iron smelting furnaces, slag and tuyere mounds. Studies in sub-Saharan Africa iron smelting revealed that it is associated with rituals and symbolisms (Ndoro 1991). It is seen as a metaphor for reproduction (Ndoro *ibid*). Different symbols are used by different groups (Collett 1985; Van der Merwe *et al.* 1987; Chirikure 2006). In addition to that there is a stonewalled enclosure whose style of construction is R (Figure 3). R–style walling is composed of a mixture of blocks that are irregularly shaped. The building blocks fit poorly together requiring the use of wedges (Ndoro 2001; Summers 1963).

Figure 3: (left) and **Figure 4:** (right): The stonewall enclosure and tuyere fragments at Chigaramboni.

The Chigaramboni metallurgical site was archaeologically investigated by Ndoro (1991). The focus was on the iron smelting technology. There are however no dates from Chigaramboni but it is believed that Chigaramboni metallurgical site lies in the catchment area of the prehistoric urban centre at Great Zimbabwe (Ndoro 1991). He is of the view that the furnaces date much earlier than the 1800. Ndoro (1994) argues that they could have attracted the attention of Karl Mauch and Theodore Bent if they were in use during the 19th century.

1.3 Aims of the study

First and foremost the aim of this study is to analyse the available charcoal from Great Zimbabwe and Chigaramboni using a modern vegetation reference collection in order to begin to understand what woods were locally and regionally selected during the occupation of Great Zimbabwe. These studies will provide a basis from which to begin to build a picture of the environment and environmental changes that may have occurred over the period of Great Zimbabwe's occupation. This would establish whether modern woody taxa correlated with archaeological woody taxa, and if climate shifts or over-exploitation could account for differences.

1.4 Objectives of the study

In order to achieve the aims listed above I proposed to:

- Set up a reference collection of local modern woods to make into charcoal
- establish wood species utilised at Great Zimbabwe archaeological site from charcoal collected from various sites in the complex and housed in the National Museum in Harare
- establish wood species utilised at a metallurgical site of Chigaramboni from charcoal collected from various sites in the complex and housed in the National Museum in Harare
- use published records of fuels, domestic and other uses of woods to determine possible uses of the charcoal

- determine the influence of climate change and wood exploitation on the past vegetation

1.5 Research hypotheses to be tested

1. wood fuel for domestic cooking and warming was different from wood used for industrial and construction purposes
2. Modern wood vegetation does not correlate with the palaeo-wood vegetation

1.6 The structure of this thesis

This chapter has provided a background to the study area. Chapter 2 reviews the studies in anthracology in Southern Africa. It also discusses different approaches to the study of charcoal. Chapter 3 contains the methods applied in this study. The vegetation currently growing in the two study areas is presented in chapter 4. Chapter 5 deals with microscopic anatomical analysis of the reference collection. The results of microscopic anatomical analysis of archaeological charcoal from Great Zimbabwe and Chigaramboni are presented in Chapters 6 and 7 respectively. Finally chapter 8 presents the discussions and conclusions of the study.

CHAPTER TWO

Literature review

2 Introduction

This chapter provides an overview of the different approaches, protocols and methods previously used in charcoal studies, with a focus on those carried out in Southern Africa. It also delves into the different protocols and methods employed in anthracological studies to ensure that charcoal materials of different size, shape, abundance and quality of preservation are recovered. Also discussed are the sampling, laboratory preparation and microscope identification techniques.

2.1 The social side of wood collection

According to Marguerie and Hunot (2007), prehistoric societies established their economies based on firewood that resulted in the production of large amounts of charcoal after burning. This is true as most archaeological excavations yield volumes and volumes of charcoal. Archaeological charcoal therefore provides valuable information about the exploited environments. Thus anthracology is an efficient approach for studying the relationship between people and the environment.

Ethnographic studies suggest that indigenous people had knowledge about firewood qualities and that selection of wood for different kinds of fire is quite precise (Best 1979; Scholtz 1986). Some wood taxa are not used as firewood for functional reasons such as unpleasant smell, toxic gas and considered sacred. Such taxa include *Spirostachys africana* and *Parinari curatellifolia*. In some communities beliefs that burning of particular woods will result in cows producing only bull calves (Scholtz 1986; Lee-Smart and Hoffman 1988) leads to its being avoided. In some communities the wood of *Euclea* is not being used because it is believed that burning it causes strife in the family, while the taxon *Spirostachys africana* is avoided as fuel wood because of the toxicity of the smoke that is produced when burning (Allott 2005; Van Wyk and Gericke 2000; van Wyk and van Wyk 1997; Palgrave 2002). Please note that the families and authors of plant genera and species are listed in Table 2. Thus charcoals in archaeological sites represent cultural selection for a variety of purposes such as wood for building, utensils and smelting (Esterhuysen 1996; Tusenius 1986) and are sensitive to cultural interpretations.

Cultural interpretations are dependent on ethnographic and in particular, ethnobotanical studies. Fortunately, for the purposes of this study a number of ethnobotanical studies have been carried out in the Zimbabwe area for the purpose of explaining archaeological changes (Matenga 2003; Ndoro 2001; Bannerman 1982). The study by Bannerman (1982) examined several hypotheses that had earlier on been advanced to explain the rise and fall of the Great Zimbabwe State. He also investigated the modern woody plants within the vicinity of Great Zimbabwe. He observed that *Brachystegia spp* and *Julbernardia sp* were absent from the taxa growing at Great Zimbabwe and his explanation for that was the long period of occupation and clearance of land for cultivation. Bannerman (1982) emphasised the need for more interdisciplinary research into various factors connected with the rise of the Zimbabwe State especially the relationship between climate and ecology, and hence this study.

Ndoro (2001) investigated vegetation management practices and their impacts on the presentation and preservation of Great Zimbabwe over the last 100 years. The study aimed at developing a holistic approach to the heritage management of Great Zimbabwe and related sites as cultural and natural landscapes. Ndoro suggested that ecological imbalances caused by a large population and the rise of the Mutapa might have led to the abandonment of Great Zimbabwe. He further argued that vegetation played an important role in the overall preservation and presentation of the Great Zimbabwe site. Ndoro showed that some woody vegetation species were introduced to the site in the last one hundred years. These are *Mimusops sp, Jacaranda acutifolia, Eucalyptus sp, Citrus limon and Lantana camara*.

On the other hand Matenga (2003) established an inventory of fruit trees that were found at Great Zimbabwe and the surrounding areas. The study was conducted within a radius of 25km of the Great Zimbabwe site. A total of 32 tree species were identified within 25km radius from Great Zimbabwe. He concluded that harvesting of fruits was one of strategies used to sustain Great Zimbabwe during ancient times. The validity of Matenga conclusions can be checked by anthracological studies.

A more archaeobotanical approach to the study of early plant economy of Zimbabwe was conducted by Jonsson (1998). In that study Jonsson paid attention to charred plant seeds from the hunter-gatherers to the Early and Late Farming Communities (FC) in Zimbabwe. Some of the charred seed samples were drawn from Great Zimbabwe during an excavation conducted by Matenga in 1996 on the Hill Complex's northern cliff. The purpose of the study was to establish if there was continuity and change in the use of plants in both hunter-gatherer and farming communities. Jonsson concluded that there were significant differences in the species gathered between the hunter-gatherer and the farming communities in Zimbabwe. This study draws on and builds on the ethnographic and ethnobotanical studies already carried out by these researchers and will attempt to provide a glimpse of the ancient woody vegetation preserved in the archaeological record as charcoal that were possibly exploited for different purposes.

2.2 Charcoal terminology

Charcoal refers to the pyrolized remains of terrestrial biomass (e.g. trees, grasses, plants) in elementary state (Smith *et al.* 1975). Pyrolysis is a thermo-chemical decomposition of organic material at elevated temperatures. Pyrolysis starts at 200 – 300 ^{o}C. Charcoal is an inert black porous residue obtained by pyrolysis or carbonification of wood and anthracology is the study or analysis of charcoal. According to Scott and Damblon (2010) the term anthracology is mainly limited to European anthracologists. Charcoal is also referred to as inertinite by coal petrographers (Scott and Glasspool 2007). For the purpose of this study I will use anthracology to refer to the study of charcoal.

2.3 Climate and vegetation

Studies on climate and vegetation show that there is a correlation between vegetation and climate. They show that climate exerts on the spatial distribution of major vegetation types on a global scale (Brovkin 2002). On the other hand vegetation affects climate through alteration of the physical characteristics of the land surface like albedo, water conductivity, and atmospheric gas composition for example, carbon dioxide (CO_2) and methane (CH_4)

(Borvik 2002). Each plant species has physiological characteristics that allow it to live in certain range of temperature, moisture, acidity. As climate changes vegetation changes as well, dying out in places where climate becomes too stressful and when a species rate of adaptation is low. Plant species prosper where climate becomes salubrious and may shift its distribution.

2.4 Charcoal as proxy evidence

There are debates about whether charcoal is a good proxy of the environment. For instance Willcox (1974) argues that charcoal data is heavily biased because of human behaviour and, therefore, not a true indicator of the local environment. In contrast Badal and Heinz (1991) argue that charcoal is highly suitable for the study of former environments. Despite all these arguments archaeological charcoal remains a useful form of data in the reconstruction of palaeoenvironments because the woods were collected from the local environment as indicated by the following studies by Allott (2005), Scholtz (1986), Cartwright and Parkington (1997), Deacon (1979, 1983), Dowson (1988), Esterhuysen (1992, 1996), Esterhuysen *et al.* (1994), February (1994a, 1994b), Prior and Williams (1985), Tusenius (1986, 1989), Shackleton and Prins (1993). Their studies inform us about palaeoenvironmental changes through time in South Africa. It is also argued that the presence of archaeological charcoal provides evidence of the local existence of a particular plant in the record of local vegetation (Dincauze 2000). The 'Least effort' principle applies when firewood is collected (Marston 2009; Asouti *et al.* 2005; Esterhuysen 1996; Tusenius 1986), whereby occupants of a site collected firewood from the within or the immediate vicinity of the site rather than travelling long distances. Thus charcoal might represent plants growing on or near the site, plants or parts brought by people or animals from any distance as food and economic resources for occupants, waste and debris of food preparation activities or a combination thereof. Palaeoenvironmental reconstructions are made possible by the fact that archaeological charcoal specimens can generally be identified to species level (Allott 2005; Scholtz 1986; Cartwright and Parkington 1997; Deacon 1979; 1983; Deacon *et al.* 1983; Dowson 1988; Esterhuysen 1992, 1996; Esterhuysen *et al.* 1994; February 1994a, 1994b; Prior and Williams 1985; Tusenius 1986, 1989; Shackleton and Prins 1993; Wadley *et al.* 1992). Changes in wood taxa through time indicate changes in the composition of vegetation and thus provide proxy evidence of general climatic conditions.

In addition anatomical features of individual species provide an indicator of environmental conditions. For example Scholtz (1986) studied vessels from charcoals from Boomplaas and found that the relative size of vessels could be linked to ecological change. Thus from archaeological charcoal it was theoretically possible to suggest whether particular species in an area were exposed to harsh ecological conditions with limiting factors such as aridity, because it would result in a decrease in the size of the vessels (Tusenius 1986).

A study on a single location can provide some insights regarding climatic change at a point in time and space, however, reliable palaeoenvironmental information is expected to come from the study of a number of contemporaneous sites, that is, charcoal from a number of localities that date to the same period.

2.5 Palaeoecological charcoal studies in Southern Africa

An anthracological study by Tusenius (1986) revealed vegetation and climate change at Colwinton, Banowe and Ravenscraig in South Africa. Tusenius (1986) concluded that the environment changed during the past 12000 years whereby the earliest Holocene was the driest period at Ravenscraig and the same conditions prevailed until about 300BP. On the other hand there was a low diversity of species at the site of Banowe in the early Holocene and that suggested a harsh environment.

Another anthracological study of charcoal from Boomplaas by Scholtz (1986) provided a relatively detailed climatic history for the interior of the southern Cape in South Africa for the last ca 60 000 years which correlated well with other proxy environmental data sources such as palynology.

Anthracological studies of sites in eastern Free State in South Africa and Lesotho by Esterhuysen (1996), Esterhuysen & Mitchell (1996) revealed that temperatures increased in the early Holocene, followed by drier conditions between 8400 and 7200BP. The same study also showed that moist conditions were re-established by 6500BP. Esterhuysen (1996) revealed that conditions were marginally cooler and more moderately moist than at present.

Hall (2010) embarked on a study of stable carbon isotopic analysis of archaeological charcoal from the Middle Stone Age occupation of Sibudu Cave in South Africa. His studies indicated that a cool and humid forest vegetation existed 65ka to 62ka ago.

2.6 Other palaeoecological and palaeoclimatic proxy data

A wide range of proxy data is studied in order to give insights into the palaeoenvironments of southern Africa. The proxy data includes among others fossilised planktonic foraminifera, sea-level records, fossilised plant and animal remains and deep sea ice core records.

Four interglacial periods were observed through deep sea and ice core records (Allott 2005). Continental ice volumes increased during glacial periods. The increase is in association with increased incorporation of ^{16}O as compared to ^{18}O (Lowe and Walker 1997; Allott 2005), thus the fluctuations between ^{16}O and ^{18}O isotopes are an indicator of global climate change.

According to Allott (2005), fossilised planktonic foraminifera from deep-sea sediment cores provide some of the best records for changes in oxygen isotope composition. Foraminifera are temperature sensitive and are therefore an important indicator of sea surface temperature (Emilliani 1955; Prell *et al.* 1975; Williams *et al.* 1998; Allott 2005).

The sea-level records at Richards Bay along the East Coast in South Africa have shown that the sea-level was >45m 200 BP and 39m 100 ± 1530 BP (Maud 2000, Allott 2005). Palaeochannels on the East Coast of South Africa that are associated with the Tugela River (Orme 1976), the Tongati and Mgeni (Maud and Botha 2000) Rivers were formed during the marine regressions when the continental shelf was exposed. According to Allott (2005), the palaeochannels were formed during low sea-stands and they are preserved in the estuarine of many rivers that feed the Indian Ocean, for example, the narrow channels found at the mouth of the Tongati River along which Sibudu Cave is located (Orme 1976; Allott 2005).

Pollen obtained from palaeopedological sections provides palaeoenvironmental records. Pollen within sediments represents the surrounding vegetation communities (Allott 2005). The pollen from Port Durnford revealed that it contained a high proportion of arboreal pollen including *Morella* and *Syzygium* species, *Ficus* pollen was also found. Scott *et al* (1992) interpreted this pollen spectrum as open sedge marshland surrounded by *Syzygium* and *Ficus* trees. *Podocarpus* pollen and small quantities of Fynbos taxa were found in the lower part of limit 2. Scott *et al.* (1992) believed that the presence of *Podocarpus* pollen indicated changes in vegetation communities that were caused by climate changes arguing that *Podocarpus* is not common in the modern vegetation in the area (Allott 2005).

Palaeontologists undertook faunal studies to reconstruct palaeoenvironments in southern Africa. Some of the pioneering work in archaeozoology focused on taphonomic studies at sites such as the Sterkfontein and Swartkrans (Dart 1957; Brain 1969). Studies on fossilised faunal remains from Port Durnford shed light on the palaeoecologies and palaeoclimates, for example the Port Durnford formation yielded fossil remains of fish, crustaceans, foraminifera and marine mollusc as well as larger mammalian bones (Maud and Botha 2000).

Plug and Engela (1992) examined macrofauna from the Robberg MSA phase and from the Robberg phase of the Wadley excavation (Allott 2005). Although the palaeoenvironmental interpretation from these samples was limited owing to low taxa numbers, they were able to find that large bovid taxa were more common than medium size bovid (Allott 2005).

In Zimbabwe faunal studies focused on Late Farming Communities (LFC) (Fagan 1966; Garlake 1973; Thorp 1995). Walker's (1995) study reconstructed the past environment of Matopos based on faunal and floral remains. Walker compared animal exploitation patterns between the MSA and LSA communities. He found about 25 edible plant species that include *Sclerocarya birrea*, *Grewia sp*, *Ziziphus sp* during the MSA period and the *Annona sp* 4500 BP at the end of LSA.

Plug (1997) analysed faunal remains from Kadzi an Early Farming Community (EFC) site in northern Zimbabwe. The analysed assemblage revealed that it was dominated by *Syncerus caffer* (Buffalo), marine resources and riverine resources. Manyanga (2001, 2007) conducted studies in the Mwenezi, Malumba and Shashe-Limpopo basin. His studies indicated that the presence of equids such as zebra, wildebeests and impala were exploited in the Mwenezi-Malumba whilst cattle, sheep and goats were exploited in Shashe-Limpopo basin.

In Nyanga, Soper's (2002) study was able to establish that people utilised cattle and hunting, whist Shenjere (2006) in the study of Murahwa's Hill comprising EFC and LFC noted that there were faunal remains from domesticated animals and a variety of wild species. Shenjere's (2011) study found cattle, buffalo, kudu, impala, common duiker, klipspringer, blue duiker, steenbok, fish, python, francolin, marine shell fragments. Katsamudanga and Pwiti (2007) found a mixed economy heavily biased towards hunting. Thorp (1995) found duiker, dassie, hare, jackal, wild dog, zebra and many others in addition to cattle at Great Zimbabwe and Khami.

Stable isotope analysis of animal bones offers means of reconstructing palaeoenvironments (Sealy 2001; Smith 2005; Shenjere 2011). Shenjere (2011) studied stable carbon and nitrogen signatures of the fauna that were obtained from bone collagen from cattle and ovicaprids from Samakande site AD 5th and AD 9th century. The nitrogen value pointed to a wet climate. Negative Oxygen values from Murahwa's Hill with an age range of AD 9th to 15th centuries pointed to a wet climate. The isotopic analyses show that there was climate change.

Norstrom *et al.* (2005) used carbon isotope composition and woody anatomy of *Breonadia salicina* trees from the Limpopo province in South Africa to show that there was climate change. The results concurred with existing climatic change model in southern Africa that dry conditions prevailed in the valley in the early 1300s, mid 1500s, 1700s and 1900s, whilst the late 1400s and the 1600s experienced wet conditions (Manyanga 2007).

Smith (2005) used multi-stable isotopes analyses of Bos Taurus and Ovis/Capra from the Shashe-Limpopo. She came up with a new sequence of alternating periods of wet and dry episodes that lasted until about the 1700. Smith's findings open important new insights into the palaeoenvironment of the Shashe-Limpopo.

It is through the analysis of the various proxy environmental data that has increased our knowledge of the palaeoclimate in southern Africa. It has been demonstrated that palaeoclimatic conditions alternated between warmer wetter periods and drier colder periods (Tyson and Lindesay 1992; Huffman 1996; Jonson 1998; Holmgren *et al.* 1999; Holmgren *et al.* 2003; Smith 2005; Manyanga 2007; Shenjere 2011). The major cooler phases were experienced in southern Africa from AD 1300 to 1500 and from AD 1675 to 1850 (Tyson and Lindesay 1992). The period dating from AD 1500 to 1675 was warm and was associated with positive and negative societal developments (Tyson and Lindesay 1992; Jonsson 1998; Manyanga 2007; Shenjere 2011). The cooler and drier periods are thought to have resulted in decline of wealth, particularly cattle whilst the wetter periods resulted in development of states such as the Khami state in western Zimbabwe (Loubser 1991; Huffman 1996a; Manyanga 2007; Shenjere 2011).

2.7 Factors affecting the survival of charcoal in the record

Not all wood survives burning. Charcoal forms in the oxygen depleted part of a fire and some woods burn better than others depending on the properties of the wood such as size, moisture content, chemical composition and taxon anatomical structure (Asouti 2006). Further post-depositional processes affect the charred wood. These post–depositional processes that transform charcoal both quantitatively and qualitatively are trampling, variations in surface exposure and sediment moisture, reheating, chemical conditions of the sediment matrix and bioturbation (Asouti 2006).

Microbial and fungal organisms cause further degradation of charcoal in the soil. This implies that charcoal reacts with organic compounds in the soil solutions, the passive microbial or fungal colonisation of spaces and possibly the active use of some charcoal components by these organisms as metabolic substrates. The *Discomycetes* of the *Ascomycotina* thought to be responsible for charcoal degradation are a group of fungi that grow on burnt wood. These microorganisms are known by various names such as anthracobionts, carbonicous, pyrophilous, fireplace fungi or phoenicoid. These names indicate that they appear after burning in the substrate rich in charcoal material (Moskal-del Hoyo *et al.* 2010). Not all fungal organisms found on archaeological charcoal came about during the post depositional phase, some would have attacked the living tree leading to its death. The dead wood was then collected for fuel. Thus the observation of fungi during anthracological analysis may give additional information concerning models of wood management by past societies and the environment (Moskal- del Hoyo *et al.* 2010). More recently Gelabert *et al.* (2011) and Chrzeazvez *et al.* (2014) studied ethnoarchaeology of wood management and impact of post-depositional processes on charcoal fragmentation respectively.

Gelabert *et al*. (2011) conducted an ethnoarchaeology study of firewood management in the Fang of Equatorial Guinea using field techniques such as participant observation and semi-structured interviews in order to explore the local habitual practices associated with fuel exploitation. The study revealed that the standard PLE could be expanded to incorporate firewood management to the broader economic strategies pursued by a given community. They concluded that perceptions of fuel scarcity amongst the Fang were not determined by net wood species available in the local environment, but that they were integrally linked to the cycles of clearance and regeneration of secondary vegetation in cultivated land.

Chrzazvez *et al*. (2014) explored how the mechanical properties of charcoal influenced fragmentation and quantification of species in anthracological assemblages. Their study combined experimental approach that combined both charcoal analysis and biomechanics. Chrzazvez also carried out laboratory compression tests on 302 samples. Chrzazvez *et al*. (2014) concluded that different anatomical structure of different tested wood taxa had a significant impact on the mechanical properties of charcoal. They also concluded that the temperature at which charcoal was formed influenced the fragmentation of material.

2.8 Charcoal recovery

2.8.1 Flotation

Flotation is a technique for palaeo-ethnobotanical recovery of macro-charcoal remains that was developed by Struever (1968) and is widely recognised as the most efficient way of retrieving different sizes of botanical remains from archaeological sites (Rose 2004 and references therein-Pearsall 2000; Wagner 1988; Miksicek 1987; Hally 1981; Muson *et al.* 1971; Brady 1989). The flotation technique is based on the principle that particles with a relatively low specific gravity float on the surface when stirred in a liquid with a relatively high specific gravity such as water (Rose 2004). The relatively low specific gravity particles are also termed the light fraction. The dense particles (heavy fraction) that sink to the bottom of the container normally comprise inorganic materials and organic materials that are attached to sediments (Rose 2004; Pearsall 2000; Wagner 1988). Authors such as Keepax (1988), Brady (1989), Asouti *et al.* (2003), Wagner (1982), Ford (1979), Lange and Carty (1975), Williams (1973), Jarman *et al.* (1972), Bohrer (1970) and Struever (1968) observed that flotation can destroy plant remains. The charcoal fragments incur a variety of destructive mechanical stresses that may lead to re-fragmentation and subsequent loss of charred plant material. These are impact stresses (that potentially affects charcoal during flotation) and internal static stress that may cause further breakage as charcoal dries out and moisture gradients develop from outer layers towards the wet inner core leading to differential compression and tension stresses.

Some researchers argue in favour of the flotation technique. For example Willcox (1974) argues that the water sieving technique is an unbiased method of recovery in terms of size, shape and distribution and more rewarding in terms of species composition. Flotation is effective for sites with relatively small fragments and low abundance of charcoal. Willcox (1974) employed the flotation method to recover 292 charcoal fragments from four sites by water sieving and trench sampling.

2.8.2 Dry sieving

This is a technique whereby sediments are separated using graded mesh. The mesh with the largest holes is placed uppermost whilst the one with the least apertures occupies the bottom. The dry sieving method was also employed by Prior and Price Williams (1985) when they collected charcoal from Siphiso archaeological site in Swaziland. They preferred the dry sieving to the flotation method for archaeological charcoal. They argued that flotation results in drying and wetting of charcoal that damages fragile excavated charcoal fragments.

2.9 Sampling Charcoal

Sampling of archaeological charcoal is done in order to produce a representative sub-sample (Allott 2005). In addition sampling is carried out when time constraints are taken into consideration.

Various sampling techniques have been used in anthracology. For example Redman (1974) implemented grab or haphazard sampling. In this technique there is no standard way of taking either the sub-sample or a guide for its size. As a result there is no way of knowing how representative the sample is of the whole, or how accurately calculations can be made from the total. Therefore the sample taken in this way cannot be regarded as truly representative of the whole.

Fasham and Monk (1978) and Green (1979) used the cumulative sampling technique. The procedure involves dividing a bag of materials to be examined randomly into subsamples of conveniently small size and arrange these in a random order. Each sample is examined in turn and they record the presence and relative frequencies of different species. As the subsamples accumulate, the running totals or proportions are calculated and plotted on a graph. The first few samples result in the graph fluctuating wildly, but will eventually settle down. Examination of further samples hardly alters the current estimate of species abundance of a particular species. Levelling off of the graph occurs well before all sub-samples have been examined. At this stage sorting can stop (van der Veen *et al.* 1982).

Cumulative curves are commonly used to examine the relation of sub-sample to a parent assemblage (Allott 2005). When a representative sample has been obtained the curve reaches a saturation point at which point further sampling will not yield new data. A cumulative taxa graph is a useful measure of sampling sufficiency with regard to possible discovery of all taxa in a context. The number of fragments is plotted against the cumulative number of taxa (Allott 2005). As the cumulative count approaches its maximum, the graph, which commences typically with a steep gradient, tends to follow a logarithmic curve, flattening off to horizontal as the maximum number of taxa is approached. Sometimes this graph is made after adjusting measurements to a logarithmic scale, a transformation which corrects for upward skewness (typically occurs in the early stages as the first taxa are identified quickly). Cumulative curve plots are useful for acquiring a rough indication of the sample size required (Smart and Hoffman 1988).

In the study of charcoal assemblages from Sibudu, Allott (2005) plotted the cumulative curves to test the adequacy of the analyzed sample. Esterhuysen (1996) employed the same method of cumulative curves. Esterhuysen (1996) argues that the amount of charcoal sampled is determined by the size of charcoal available. In the case of small sample the entire sample maybe analyzed in order to maximize the potential for identifying as high a diversity of species as possible and in situations where there is a large data set then there may be need to extract a sub sample.

The random sampling or the riffle box techniques are also applied in the sampling of archaeological charcoal fragments. This method involves dividing the sample into different categories using graded sieves then selecting random samples from each category (van der Veen *et al.* 1982). It eliminates the subconscious bias being introduced to the subsample (Allot 2005). The method ensures equal representation of different size classes (Allott 2005). Cartwright and Parkington (1997) recovered over 6700 wood charcoal fragments for which they split the whole sample on the riffle principle in order to avoid bias.

The riffle technique is a method that allows sediments to split irrespective of size categories and it can be carried out initially on the basis of volume or weight of the entire wood charcoal from each archaeological context. The subsample can be expressed in terms of volume per litre, fragments or weight. According to Allott (2005) the grab and sample technique can introduce significant biases into the sample being analyzed because the procedures are rarely standardized (van der Veen and Fieller 1982). Allott *(ibid)* also argues that it is difficult to have an idea of how representative a sub-sample is of the assemblage from which it is selected. Allott (2005) argues for the avoidance of the methodology because of the difficulties.

2.10 Charcoal identification by a microscope

Researchers use the scanning electron microscope (SEM) and Light/dark field microscope in anthracology. The charcoal specimens are examined in three different sections that are the Transverse (TS), Tangential Longitudinal (TLS) and Radial Longitudinal (RLS).

2.10.1 Light/dark field microscope

Reflected bright or dark field light is used on hand or blade fractured charcoal surfaces and transmitted light is used for thin sections. Identification is made by comparing the three-dimensional features of the charcoal or wood sections with published sources on wood and with modern charcoal reference material. Some of the studies that applied the use of light/dark field microscopes include charcoal assemblages from Elands Bay Cave (EBC). The EBC charcoal assemblages were identified using an optical microscope using reflected (incident) light on a Polyvar polarizing microscope with dark field capabilities with magnifications ranging from x20 to x1000 (Cartwright *et al.* 1997). A confocal scanning laser microscope was also used for specimens that were in poor condition.

2.10.2 The Scanning Electron Microscope (SEM)

The scanning electron microscope (SEM) has an excellent depth of field and better resolution than optical microscopes. An SEM with magnifications of up to 90 000x is ideal for taking micrographs (Tusenius 1986). It provides high quality and detailed three dimensional images which allow anatomy and preservation of plants to be assessed (Scott *et al.* 2000). The SEM is neither an economic nor time efficient method because preparation of specimens is more complicated than that of the incident light microscope.

2.11 Analytical procedures

Cartwright *et al.* (1997) states that there is no quantitative method currently in use by anthracologists that is entirely satisfactory although expression of relative proportion of taxa present through percentages by weight (grams) provides a certain measure of inter-site comparability. In the same vein the Montpellier School has objectively demonstrated that fragment numbers and weight measurements represent in nearly all cases varying parameters.

The ubiquity analysis is used in anthracology (Willcox 1974; Smart and Hoffman 1988; Thompson 1994). Ubiquity analysis is a presence or absence kind of analysis. It helps in averting the problems of absolute counts/ weight (Rose 2004; Popper 1988; Hubbard 1980, 1976, 1975). Ubiquity analysis lessens the biasing effects of differential preservation and recovery of plant remains at an archaeological site (Rose 2004). Differential preservation has been observed to play a significant role in determining the content of macro botanical assemblage (Rose 2004). According to Rose *(ibid*), a single fragment of a seldom preserved taxon has equal significance to many fragments of commonly preserved taxon. This means that both the commonly preserved and the seldom preserved taxon are recorded as present. Rose (2004), Rocek (1995) and Hubbard (1980) applied the ubiquity analysis in ancient agriculture and anthracology studies. Besides the ubiquity analysis being widely applied in palaeo-ethnobotanical studies, authors such as Rose (2004), Pearsall (2000), Rocek (1995), Kadane (1988) and Popper (1988) acknowledge that the technique does not completely deal with the taphonomical biases. For instance ubiquity analysis may result in an overestimation of taxa that are represented in low numbers since only one specimen needs to be present to be counted in the ubiquity score calculation (Rose 2004 and references therein). In addition Asouti *et al.* (2005) and Popper (1988) argued that the method obscures patterns relating to intensity of fuel exploitation especially when the frequency of use of individual taxa remains broadly the same but abundance changes. Some scholars have even suggested that estimating sample efficiency can be achieved through use of the Ginio-Lorenz concentration curves. This allows the identification of standard numbers of fragments common for most types of analyses, through estimation of generally acceptable levels of accuracy corresponding to different vegetation types.

2.12 Summary

This chapter has given account of anthracological studies in Southern Africa. It also gave some insights into different methods used in anthracology. The next chapter will discuss methods implemented in this study.

CHAPTER THREE

Materials and methods

3 Introduction

This chapter deals with materials and methods for the implemented in order to achieve the aims and objectives of this thesis a number of steps were employed that are in line with charcoal studies elsewhere. These included establishment of a comparative collection for identification of archaeological charcoal, a desktop study of literature on ethnographic study on uses of different trees, and sampling techniques for archaeological charcoal under the custody of National Museums and Monuments of Zimbabwe (NMMZ). Each of these stages or phases required different materials, methods and sampling techniques. A research protocol in figure 5 below was designed to guide the process of data collection and processing.

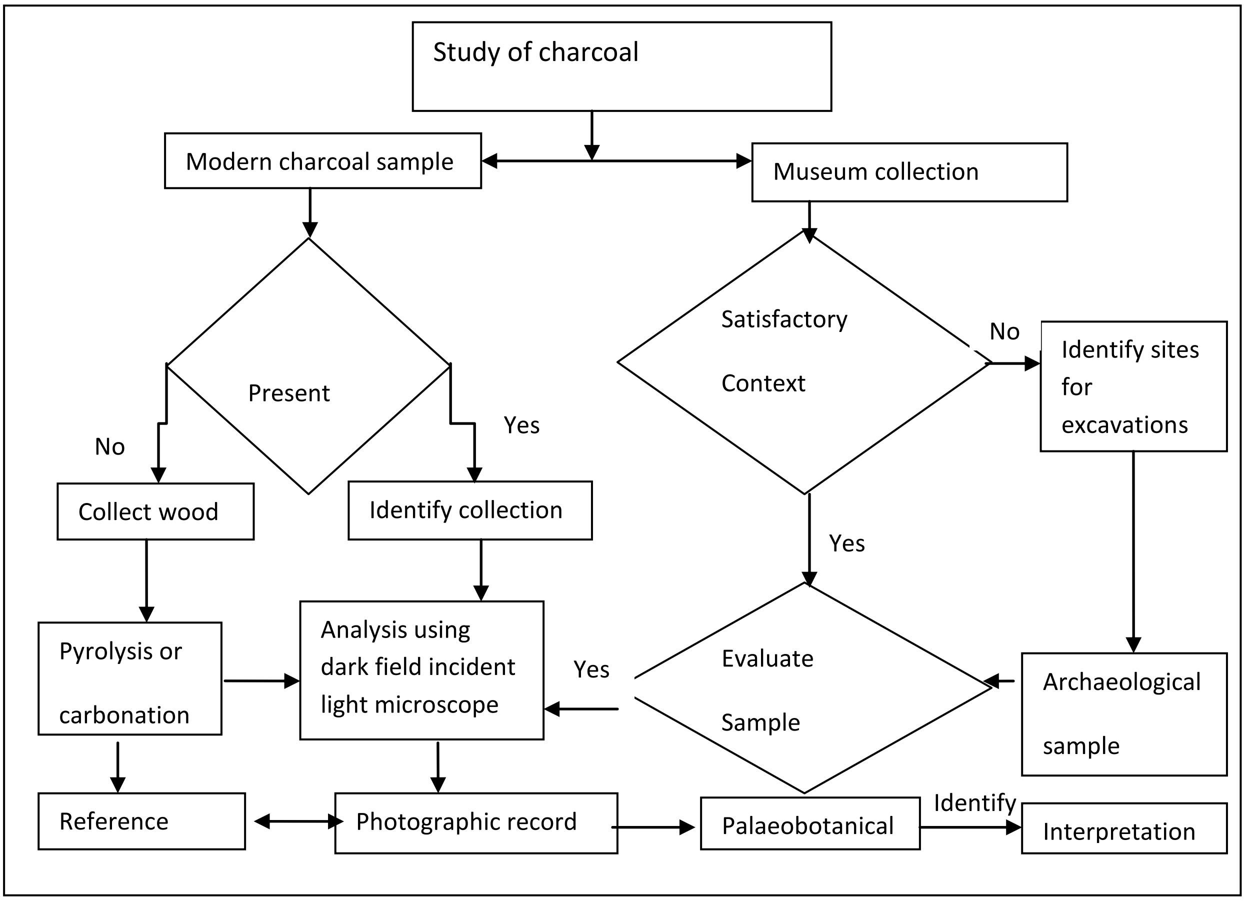


Figure 5: The research protocol

3.1 Charcoal data recovery

Museum collections stored at Great Zimbabwe Conservation Centre and the Museum of Human Sciences were examined for charcoal samples that had been recovered from Great Zimbabwe and Chigaramboni.

3.2 Great Zimbabwe

The charcoal assemblages from different contexts at Great Zimbabwe were collected by means of excavations under different circumstances. Some of the charcoal was recovered from properly planned excavations. This includes charcoal collected by Matenga in 1996 from the Hill Complex, Collett in 1987 from the Barrier Hut, and Robinson (mid 1950s) from the Hill Complex. The samples were handpicked in the trench and some were collected from the sieve. Dry sieving of sediments is a commonly preferred technique because the sandy sediments separate easily from the charcoal. In addition the technique does not damage samples as compared to flotation (Esterhuysen 1996; Prior and Price Williams 1985). The charcoal that was collected through proper excavations however, constitutes a small proportion of the total charcoal assemblage from Great Zimbabwe. The rest of the charcoal was accidentally recovered during conservation and rescue work. Immediately after the attainment of independence in Zimbabwe a comprehensive conservation program was launched at Great Zimbabwe as a way of preserving the World Heritage Site. The programme involved restoration of the stone walling structures at this magnificent site. Charcoal fragments were encountered, handpicked and packed.

3.3 Chigaramboni metallurgical site

The charcoal from Chigaramboni was excavated by Webber Ndoro around 1993/4. Unlike Great Zimbabwe all the charcoal recovered there was done by proper excavations whereby trenches and test pits were sunk and then systematically excavated. The charcoal fragments were either handpicked in the trench or recovered from the sieve by means of dry sieving. The recovery of charcoal was not done with the idea of anthracological study but for radiometric purposes. In fact the furnaces were excavated in order to understand the significance of symbolism on furnaces and the different types of furnaces. After the charcoal had been collected it was packed in khaki bags and allocated accession numbers and then stored at Great Zimbabwe Conservation Centre.

3.4 Sampling charcoal

The choice of where to sample was dictated by the research questions and objectives of the thesis. Thus samples drawn from contexts with the potential to provide reliable information on long term patterns of vegetation change and fuel exploitation were targeted and prioritised (Table 1 below). In order to provide answers to questions about the socio-economic significance of wood sampling of hut floors, hearth and metallurgical working contexts was done. Questions relating to past environments on the other hand necessitate the systematic sampling of charcoal from both the horizontal and vertical layout of the site in order to obtain a reasonable resemblance of past environments (Tusenius 1986; Esterhuysen 1996). According to Figueiral (1995) dispersed charcoal data provides reliable palaeoenvironmental information while concentrated charcoal is usually heavily biased by human behaviours (Figueiral 1995), hence the decision to sample from the two sites of Great Zimbabwe and Chigaramboni.

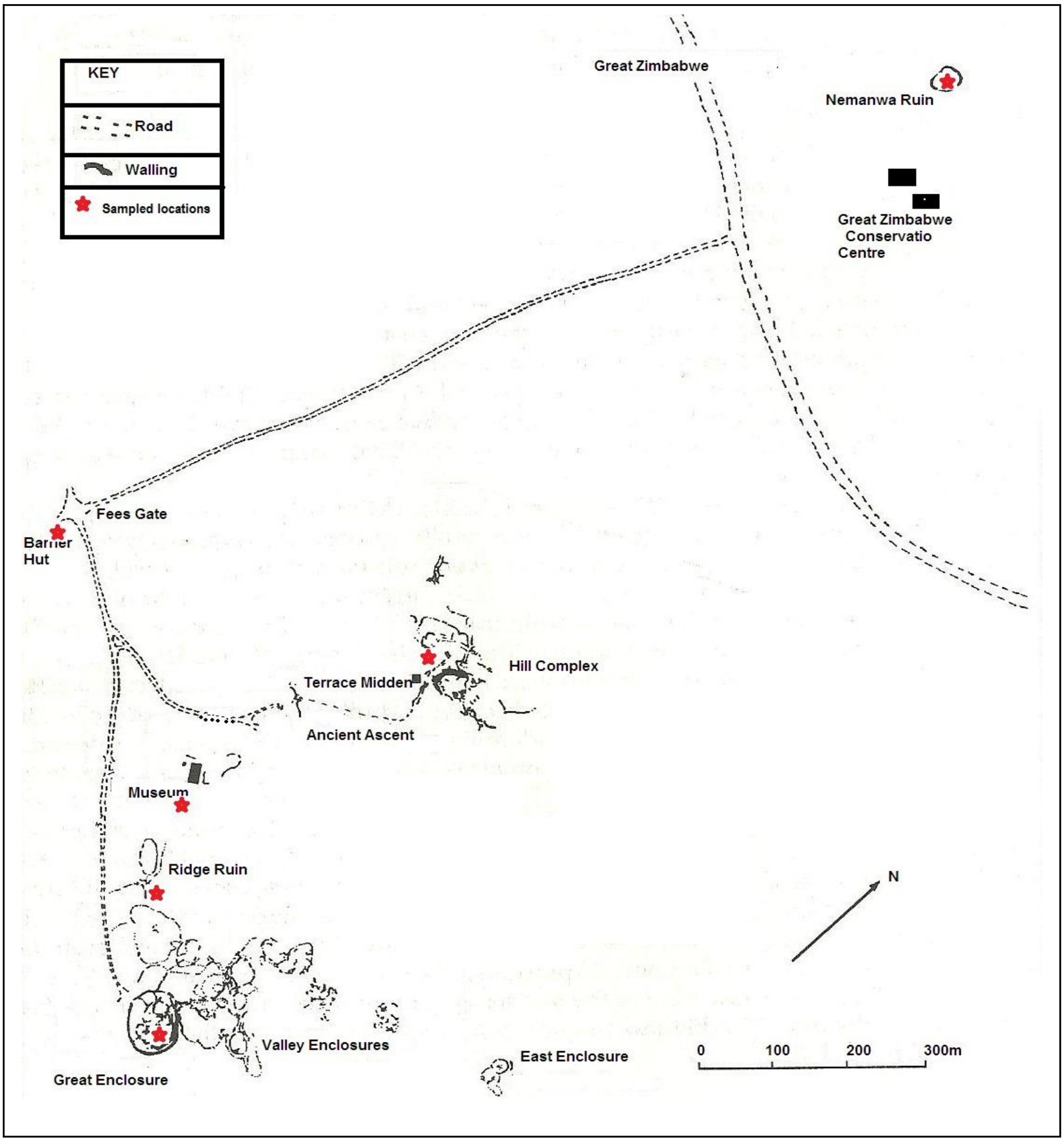


Figure 6: Charcoal sampling contexts at Great Zimbabwe (modified after Thorp 1995).

The nature and complexity of the site of Great Zimbabwe in terms of size and different activity areas determined where samples were to be drawn. Charcoal assemblages that had been recovered within and outside the stone walls were targeted in order to come up with an intra-site comparison between contexts and or excavated levels; equally important was the size range of the fragments chosen for analysis. Choosing large fragments alone ran the risk of overlooking naturally small sized taxa, for example, shrubs/branches, and twigs. Figure 6 above shows the contexts from which the charcoal assemblages were obtained.

Graded sieves were used in this project to sub-sample charcoal fragments approximately 450µm in size. In general sampling a greater diversity of contexts will retrieve more charcoal taxa and provide a more representative selection than over-analysing fewer, larger samples. Choosing a suitable sub-sampling strategy involves reaching a decision on the number of fragments to be examined (Smart and Hoffman 1988). In practice such a decision should allow recovery of an adequate charcoal flora, without at the same time compromising the need for the examination of as many samples as possible within the available time. Sub-sampling of the charcoal assemblages was motivated by the NMMZ policy that requires only a third of the collections to be loaned out. In addition sub-sampling was exercised for conservation purposes and time. Given that this thesis had to be completed within three years it was necessary that sampling strategies were put in place in order to meet the deadline.

Table 1: Archaeological charcoal from Great Zimbabwe and Chigaramboni

Site Name	Site Number	Context	Collection Method	Collector	Quantity	Acc Number	Two Thirds Of total charcoal Sample
Great Zimbabwe	2030:Bd:Tm1	Terrace Midden	Exc		10	SN1150-96	6.6
Great Zimbabwe	2030:Bd:Bh	Barrier Hut	Exc		5	SN1102-96	3.3
Great Zimbabwe	2030:Bd:Bh	Barrier Hut	Exc		35	SN1143-96	23.3
Great Zimbabwe	2030: Bd?	?	?		10	SN263-96	6.7
Great Zimbabwe	2030:Bd:Wv:1	Great Enclosure	?		1	SN1108-96	0.7
Great Zimbabwe	2030:Bd:Tp	Terrace Path	Exc		11	SN1173-96	7.3
Great Zimbabwe	2030:Bd:Lm:1-3	Lightning Mast	Exc		23	SN1131-96	15.3
Great Zimbabwe	2030:Bd:1	Plateau Passage	Exc	Thorp 1984	5	QMIA1294	3.3
Great Zimbabwe	2030:Bd:Wv:1	Great Enclosure	Exc		12	SN1179-96	8
Great Zimbabwe	2030: Bd?	Acropolis/Hil l Complex	Ex c	Robinson 1954	50	QMIA1691	20
Great Zimbabwe	2030:Bd				2	QMIA1721	4
Great Zimbabwe	2030:Bd:W8:T1:L 3	Hill Complex Wall8	Exc		8	SN274-96	5.3
Great Zimbabwe	2030:Bd:W8;T1:L 5	Hill Complex Wall8	Exc		10	SN293-96	6.7
Great Zimbabwe	2030:Bd:W8:T1:L 5	Hill Complex Wall8	Exc		2	SN296-96	1.3
Great Zimbabwe					6	SN484-96	4
Great Zimbabwe	2030: Bd?	Hill Complex Northern Shelter	Exc		6	SN1516-97	4
Great Zimbabwe	2030: Bd?	?	Exc		34	QMIA1722	5
Great Zimbabwe	2030:Bd:Nr:T1:L6	Nemanwa Ruin	Exc		6	SN353-96	4

Great Zimbabwe	2030:Bd:Nr:T1:L5	Nemanwa Ruin	Exc	5	SN348-96	3.3
Great Zimbabwe	2030: Bd?	1a	Exc	11	QMIA1721	4
Montevideo				24	2030BC:02	34
Great Zimbabwe	2030:Bd:Tm1	Terrace Midden	Sur	7	SN245-96	4.7
Great Zimbabwe	2030:Bd:Nrs:T1:L 2	Hill Complex Northern Shelter	Exc	2	SN1503-96	1.3
Great Zimbabwe	2030:Bd:Nrs:T1:L 1	Hill Complex Northern Shelter	Exc	2	SN1475-96	1.3
Great Zimbabwe	2030bd:Bh69	Barrier Hut	Exc	23	SN22-98	15.3
Great Zimbabwe	2030: Bd: Lm?	Lightening Mast	Exc	15	SN1217-96	10
Great Zimbabwe	2030:Bd:Tpw:1	Terrace	Exc	8	SN1092-96	5.3
Great Zimbabwe	2030:Bd:Hc:W20	?	Exc	10	SN1700-97	6.7
Great Zimbabwe	2030: Bd: Nrs?	Hill Complex Northern Shelter	Exc	14	SN1589-97	9.3
Great Zimbabwe	2030: Bd: Nrs?	Hill Complex Northern Shelter	Exc	1	SN1546-97	0.7
Great Zimbabwe	2030:Bd:W8	Hill Complex Wall8	Exc	15	SN1415-96	10
Great Zimbabwe	2030:Bd:Bh	Barrier Hut	Exc	9	SN1391-96	6
Chigaramboni	2030:Bd:Cb1	?	Exc	1384	SN1624-97	922.7
Great Zimbabwe	2030:Bd	?	Exc	120	SN394-98	80
Chigaramboni				1305	SN394-98	870
Great Zimbabwe				4	SN430-90	2.7
Great Zimbabwe				10	SN274-96	6.7
Great Zimbabwe	2030:Bd:Er:W30	Eastern Ruins?	Exc	1	SN413-99	0.7
Great Zimbabwe	2030: Bd?	?	Exc	8	SN36-98	5.3
Great Zimbabwe	2030bd:Pl:T1:L1	Platform	Exc	12	SN395-96	8
Great Zimbabwe	2030bd:Wv	Great Enclosure	Exc	22	SN334-96	14.7
Total				3248		2151.5

Exc= excavation

3.5 Laboratory preparation of archaeological charcoal

The fracturing technique for preparing macro charcoal samples was applied in this project. The technique was developed for rapid identifications of archaeological charcoals. Specimens were fractured by manually snapping or pulling apart the fragment of charcoal between the fingers and along the transverse (TS), tangential longitudinal (TLS) and radial longitudinal sections (RLS) for observation. The resultant planes are inevitably irregularly shaped. The fragments were then fixed on a standard glass slide using Prestik. Prestik (a commercially available tacky substance for poster mounting) offered sufficient support for the charcoal specimens under observation. It also allowed easy adjustment of the angle and orientation of the specimen for an even plane of focus. Specimens were observed with a compound microscope equipped with reflected light objectives of x5, x10, and x20. The fracturing technique was preferred because it is quick, simple and enabled the identification of large numbers in a relatively short time as compared to the embedding procedure. The fracturing technique is relatively less destructive since the specimens are not ground down and the charcoal can be used afterwards for other purposes such as radiometric or isotopic analysis (Dimbley 1967). Traces of prestik can be removed and the cleaned charcoal specimens can be used for dating. There is an inherent problem though of fracturing charcoal for microscopy as the prepared surface is very rarely, if ever, absolutely flat, but the results were satisfactory.

3.6 Field and laboratory equipment for collecting and processing reference woods

The following equipment was used in the establishment of a reference collection:

1. Pruning saw
2. Indelible pens/paper/plastic tape for labelling
3. Large plastic bags
4. Flower/leaf press (optional – acid free tissue and some heavy books will do) for herbarium vouchers
5. Aluminium foil (to char wood in furnace)
6. Storage bags for each taxon
7. Muffle furnace

3.7 The reference collection

An adequate comparative collection of identified modern woods had to be established to aid with identification of archaeological charcoal. A study of the modern habitats, ecological status and uses of species in the area around Great Zimbabwe and Chigaramboni today had to be undertaken to provide a baseline from which one can extrapolate into the past. The description of the reference collection adhered strictly to the definition of anatomical features published by the International Association of Wood Anatomists (IAWA) committee (Wheeler *et al.* 1989) and descriptions in Bamford (2005). It was born in mind that differing soil substrates, altitudes edaphic factors- variations due to these factors are on occasion visible in anatomical structure (Cartwright *et al.* 1997; Zimmerman 1983; Barefoot and Hankins 1982; Rendle and Clark 1934).

The decision on where to sample for modern vegetation specimens at Great Zimbabwe and Chigaramboni was preceded by a detailed understanding of various ecological habitats, especially at Great Zimbabwe where streams, valleys and mountainous or hilly conditions prevail. Thus where to sample was to a greater extent determined by these environmental parameters. A team of four to five persons was assembled and walked in transects with members being 10 meters apart. The valleys and hills of Great Zimbabwe were traversed and collected specimens not previously collected. Eleven transects were traversed in the study of the vegetation from Great Zimbabwe and Chigaramboni all combined. This was so because of the need to cover for the variations that existed in vegetation. Therefore all plant species were recorded until no new species were encountered within the defined area. This method ensured an adequate area to record species is sampled. The nomenclature of the trees followed Coates-Palgrave (2002) and van Wyk and van Wyk (1997). Most patches of vegetation were dominated by different types of trees. Much of the vegetation in the study area falls within the moist *Brachystegia* savanna woodlands. The specimens (15-25cm long and 0.7 -2.8 cm in diameter) were collected from mature branches of trees. Samples could have been collected from larger branches but this would have resulted in the destruction of the whole tree in some cases. Therefore to be consistent collection of samples from branches was done for conservation reasons. The trees were identified with the assistance of Professor Marion Bamford.

A total of 149 specimens were collected from the two sites of Great Zimbabwe and Chigaramboni. The specimens were then allowed to dry naturally and others had to be further dried in an oven at 100^{o}C for at least 12 hours. The dried specimens were then cut into pieces varying from 1cm to 15cm long. The specimens were then wrapped in aluminum foil with the specimen number marked on both sides of the foil. Charring was done in a Lenton muffle furnace at 350^{o}C for 2 ½ hours.

Charring of wood results in shrinkage of the anatomical structure by approximately 1/6. Despite the shrinkage and distortion caused by charring process the anatomical structure is sufficiently well preserved to show the diagnostic features which assist in identification to taxon (Mcginnes *et al.* 1971). The charred specimens from Great Zimbabwe and Chigaramboni were then prepared for microscopic anatomical analysis and identification by manually fracturing into three different planes.

The charred specimens were identified using a Zeiss Stemi, high power Olympus BX51 microscope with dark field at magnifications of x50, x100 and x200. The transverse planes were identified at x50, x100 and x200 all the times whilst the transverse longitudinal planes were mostly analysed at a magnification x200, and rarely identified at x50 –x100. Only specimens with huge ray widths were identified under the latter. The radial longitudinal section of different specimens was first viewed at a magnification of x100 and then at x200. Microphotographs were taken using an Olympus SC30 camera mounted on the Olympus BX51 petrographic microscope (with light and dark field) and connected to a computer for image storage and analysis.

The computer was installed with an Olympus Imaging Solutions Software. The software allows image acquisition, archiving and analysis. It also offers interfacing to the microscope and camera. The Imaging Solutions application software has a function known as the Extended Focal Input (EFI). The EFI function if activated puts every separate image through the EFI procedure during its acquisition. In the end an EFI image will be calculated from the series of different images. An EFI image is therefore an image that has been calculated in such a way that it is sharply focused everywhere.

A data recording sheet was used for recording different anatomical features that were observed under different magnifications. Sketches of the anatomical features were done together with taking of micrographs. A detailed micro-photographic database of the charred specimens was established. The determination of wood taxa of charcoal follows IAWA (Wheeler *et al.* 1989) procedures. A reference collection of charred known woods that had been earlier established in the study was essential for the identification of archaeological specimens because it is more complete for this study except for a few taxa that were missing. An online Inside Wood database was also used in the identification of archaeological charcoal specimens. The Inside Wood database was not always helpful as some taxa are presented in the form of images (e.g. *Acacia burkei*, *Brachystegia spiciformis*, *Combretum erythrophyllum*, *Faurea macnaughtonii*, *Faurea saligna*, *Schotia brachypetala and many others)* or completely missing (e.g. *Brachystegia boehmii*, *Colophospermum mopane etc.)*. The quantity of each taxon was determined by counting the number of pieces.

3.8 Charcoal identification by a microscope

Expertise in identification enabled identification of charcoal assemblages from Great Zimbabwe and Chigaramboni. It enabled analysis of small fragments of wood charcoal as long as the preservation condition of the fragments was good. In most cases adequate and sufficient diagnostic features were recorded. The charcoal assemblages were identified at magnification of x50, x100 and x200. The transverse planes were identified at x50, x100 and x200 all the times whilst the tangential longitudinal planes were mostly analyzed at a magnification x200, and rarely identified at x50 –x100. Only specimens with huge ray widths were identified under the latter. The radial longitudinal section of different specimens was first viewed at a magnification of x100 and then at x200. Microscopic anatomical features were studied. The studied features included growth ring boundaries, wood porosity, vessels per square millimeter, parenchyma types, rays (ray width, height, cellular composition, storied structure), fibres (septate fibre, fibres with simple pits), tracheids (vascular/ vasicentric tracheids), and tyloses.

3.9 Materials

The following list of equipment was used in the processing of specimens in the laboratory.

1. Olympus BX51 microscope with eye piece WHN 10x/22 lenses and stage lenses of 5x/0.15 BDP, 10x/0.25BDP and 20x/ 0.40 BDP lenses
2. Olympus SC30 camera
3. Computer
4. Olympus Imaging Analysis application Software
5. Microscope slides, prestik (holds charcoal in place), range of scalpel(s) and blades for fracturing charcoal.
6. Aluminium foil and plastic bags for storing fragmented and identified charcoal; larger storage bags for storage
7. Indelible markers

Archaeological charcoal samples will be returned to the National Museums and Monuments of Zimbabwe. The modern reference charcoal samples and herbarium voucher sheets will be added to the collection housed in the palaeobotany herbarium of the Bernard Price Institute, University of the Witwatersrand.

3.10 Summary

In this chapter recovery, sampling and sub-sampling methods that were implemented in this study were discussed. The next chapter deals with modern vegetation collected from Great Zimbabwe, Chigaramboni and the areas around them.

CHAPTER FOUR

The Modern Vegetation

4 Introduction

This chapter provides descriptions of the vegetation currently growing at Great Zimbabwe and Chigaramboni. The list of taxa, their ecological habitats and uses are presented in this Chapter as well.

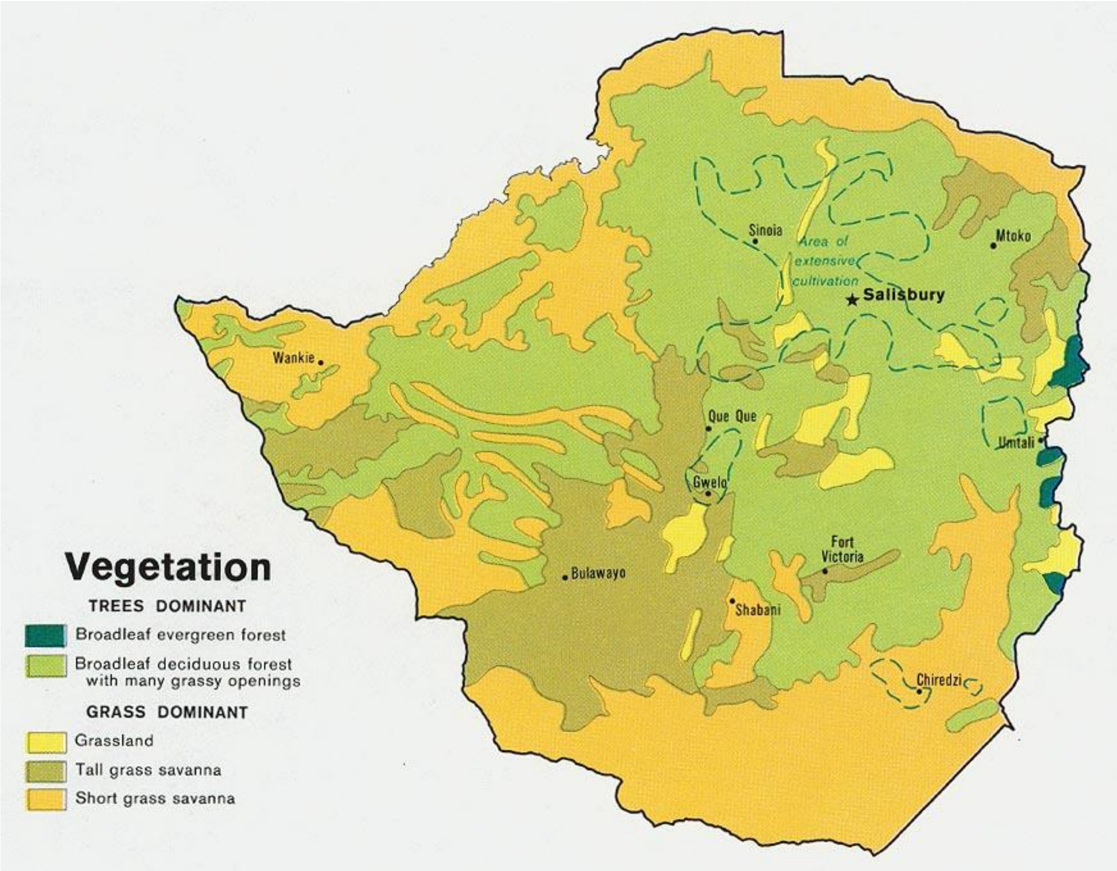


Figure 7: The vegetation map of Zimbabwe (Source: http://www.lib.utexas.edu/maps/africa) Fort Victoria is now called Masvingo and the sites are just to the south.

4.1 The modern vegetation

The modern vegetation of Great Zimbabwe is typical *miombo* woodland reflecting the savannah, grasslands and tree, and shrub biomes that are typical of Zimbabwe (Figure 3 above). Great Zimbabwe archaeological site is located within the southern *miombo* woodlands ecoregion. It lies within ecological zone 2b. The vegetation occurs in soils that are derived from granite. The vegetation is *Brachystegia/Julbernardia* or *miombo* woodland savanna. The southern *miombo* woodlands ecoregion mixes with *Colophospermum mopane.* The *Colophospermum mopane* is dominant to the west and southern parts of Chigaramboni which is warm and dry.

The study area experiences a tropical savanna climate with distinct seasons that are, hot dry season, hot wet season, warm and dry. Rainfall is highly seasonal with marked winter droughts (Cole 1986). Rainfall is received in October and persists well into April-May (Bannerman 1982). Much of the rainfall around Great Zimbabwe comes in the form of mist, locally known as *guti* that comes with the southeast trade winds (Pikirayi 2005; Bannerman 1982). *Miombo* communities are dominated by trees belonging to the family of the *Caesalpiniaceae* that is dominated by *Brachystegia* and *Julbernardia* species but there is a great diversity in tree species. The diversity of the content of the vegetation particularly at Great Zimbabwe has been affected to a greater extent by the management regime of the monument (Ndoro 2001). Historically vegetation was seen as a major problem for the stone structures from aesthetical and conservation viewpoints. This point is reinforced by the work of R N Hall who was concerned partly with the clearance of vegetation. Thus clearing of vegetation at Great Zimbabwe has had a lasting effect on the local species composition.

In addition the area around Great Zimbabwe has been for a long time inhabited by the Nemanwa, Charumbira and Mugabe people who have trees that they consider important in communicating with their ancestors. Some of these are within the present day designated monument.

The overall picture of the present day vegetation in the study area has been established using the writings of Theodore Bent (1896), Carl Mauch (1876), Ndoro (2001) and Bannerman (1982). Chikumbirike (present study) also contributed to the establishment of the list of tree species in Table 2 below that are currently growing within Great Zimbabwe, Chigaramboni and the areas around them.

Table 2: List of modern tree species identified at Great Zimbabwe.

CH= Chikumbirike collection, BN= Bannerman and Ndoro collection, MB= Mauch and Bent collection, x= taxon present.

Family	**Genus & Species; author***	**CH**	**BN**	**MB**	**Habit, habitat and uses**
	Polypodiodes- (Viene de Frutales)		x		Tree/
	Verbena/Solanum??	x			Shrub
Anacardiaceae	*Lannea discolor* (Sond) Engl.	x	x		Tree occurring in bushveld, often on rocky ridges or termitaria (McCallum 1976; van Wyk & van Wyk 1997; Ndoro 2001)
Anacardiaceae	*Lannea edulis* (Sond.) Engl		x		Edible fruit (Ndoro 2001)
Anacardiaceae	*Ozoroa obvata* (Hook. f. ex Oliv.) Engl.	x			Tree/shrub usually associated with coastal dune bush, but also occurs in bushveld (van Wyk & van Wyk 1997)
Anacardiaceae	*Ozoroa paniculosa* (Sond.) R. Fern. and A. Fern.	x			Tree occurring in bushveld, often on rocky hillsides (van Wyk & van Wyk 1997). The bark is used for dyeing leather.
Anacardiaceae	*Ozoroa reticulate* (Baker f.) J. B. Gillet		x		
Anacardiaceae	*Protorhus longifolia* (Bernh.) Engl.	x			Tree occurs in forest along forest margins, in open woodland and river banks. The wood provides general purpose timber. The exudates from the bark are used to fix assegai blades in their handles and also as a depilatory (Palgrave 2002; van Wyk & van Wyk 1997). The bark is used medicinally.

Anacardiaceae	*Rhus chirindensis* Baker f.	x			Tree/shrub occurs in a variety of latitudes that are stony hillsides and open woodland to mountain scrub and forest, frequently along streams and in coastal and inland forests (van Wyk & van Wyk 1997; Palgrave 2002).
Anacardiaceae	*Rhus pyroides* Burch.	x			Shrub or small sized tree occurring in a wide variety of habitats, from coastal dunes through montane grassland and bushveld to semi –desert areas (van Wyk & van Wyk 1997). Roots are used for medicinal purposes.
Anacardiaceae	*Sclerocarya birrea* (A.Rich.) Hochst.	x	x		Tree occurring in bushveld and woodland. The bark is used for medicinal purposes and as a dye. Fruits and kernels are edible (McCallum 1976; van Wyk & van Wyk 1997; Ndoro 2001).
Annonaceae	*Annona senegalensis* Pers.	x	x		Tree occurring in bushveld, usually on sandy soils or along rivers. Bark, leaves and roots are used for medicinal purposes. The fruits are edible (van Wyk & van Wyk 1997; Dery *et al.* 1999; Ndoro 2001).
Annonaceae	*Artabotrys brachypetalus* Benth		x	x	Climber, shrub or low-spreading tree. Edible fruits. Occurs in hot, dry low altitude areas and along rivers or streams (Coates Palgrave 2002).
Apocynaceae	*Carissa edulis* Vahl	x			Shrub or small tree occurring 300 -1950 m above sea level. It also occurs in bushveld (van Wyk & van Wyk 1997). Roots are used as medicines. It is also used to kill intestinal worms in man and cattle. The fruits are edible (van Wyk & van Wyk 1997).
Apocynaceae	*Diplorhynchus condylocarpon* (Mull.Arg.) Pichon	x			Shrub or small tree found in altitudes from 320-1600 m. It also occurs in bushveld, often on rocky ridges and sandy soils. Leaves and roots are used in traditional medicines. The latex is used as bird lime and also applied to hides of drums to improve their quality (McCallum 1976; van Wyk & van Wyk 1997; Dery *et al.* 1999).
Apocynaceae	*Rauvolfia caffra* Sond	x	x		Tree occurring in riverine bush and along forest margins. Bark and latex are used for medicinal purposes. The wood is used in carpentry (van Wyk & van Wyk 1997). .
Araliaceae	*Cussonia arborea* Hochst.ex A.Rich	x			Tree occurs in *Brachystegia* woodland often on rocky places. The wood is used in making traditional xylophone keys (van Wyk & van

					Wyk 1997).
Araliaceae	*Cussonia kirkil*		x		Used in wood carving (McCallum 1976)
Araliaceae	*Cussonia natalensis* Sond		x		Tree occurs in the altitudes from 100-1640 m above sea-level
Araliaceae	*Cussonia spicata* Thunb		x		Tree occurring in bushveld, on forest margins and on rocky outcrops in grassland (van Wyk & van Wyk 1997). The root is used for medicinal purposes.
Asteraceae	*Brachylaena discolor* DC.		x		Shrub or small tree occurring in coastal bushveld. The wood is used for construction purposes (van Wyk & van Wyk 1997).
Asteraceae	*Brachylaena rotundata* S. Moore	x	x		Shrub or small tree occurring in bushveld, usually in rocky places (van Wyk & van Wyk 1997; Ndoro 2001).
Asteraceae	*Vernonia myriantha-* Hook.f.		x		Spreading shrub or small tree found in moist localities, evergreen forest margins, high rainfall woodland, riverine vegetation or open mountain grassland. Leaves toxic to stock (Coates Palgrave 2002).
Bignoniaceae	*Kigelia africana* Benth	x			Tree occurs in forest and wooded riversides or on rocky outcrops in grassland. It occurs in low altitude in open woodland and along riverbanks. It is common on alluvial soils. The fresh and dry fruits are pulped or powdered and applied to wounds, sores and ulcers (Venter *et al.* 1996, van Wyk & van Wyk 1997). It is used as an ingredient in cosmetics. The tree has been traditionally used to treat syphilis. It contains quinones and coumarins which is likely to be responsible for antibacterial and skin healing effects (Venter *et al.* 1996; van Wyk and Gericke 2007). The fruits also treat rheumatism. Ripe fruits are baked to add fermentation, ulcers, sores, increases lactation and powdered fruits are rubbed on the bodies of babies to make them fat (Dery *et al.* 1999*).*
Bignoniaceae	*Markhamia acuminata* K Schum Now *M. zanzibarica*		x	x	Shrub or tree occurring in bushveld, usually on rocky hillsides and in riverine fringes. The roots are used for medicinal purposes (van Wyk & van Wyk 1997).
Bignoniaceae	*Podranea brycei-* (N.E.Br.) Sprague		x		Woody climber occurring in bushveld (van van Wyk & van Wyk 1997; Ndoro 2001).
Boraginaceae	*Cordia africana* Lam	x			Tree/shrub occurs in the following altitudes 730-745 m above sea-level.
Boraginaceae	*Cordia monoica* Roxb	x			Shrub or small bushy tree that occurs in bushveld and thicket, often on floodplains and termitaria (van Wyk & van Wyk 1997).

					The fruit is edible.
Burseraceae	*Commiphora schimperi* O Berg	x			Shrub or small tree that occurs in hot arid bushveld, usually on sandy soil. The bark is used medicinally. The twigs were once used to start fires (van Wyk & van Wyk 1997).
Burseraceae	*Commiphora sp* Jacq		x		Shrub or small tree occurring in bushveld and thicket, usually in rocky areas or near streams.
Caesalpiniaceae	*Bauhinia sp.*	x			Tree
Caesalpiniaceae	*Bauhinia galpinii* N. E.Br.		x		Tree/shrub occurring in altitudes from 25-1400 m above sea-level. Used as an ornamental plant (van Wyk & van Wyk 1997).
Caesalpiniaceae	*Afzelia quanzensis* Welw		x	x	Tree occurring in hot and arid bushveld and sand forest, usually on deep sand. Bark and roots are used medicinally. The wood is used for furniture (McCallum 1976, van Wyk & van Wyk 1997; Dery *et al.* 1999).
Caesalpiniaceae	*Brachystegia glaucescens* Hutch and Burtt Davy	x	x	x	Tree occurring on the slopes and summits of rocky hills. The tree is suitable for general purpose timber. It is also used as firewood (van Wyk & van Wyk 1997).
Caesalpiniaceae	*Brachystegia spiciformis* Benth.	x	x	x	Tree tolerates a wide range of soil types. The wood is suitable as general purpose timber whilst the bark fibre is used for ropes. The bark is used in tanning hides. An infusion of the roots is used medicinally as treatment for dysentery and diarrhoea, whilst a decoction is applied to the eyelashes in case of conjunctivitis. The wood is widely used as fuel (Drumond and Palgrave 1973; Palgrave 2002; van Wyk & van Wyk 1997).
Caesalpiniaceae	*Burkea africana* Hook.	x	x		Tree occurs in various types of woodlands over a wide range of altitudes and habitats, but most characteristic of hot low lying areas (Palgrave 2002) the wood is hard and tough. It occurs in bushveld often on deep sandy soils. The root and bark are used in tanning hides. It is used in furniture and parquet blocks. *Burkea africana* is host to a species of caterpillar of *Carina* which are dried and then consumed as relish (van Wyk & van Wyk 1997). Medicinally the bark is chewed and used as poultice to septic sores.
Caesalpiniaceae	*Julbernardia globiflora* (Benth.) Troupin	x	x		Tree occurs in mixed woodland, frequently co-dominant with *Brachystegia spiciformis* in miombo woodland (van Wyk & van Wyk 1997). The wood is used as a general purpose timber and also in making mortars and canoes. The bark is used for rope. The fibre and rope is of poor quality, and the bark is used to make *gudza* cloth (Palgrave 2002; van Wyk & van Wyk 1997; van Wyk and Gericke 2007).

Caesalpiniaceae	*Piliostigma thonningii* (Schumach) Milne Redh	x	x		Tree occurring in bushveld, usually on sandy soil. It also occurs in altitudes between 250-1525m above sea- level. Used medicinally. The bark is used as twine whilst the pods are pound to make a meal rich in Vitamin C (van Wyk & van Wyk 1997; Dery *et al*. 1999; Ndoro 2001)
Caesalpiniaceae	*Schotia brachypetala* Burtt Davy	x			Tree occurring in bushveld and scrub forest, often on river banks or on termitaria. The bark is used medicinally and in tanning (van Wyk & van Wyk 1997)
Cannaceae	*Canna indica* L		x	x	Perennial herb. Not indigenous.
Capparaceae	*Maerua angolensis* DC		x	x	Tree/shrub occurring in bushveld, usually at low altitude of between 5-1220 m above sea-level (van Wyk & van Wyk 1997).
Celastraceae	*Gymnosporia buxifolia* (L.) Szyszy l	x			Shrub or small tree occurring in a wide range of habitats, often as a pioneer in disturbed places or along forest margins The wood is used in making tool handles (van Wyk & van Wyk 1997).
Celastraceae	*Maytenus senegalensis* (Lam) Loes	x			Shrub or small tree occurring in bushveld. The root is used for medicinal purposes (van Wyk & van Wyk 1997).
Celastraceae	*Maytenus undata* (Thunb). Blakelock	x	x		Tree/shrub occurs in forest and bushveld, often in rocky places. It is also found in altitudes between 5-2225m above sea- level. The wood was once used in wagon building (van Wyk & van Wyk 1997).
Celtidaceae	*Celtis africana* Burm.f.	x	x		Tree/shrub occurring in altitudes from 4-2160 m above sea-level. Tree occurs in forest, bushveld and grassland often on dolomite. Widely planted as shade tree in gardens (van Wyk & van Wyk 1997).
Chrysobalanaceae	*Parinari curatellifolia* Planch. Ex Benth	x	x		Tree occurs in altitudes of 500-1500 m above sea-level. (van Wyk and Gericke 2007). It grows in bushveld areas, usually deep sandy soils underlain by poorly drained soils (Venter *et al.* 1996; van Wyk and van Wyk 1997). It is an indicator of high water table and poor drainage. The fruit is eaten fresh, made into beer and the kernels are opened and the nuts are eaten alone or mixed with green vegetables as relish (Venter *et al.* 1996; van Wyk and van Wyk 1997; van Wyk and Gericke 2007). The bark is used in tanning and medicinally. The wood is used for general purpose timber. It is used in rituals like rainmaking (McCallum 1976; Palgrave 2002; van Wyk & van Wyk 1997; Ndoro 2001; Chitemerere *et al.* 2011).
Clusiaceae	*Garcinia buchananii* Baker	x			Tree occurs in open woodland and also along forest margins, often on granite outcrops. The bark is used for medicinal purposes. The fruit is

					edible and is rich in Vitamin C, used to prepare sour milk. The wood is used in curving (van Wyk & van Wyk 1997).
Combretaceae	*Combretum erythrophyllum* (Burch). Sond	x			Tree occurring mainly along river banks. The seed is used to purge dogs of intestinal worms. The wood is suitable for general purpose timber. The gum can be used as varnish (van Wyk & van Wyk 1997).
Combretaceae	*Combretum molle* R.Br.ex G.Don	x	x		Tree occurs in bushveld or in sheltered rocky places in grassland. The wood is suitable for household utensils, house building and tool handle making. The leaves and roots are used medicinally (van Wyk & van Wyk 1997).
Combretaceae	*Pteleopsis* ENG1		x		Tree occurs in hot and low altitudes between 20 -1050 m above sea-level. The wood is good for furniture, and construction (van Wyk & van Wyk 1997).
Combretaceae	*Terminalia mollis* M.A.Lawson	x	x		Tree occurs in bushveld often in association with *Colophospermum mopane* and *Brachystegia* (van Wyk & van Wyk 1997).
Combretaceae	*Terminalia sericea* Burch.ex DC	x	x		Tree that occurs in altitudes from 45-1920 m above sea-level. It also occurs in bushveld, on sandy soils and in dense strands. It roots are widely used for medicinal purposes. The wood is used for general purpose timber (van Wyk & van Wyk 1997; Dery *et al.* 1999).
Cyatheaceae	*Cyathea dregei* Kunze		x		Tree occurs in altitudes from 60- 1700m above sea-level and forest margins and along streams in ravines and montane grasslands (van Wyk & van Wyk 1997).
Dipterocarpaceae	*Monotes glaber* Sprague	x			Tree occurs in open woodland, often sandy soils. The roots are used medicinally and the wood is used in making furniture (van Wyk & van Wyk 1997).
Ebanaceae	*Diospyrois lycioides* Desf	x			Shrub/tree occurs in a variety of habitats and altitudes between 12-2140m above sea-level. The roots are used as tooth (van Wyk & van Wyk 1997).
Ebenaceae	*Diospyros mespiliformis* Hochst		x		Tree occurring in altitudes from 210-1300m above sea-level, bushveld, often on floodplains along rivers or on termitaria. The heartwood is suitable for furniture, the fruit is edible and the leaves and roots are used medicinally (van Wyk & van Wyk 1997; Ndoro 2001).
Ebenaceae	*Diospyros sp*? De Winter, Hochst,	x			Shrub
Ebenaceae	*Euclea divinorum* Hiern	x			Tree /shrub occurring in altitudes from 30-1840m above sea-level, bushveld, often on floodplains along rivers or on termitaria (van

					Wyk & van Wyk 1997).
Euphorbiaceae	*Antidesma venosum* E.Mey.ex Tul	x	x		Tree/shrub occurring in moist bushveld and wooded grassland, sand forest and along forest margins. It also occurs in altitudes from 7-1220m above sea level. The root is used medicinally for physiological effects on the heart. The fruit is edible (van Wyk & van Wyk 1997; Dery *et al*. 1999).
Euphorbiaceae	*Bridelia micrantha* (Hochst) Baill	x	x		Tree occurring in coastal, riverine and swamp forest usually in moist places. The roots and bark are used medicinally and the heart wood is used for furniture (van Wyk & van Wyk 1997).
Euphorbiaceae	*Bridelia mollis* Hutch	x			Tree or shrub occurring in altitudes from 109-1525m above sea-level, in bushveld, often on rocky places. The fruit is edible and made into jam (van Wyk & van Wyk 1997).
Euphorbiaceae	*Euphorbia capensis* A Spreng.		x		
Euphorbiaceae	*Euphorbia ingens* E. Mey.ex Boiss		x		Tree occurring in bushveld, often on rocky outcrops or deep sand, also termitaria. The latex is used medicinally and as fish poison (van Wyk & van Wyk 1997).
Euphorbiaceae	*Euphorbia* L	x		x	
Euphorbiaceae	*Phyllanthus reticulatus* Poir	x			Trees/shrub that occurs in altitudes from 5-1400m above sea-level and bushveld, particularly riverine thicket and in shade of bush clumps. The leaves and roots are used medicinally (van Wyk & van Wyk 1997).
Euphorbiaceae	*Pouzolzia mixta*	x			Shrub or small tree occurring in bushveld, particularly in rocky places, usually in dense stands. The root is used for medicinal purposes; the leaves are cooked to give a green vegetable (van Wyk & van Wyk 1997).
Euphorbiaceae	*Pseudolachnostylis maprouneifolia* Pax	x			Tree/shrub that occurs in latitudes from 109-1495m above sea-level, bushveld often on rock ridges. The bark, roots, and leaves are used medicinally (McCallum 1976 and van Wyk & van Wyk 1997).
Fabaceae	*Brachystegia boehmii* Taub	x			Tree occurring in woodland, particularly on poorly drained soils and rocky slopes. The bark is used in tanning of hide (Palgrave 2002; van Wyk & van Wyk 1997; Chitemerere 2011). It also provides bark rope.
Fabaceae	*Dichrostachys cinerea* Marloth and Engl, White and Arn	x	x		Tree /shrub is common in low altitudes. It is an indication of overgrazing as it forms secondary bush that grows in impoverished ground (van Wyk and van Wyk 1997; Venter *et al*. 1996; Palgrave 1981; Drummond and Palgrave 1973). It grows on all types of soil. The tree has a great

					range, it is very variable. The roots and leaves are chewed and placed on the sites of snakebites and scorpion stings (Drummond and Palgrave 1973). The leaves are also used for sore eyes and toothache (van Wyk and van Wyk 1997; Venter *et al*. 1996; Palgrave 1981). The wood is used for making tool handles. *Dichrostachys cinerea* is an excellent fire wood that burns well and not very fast (Palgrave 2002; van Wyk & van Wyk 1997).
Fabaceae	*Lonchocarpus capassa* Rolfe		x		Now *Philenoptera violacea*. Small to medium sized tree in various woodland types at medium to low altitudes or along rivers. It is fire sensitive and a rain tree. It is used medicinally (Coates Palgrave 2002).
Fabaceae	*Peltophorum africanum* Kuntze	x			Tree occurs in bushveld, often on sandy soils. The bark and root are used for medicinal purposes (van Wyk & van Wyk 1997; Dery *et al.* 1999).
Fabaceae	*Pterocarpus?*	x			Tree
Flacourtiaceae	*Dovyalis caffra* (Hook.f.and Harv). Hook.f.	x	x		Shrub or small tree occurs in coastal forest, bushveld and riverine thicket. The fruit is edible, makes jam (van Wyk & van Wyk 1997).
Flacourtiaceae	*Dovyalis tristis* (Sond) H. Wild		x		Now *D. zeyheri*. Shrub or small tree occurring in open woodland, bushveld, forest margins. Fruits edible (Coates Palgrave 2002).
Flacourtiaceae	*Flacourtia indica* (Burm. F) Merr	x	x		Shrub/tree occurs in altitudes between 10-1555m above sea-level, bushveld and riverine vegetation. The fruit is edible, the leaves, bark and roots are used medicinally (van Wyk & van Wyk 1997; Ndoro 2001).
Heteropyxidaceae	*Heteropyxis natalensis* Harv	x			Tree occurring in altitudes between 30-2000m above sea-level, in bushveld and along forest margins, often in rocky places. The leaves and roots are used medicinally (van Wyk & van Wyk 1997).
Heteropyxidaceae	*Meteropyxis dehniae* Suess		x		Tree
Loganiaceae	*Nuxia floribunda* Benth.	x			Tree occurring in and around forest. Bark used medicinally. The wood is used for fencing and in general carpentry (van Wyk & van Wyk 1997).
Malvaceae	*Azanza garckeana (*F.Hoffm) Exell and Hillc	x	x		Tree /shrub occurring in altitudes up to 2000m above sea-level and bushveld. The fruit is edible (van Wyk & van Wyk 1997; Dery *et al.* 1999; Ndoro 2001).
Meliaceae	*Turraea* Sprague and Hutch.ex Hutch.	x			Tree

Meliaceae	*Ekebergia benguelensis*	x			Tree occurring in open woodland (van Wyk and van Wyk 1997). The root used medicinally and the fruit is edible.
Meliaceae	*Ekebergia* Sparrm	x			Tree occurring in altitudes from 5-2075m above sea-level.
Mimosaceae	*Acacia karoo* Hyne		x		*Acacia karoo* is the most widely distributed tree in the region. It is adapted to various climatic and moisture regimes (Venter *et al.* 1996). In Zimbabwe it is found at medium and higher altitudes up to 1800m above sea-level. It is found in woodland and bush land on clay and loam soils. It is generally found in association with other acacia and some *Combretum* species. *Acacia karoo* can form dense strands on alluvium along rivers and or red clay soils for example those associated with the Great Dyke. It is also found in forest edges and tolerates frosts that occur in river valleys of Matebeleland region. According to Timberlake *et al.* (1999), *Acacia karoo* is mostly found on deeper red or blackish nutrient rich clay soils and not on sandy soils and it is considered to be an indicator of good agricultural soils and rangeland. *Acacia karoo* occurs in a wide range of altitudes from coastal scrubs to woodlands, wooded grassland often clay soils, along rivers and streams (Palgrave 2002). Its presence is considered an indication of sweet veld (Timberlake *et al.* 1999; Palgrave 2002). *Acacia karoo* produces wood of high density 800-890kg/m^3. The firewood generates a lot of heat and burns very evenly and cleanly with little smoke, therefore the wood is popular as firewood in many parts of southern Africa. It also makes excellent charcoal. It produces resilient timber (Timberlake *et al.* 1999). The tree produces edible gum that has been marketed and sold as Cape gum. Cape gum is traditionally used for various ailments that include hemorrhage and oral thrush (Ndoro 2001; van Wyk Gericke 2007). The leaves are used as traditional medicines mainly to treat diarrhoea and dysentery. Traditional healers in Zimbabwe use an infusion of roots to treat general body pains, dizziness, convulsions and diarrhoea, aphrodisiac. In addition the roots are laced in chicken runs to reduce parasites. A decoction of the bark has been used as an astringent and emetic and as an antidote to "tulp" (moraceaec) poisoning in cattle. Thrush in the mouth is relieved by umliage of the gum.
Mimosaceae	*Acacia schweinfurthii* Brenan and Exell		x		Tree / shrub/climber. Occurring in riverine vegetation ((van Wyk & van Wyk 1997).
Mimosaceae	*Acacia sieberiana*	x	x		Tree occurs in bushveld and grassland, often in deep soils and along rivers (Palgrave 2002; van

	Keay and Brenan				Wyk & van Wyk 1997). It is widely found at medium and higher altitudes above 900m above sea-level. It is also confined to recent alluvial soils and riverine situations. *Acacia sieberiana* can be found in a variety of habitats ranging from grasslands with scattered trees to open woodland. It is mostly found in higher moisture sites for example such as the edge of vleis or drainage lines or occasionally water logged open areas where other species struggle to survive. *Acacia sieberiana* is of little value as firewood (Timberlake *et al.* 1999). It has medicinal uses (Dery *et al.* 1999).
Mimosaceae	*Acacia sp* Mill	x			Tree
Mimosaceae	*Albizia adianthifolia* W. Wight		x		Tree occurring in altitudes ranging from 0-1050 m above sea-level. It also occurs in woodland, usually associated with coastal and montane forest. The wood is suitable as general purpose timber. The root and bark are used for medicinal purposes (van Wyk & van Wyk 1997).
Mimosaceae	*Albizia amara* (Roxb) Boivin	x	x		Tree occurs in altitudes that range from 200-1050m above sea-level, bushveld, often sandy soils. Root used as soap substitute and the fruit is used in traditional medicines (van Wyk & van Wyk 1997; Ndoro 2001).
Mimosaceae	*Albizia gummifera* (J.F.Gmel.) C.A.Sm.	x	x		Tree occurring in coastal and montane forests. Used medicinally for back aches (McCallum 1976; van Wyk & van Wyk 1997); Dery *et al.* 1999).
Mimosaceae	*Albizia versicolor* Welw. Ex Oliv		x		Tree occurs in various types of open woodland over a wide range of altitudes. It grows in well drained soils. The pods are poisonous and often poison stock (van Wyk and Gericke 2007; van Wyk and van Wyk 1997). In Botswana the roots and bark are used as a substitute for soap (Palgrave 1981). The bark is used for tanning leather. The root bark is used as an enema and purgative (Venter *et al.* 1996; van Wyk & van Wyk 1997; Dery *et al.* 1999). The root and bark are used to soothe headaches. Also an infusion made from the bark is used as a wash for sore eyes and to treat skin disease (Venter *et al.* 1996). The wood is used for making grain stamping mortars. The wood is used for making furniture, cabinets, and parquet floors and as general timber wood. The wood is also used for beams. It is termite resistant (van Wyk & van Wyk 1997).
Mimosaceae	*Acacia ataxacantha* DC	x			Scandent shrub, medium sized tree occurring in rocky ridges, forest margins and riverine bush (van Wyk & van Wyk 1997).
Moraceae	*Ficus burkei* (Miq.)		x		Tree occurs in altitudes between 900-1800m above sea-level and bushveld and forest, usually

	Miq.				on rocky hills or ravines. Fibres from the bark used in mate making (van Wyk & van Wyk 1997). The fruit is edible (Ndoro 2001).
Moraceae	*Ficus capensis* Thunb	x	x		Tree occurring in altitudes between 15-230m above sea-level, and forest and bushveld, usually along streams and in moist ravines. The latex is used as medicinal and veterinary purposes. The bark is used in traditional medicine (van Wyk & van Wyk 1997). Burns and septic conjunctivitis are treated with the application of the latex. An infusion from the leaves and bark is administered to cows if their milk production is considered inadequate (Palgrave 2002; Drummond and Palgrave 1973). Magical powers are ascribed to the *Ficus capensis* particularly in East Africa where through many generations certain trees have been regarded as sacred shrines and symbolic of Earth and Forests. According to Palgrave (2002), sacrifices of goats are made at these trees to appease ancestral spirits to bring rain and to relieve famine and ensure a rich harvest. The heavily clustered fruits are used in a variety of ways including the promotion of both human fertility and an abundance of crops. In addition eating of the first fruits is believed to safeguard the welfare of the tribe itself and the entire area in which it lives (Palgrave 2002). An infusion is taken by both sexes for fertility, uterine, pain and prevents abortion. The latex is taken by mouth as an anti-emetic. The bark is taken to increase lactation and the powered root taken orally in porridge to treat nose bleeds. An infusion of the root is taken for constipation in humans and animals. A root infusion is taken by mouth to treat a sore throat. The latex is dropped into the eye to treat cataracts or painful eyes and powered bark is applied to the skin to treat rashes (van Wyk and Gericke 2007). The fruit is edible (Ndoro 2001).
Moraceae	*Ficus lutea* Vahl	x			Tree occurs in altitudes between 15-915m above sea-level and in coastal forest and bush. Bark woven into clothes, latex used for bird lime (van Wyk & van Wyk 1997).
Moraceae	*Ficus sp* L	x			Tree leaves are used medicinally (Chitemerere 2011).
Moraceae	*Ficus sur* Forssk	x	x		Tree occurs in altitudes between 15-2300m above sea-level, and forest and bushveld, usually along streams and in moist ravines (van Wyk & van Wyk 1997).
Moraceae	*Ficus sycomorus* L	x			Tree occurs in altitudes between 6-1500m above sea-level. *Ficus sycomorus* occurs along riverbanks, streams and also in mixed woodland on alluvial soils (Palgrave 2002; Venter *et al.* 1996; van Wyk & van Wyk 1997).It needs a

					substantial amount of water. It occurs often in dolomite (van Wyk & van Wyk 1997).An infusion of the bark and latex is used for treatment of chest and glandular complains diarrhoea and inflamed throat. A cold water infusion of the steam bark is taken to stimulate milk production in nursing mothers (van Wyk and van Wyk 2007). Throughout Africa a piece of dry wood of *Ficus sycomorus* is used as a base block when making fire by friction methods.
Myrtaceae	*Pomheyarosea* Kameha		x		Tree
Myrtaceae	*Syzygium cordatum* Hochs.ex C.Krauss	x	x		Tree/shrub occurs in altitudes between 5-2300m above sea-level and in wooded areas and forest, nearly always near water, sometimes dominant in swamp forest. Bark provides reddish brown dye. The fruit is edible and is used medicinally (van Wyk & van Wyk 1997).
Myrtaceae	*Syzygium guineense* (Wild) DC.	x			Tree/shrub occurs in altitudes between 10-1457m above sea-level and in open woodland, often in sandy soil or near water. The root and bark are used for medicinal purposes and the fruit is edible (van Wyk & van Wyk 1997).
Ochnaceae	*Ochna schweinfurthiana* Hoffm. f.	x			Tree/shrub occurs in bushveld and *Brachystegia* woodland (van Wyk & van Wyk 1997).
Olacaceae	*Ximenia caffra* Sond	x	x		Shrub/tree occurs in altitudes between 152-1675m above sea-level and in bushveld and coastal bush. Bark and leaves are used medicinally. The fruit is edible (van Wyk & van Wyk 1997; Dery *et al.* 1999; Ndoro 2001).
Oleaceae	*Olea africana* L	x			Tree/shrub occurs in altitudes from 5-2479m above sea-level and in a wide range of habitats, usually on rocky hillsides or on stream banks rivers Leaves and bark is used medicinally. The wood is used for furniture and ornaments (van Wyk & van Wyk 1997).
Oleaceae	*Olea europea* L		x		Tree/shrub occurs in altitudes from 5-2479 m above sea-level and in a wide range of habitats, usually on rocky hillsides or on stream and river banks. Leaves and bark are used medicinally. The wood is used for furniture and ornaments (van Wyk & van Wyk 1997).
Oleaceae	*Schrebera alata* (Hochst.) Welw	x			Tree/shrub occurs in altitude 30-1980m above sea-level, in bushveld, coastal and montane forest rivers (van Wyk & van Wyk 1997).
Fabaceae	*Bolusanthus speciosus* Harms	x			Tree occurs in altitudes 25-1400m above sea-level, bushveld, often on heavy alkaline soils rivers. Bark used medicinally (van Wyk & van Wyk 1997).

Papilionaceae	*Erythrinia abyssinica* Lam.ex DC	x	x		Tree occurs in altitude 950-1100m above sea level, bushveld and wooded grassland. Root and bark are used medicinally (van Wyk & van Wyk 1997; Dery *et al.* 1999).
Papilionaceae	*Erythrinia caffra* Thunb		x		Tree occurs in altitude 0-1500m above sea-level, occurring in costal forest and bush, often along rivers The wood is used to make drums and fishing net floats (van Wyk & van Wyk 1997).
Papilionaceae	*Erythrinia lysistemon* Hutch,	x	x		Tree occurs in altitude 0-1800m above sea-level, coastal forest and bush, often on warm, north facing aspect of rocky ridges. Various parts of the plant used for medicinal and magical purposes (van Wyk & van Wyk 1997).
Papilionaceae	*Pterocarpus rotundifolius* Sond	x			Tree occurs in altitude 0-1550m above sea-level. *Pterocarpus rotundifolius* occurs in open woodland and wooded grassland, sometimes rocky hillsides. It is more common on sandy soils but also on loamy and clay soils (Venter *et al.* 1996). The wood can be used for general purpose timber. An infusion made from the leaves of *Pterocarpus rotundifolius* is dropped into sore eyes.
Papilionaceae	*Pericopsis angolensis* DC	x	x		Tree occurs in altitude 300-1550m above sea-level. It is an indicator of well drained soils. It occurs in coastal and montane forest. It is used for furniture, mortar and drums. A decoction made from the roots is used in the treatment of malaria and blackwater fever. Abdominal pains, diarrhoea and bilharziasis are treated from an infusion made from the roots (Dery *et al.* 1999). Asthma and tuberculosis are some of the diseases that are treated from ashes of burnt roots and then drunk in water (Venter *et al.* 1996). Skin lesions and ringworm are treated from boiled bark and the resulting red fluid is used.
Polygalaceae	*Securidaca longipedunculata* Fresen.	x			Tree/shrub growing in altitudes up to 1700m above sea-level. It occurs in bushveld. Roots and leaves are used for medicinal purposes. The bark is also used to make soap (van Wyk & van Wyk 1997).
Proteaceae	*Faurea saligna* Harv	x			Tree/shrub occurs in altitude 900-1500m above sea-level, bushveld on sandy soils. Bark used for tanning leather. The wood is suitable for general purpose timber (van Wyk *et al.* 1997). It has medicinal properties (Chitemerere 2011)
Proteaceae	*Protea repens* (L) L		x	x	Tree/shrub occurs in altitudes between 0-1400m above sea-level. It also occurs in fynbos, often in dense stands (van Wyk & van Wyk 1997).Used medicinally to treat coughs and other chest complaints. Grown as a garden

					ornamental and for the cut flower trade.
Rhamnaceae	*Berchemia discolor* (Klotzsch) Hem1.		x		Tree/shrub occurs in altitude 30-1465m above sea-level. It occurs in coastal woodland and bush. The wood is used for hut building and in making handles of implements because it is strong, hard and durable (van Wyk & van Wyk 1997; Venter *et al.* 1996). Leaves and bark are popular in traditional medicine and are used to make poultices for wound treatment, diabetics and roundworm infection (van Wyk and Gerick 2007, Venter *et al.* 1996; Dery *et al.* 1999). An infusion of the roots is used as an enema to stop bleeding of the stomach (Venter *et al.* 1996). Edible fruit (Ndoro 2001).
Rhamnaceae	*Ziziphus mucronata* Willd	x	x		Tree/shrub occurs in a wide range of habitats. Widely used for medicinal and magical purposes. It is also used as mixing agent for arrows by the San (van Wyk & van Wyk 1997; Chitemerere *et al.* 2011).
Asteraceae	*Brachylaena rotundata*	x	x		Tree/shrub occurs in bushveld usually in rocky places. It has general purpose uses (van Wyk & van Wyk 1997; Ndoro 2001).
Rubiaceae	*Canthium mundianum* Cham. and Schltdl	x			Tree/shrub occurs in altitudes ranging from 460-1300m above sea-level. The wood is used for fencing. The fruits are edible (van Wyk & van Wyk 1997).
Rubiaceae	*Gardenia ternifolia* Schumach. and Thonn	x	x		Tree/ shrub occurring in altitudes of 520- 945m above sea level (van Wyk & van Wyk 1997).
Rubiaceae	*Gardenia volkensii* K.Schum	x			Tree/shrub growing in the following range of altitudes 30-1540m above sea-level. The fruit and roots are used medicinally (van Wyk & van Wyk 1997).
Rubiaceae	*Lagynias lasiantha* (Sond.) Bullock	x			Tree/shrub occurring in bushveld, sand forest and along forest margins. It grows in the following range of altitudes 5-1168m above sea-level (van Wyk & van Wyk 1997).
Rubiaceae	*Pavetta schumanniana* F.Hoffm.ex K.Schum	x			Tree/shrub occurring in bushveld and in the following range of altitudes 60-1538m above sea-level. The root is used medicinally (van Wyk & van Wyk 1997).
Rubiaceae	*Rothmannia fischeri* (K.Schum.) Bullock		x		Tree/shrub occurs in bushveld and sand forests. The tree grows in the following range of altitudes 460 -1525m above sea- level.
Rubiaceae	*Sericanthe andongensis* Hiern	x			Shrub or small tree occurring in bushveld, usually along rocky ridges or streams (van Wyk & van Wyk 1997).
Rubiaceae	*Vangueria infausta* Burch	x	x		Shrub or small tree occurring in the following altitudes 20-3333m above sea-level. It also occurs in wooded grassland, bushveld and

					coastal forest often rocky. The fruit is edible (van Wyk & van Wyk 1997; Ndoro 2001).
Rutaceae	*Teclea swynnertonnii* (S.Moore) Boridson		x		Tree
Rutaceae	*Zanthoxylum capense* (Thunb.) Harv	x			Tree/shrub occurring in grassland, bushveld and along forest margins usually associated with bush clumps and rocky places. The leaves, fruit and bark are used medicinally (van Wyk & van Wyk 1997).
Sapindaceae	*Dodonea angustifolia* L. f.	x			Shrub or small tree occurring in open areas associated with bushveld, wooded grassland, karroid vegetation and fynbos. The leaves and roots are used medicinally (van Wyk & van Wyk 1997).
Meliaceae	*Khaya sp?*	x			Tree
Sapotaceae	*Englerophytum magalismontanum* (Sond.) T.D.Penn	x			Small tree occurring on rocky outcrops or riverine fringing forest. The root is used medicinally (van Wyk & van Wyk 1997).
Sapotaceae	*Mimusops zeyheri* Sond	x	x		Tree/shrub occurs in altitudes 45-1600m above sea-level. *Mimusops zeyheri* usually grows in riverine vegetation, woodland and on rocky hillsides. The wood makes a general purpose timber. The fruit is edible and it contains 50-80mg/ vitamin (Ndoro 2001; van Wyk & van Wyk 1997).
Scrophulariaceae	*Halleria lucida* L	x			Shrub or small tree occurring in forest, forested ravines and grassland, often along streams or rocky places. Fruit edible and various parts used medicinally (van Wyk & van Wyk 1997).
Simaroubaceae	*Kirkia acuminata* Oliv	x	x		Tree occurring in bushveld, often on rocky outcrops (van Wyk & van Wyk 1997).
Solanaceae	*Solanecio mannii* C.H.Wright		x		Shrub or much-branched soft-wooded tree. At high altitudes on rocky hillsides, thicket or forest margins (Coates Palgrave 2002).
Sterculiaceae	*Cola* Schott and End1	x			Tree, 25-1730m above sea-level.
Sterculiaceae	*Dombeya burgessiae* Gerrard ex Harv	x			Shrub or small tree occurring along forest margins and in rocky places in high rainfall. It is also found in the following range of altitudes 45 – 1675m above sea-level. The bark is used for fibre (van Wyk & van Wyk 1997).
Sterculiaceae	*Dombeya rotundifolia* (Hochst) Planch	x	x		Tree occurring in bushveld. Bark, root and leaves used are medicinally. The wood is used for implement handles (van Wyk & van Wyk 1997).
Strychnaceae	*Strychnos cocculoides* Baker	x	x		Shrub or small tree occurring in bushveld, usually on sandy soils or in rocky places. Fruit is edible. The wood is used for implement handles (Ndoro 2001; van Wyk & van Wyk

					1997; McCallum 1976).
Strychnaceae	*Strychnos madagascariensis* Poir	x			Shrub or small tree occurring in bushveld, usually on sand forest and coastal bush. Fruit pulp is edible (van Wyk & van Wyk 1997).
Strychnaceae	*Strychnos pungens* Soler		x		Tree occurs in bushveld, often in rocky places. Leaves and roots are used medicinally. The fruit pulp is edible (van Wyk & van Wyk 1997).
Strychnaceae	*Strychnos spinosa* Lam	x			Tree/shrub occurs in altitudes up to 1500m above sea-level. The roots or green fruits are used as antidote to snakebites while the roots alone are emetic and also as remedy for fevers and inflamed eyes. The fruits are edible when ripe (Palgrave 1981; van Wyk & van Wyk 1997; Dery *et al*. 1999; van Wyk and Gericke 2007).
Tiliaceae	*Grewia flavescens* Juss	x			Shrub or small tree occurs in bushveld. It is also found in altitudes of 100-1525m above sea-level (van Wyk & van Wyk 1997).
Tiliaceae	*Grewia* L	x	x	x	Shrub
Uapaceae	*Uapaca kirkiana* Mull. Arg	x	x		The tree occurs in medium altitude in open woodlands in association with *Brachystegia* in well drained soils. The fruits are suitable for making jam. An infusion of the roots is used to treat indigestion. The wood is reasonably durable as it is termite and borer proof. *Uapaca kirkiana* provides good charcoal. The timber is suitable for furniture. (Palgrave 2002; Ndoro 2001; van Wyk & van Wyk 1997).
Ulmaceae	*Celtis africana* Burm. f.	x	x		Tree occurs in forest, bushveld and grassland, often on dolomite. It also occurs in altitudes within the following range 4-2160m above sea-level. The tree is widely planted as shade in gardens (van Wyk & van Wyk 1997).
Ulmaceae	*Trema guineenisis* Schumach and Thonn		x		Now *T. orientalis*
Ulmaceae	*Trema orientalis* (L.) Blume		x		Tree occurs as a pioneer in forest, in bush and grassland, also in bushveld along rivers. The leaves are cooked as green vegetables (van Wyk and van Wyk 1997).
Urticaceae	*Obetia tenax* (N.E.Br.) Friis	x	x		Shrub or small tree occurring in bushveld, often on hot, dry, rocky hillsides. Leaves are cooked as vegetable (van Wyk and van Wyk 1997).
Verbenaceae	*Vitex payos (*Lour.) Merr	x	x		Tree occurring in woodland, often on rocky outcrops and termitaria. The fruit is edible (Ndoro 2001; van Wyk & van Wyk 1997; McCallum 1976).
Vitaceae	*Rhoicissus revoilii* Planch	x			Scrambling shrub or small tree occurring in bushveld, often on rocky places. It is used

					medicinally (van Wyk & van Wyk 1997).

4.2 Chigaramboni

Figure 8: The site positions of Great Zimbabwe and Chigaramboni in the landscape (modified after Google Earth 2012).

The vegetation is mainly broad leaf deciduous forest with open grassy patches (Figure 7). There is a combination of short and tall grass in the area. The vegetation resembles that of Great Zimbabwe. Some of the trees documented by the author found at Chigaramboni include *Kirkia acuminata, Strychnos madagascariensis, Monotes glaber, Grewia sp, Ficus sp, Faurea saligna, Brachystegia spiciformis, Brachystegia glaucescens, Julbernardia globiflora, Diplorhynchus condolycarpon, Syzygium sp.* The soils are mainly moderately shallow greyish brown, coarse grained sands throughout the profile to similar sandy loams, over reddish brown sandy clay loams formed on granite. However, the areas around

Chigaramboni are characterised with heavy reddish clay soils and the hills are mainly haematite iron stone with scattered *Acacia spp* vegetation (Ndoro 1991).

4.3 Summary

In summary this chapter provided an account of the vegetation of Great Zimbabwe and Chigaramboni since the late 19th century to the present. Historical documents and actual field surveys were conducted in order to produce a table of taxa presented in this chapter. The next chapter presents the reference collection.

CHAPTER FIVE

Anatomical analysis of modern vegetation

5 Introduction

This chapter deals with the anatomical analysis of the modern wood vegetation collected from Great Zimbabwe and Chigaramboni in March 2011. More than 148 wood vegetation specimens were collected from the two sites of Great Zimbabwe and Chigaramboni and the areas around them. The woods presented here are approximately a third of the total woods sampled and analysed. The selection of woods for presentation in this chapter has been to a greater extent influenced by the fact that most of them occurred in the archaeological record. The rest of the modern woods will be used for other publications. The woods are presented in the order in which they were collected (Z—number in the upper right) and follow the same format so that like features can be easily compared.

Family: LEGUMINOSAE CEASALPINIOIDEAE ***Genus and species***: *Peltoforum africanum* ***Collection No***: *Z02*

Transverse plane (TS)
•no distinctive growth rings
•semi-diffuse ring porous
•uniseriate
•solitary
•amorphous deposits (gum/resins)
•crystalliferous deposits in ray cells
•the ray cells are procumbent to square
•vasicentric axial parenchyma up to 4 cells wide, aliform to confluent parenchyma
•apotracheal in some cases running along the rays
•tyloses are present
•Mean tangential vessel diameter=76 µm

Tangential longitudinal plane (TLS)
Rays:
•have a width of 1-3 cells wide
•are heterocellular
•Parenchyma cells are storied
•Tracheids are present
•Horizontal perforation plate
Fibres
•have simple pits and septa
•are sclariformed

Radial longitudinal plane (RLS):
•mixed cell arrangements that are procumbent, and square in the same row
•alternating procumbent and square cells in the same row
•Sometimes they are rows of procumbent cells.
•axial parenchyma

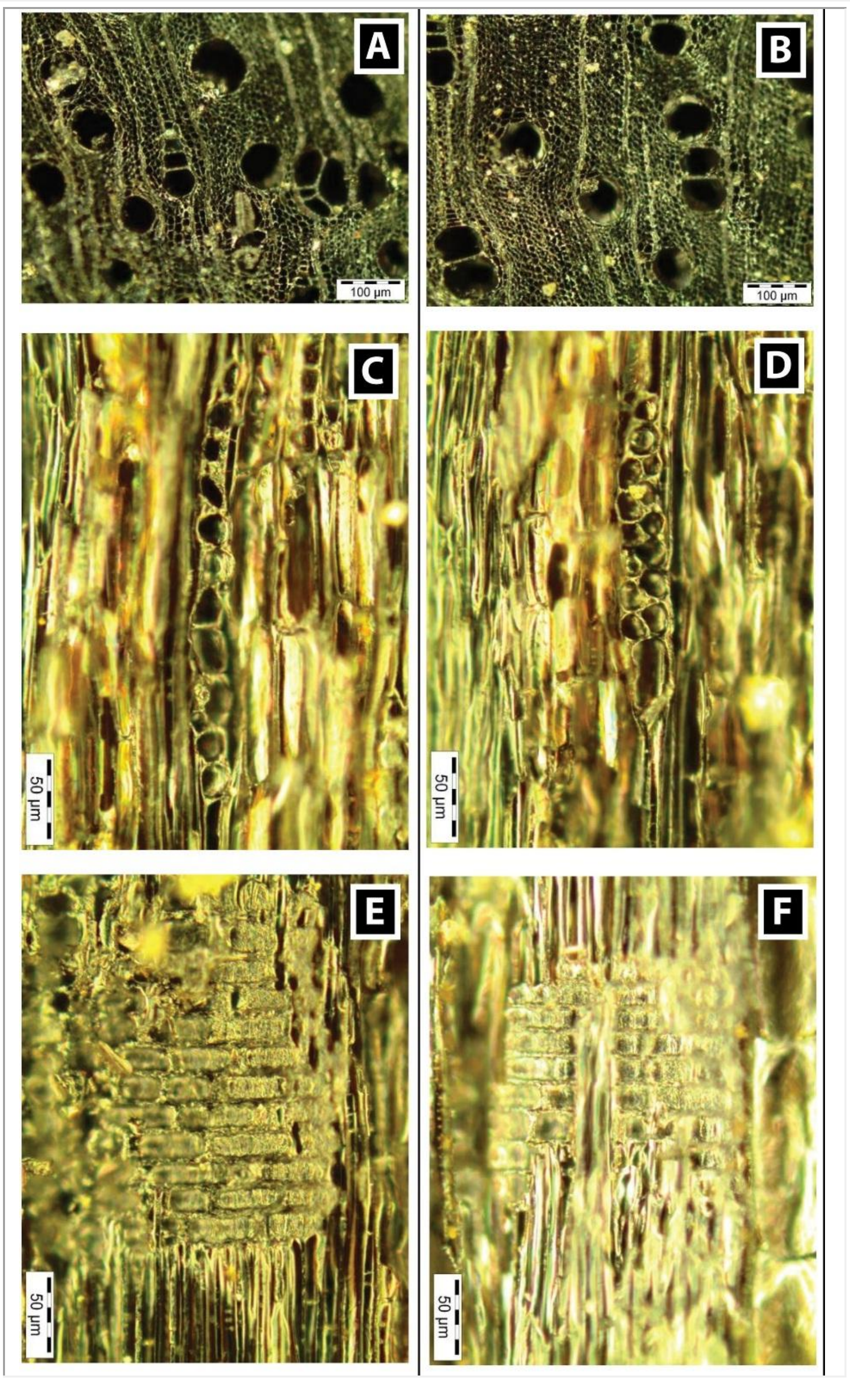


Figure 9: LEGUMINOSAE CAESALPINIOIDEAE *Peltoforum africanum* (Z02).

Extra features from Inside Wood Online database that are not visible in the charcoal reference collection:-Growth ring boundaries distinct, -Simple perforation plates, -Intervessel pits alternate, -Shape of alternate pits polygonal, -Small 4-776 µm, --Vestured pits, -Vessel ray pits with distinct boarders; similar to intervessel pits in size and shape through cell, -5-20 vessels per square millimeter, -Fibres with simple to minutely bordered pits, -Non-septate fibre present, -Fibres with thick walled, -axial parenchyma lozenge-aliform, axial parenchyma winged-aliform, axial parenchyma in seemingly marginal bands, -prismatic crystals, -prismatic crystals in chambered axial parenchyma

***Family**: SAPINDACEAE* ***Genus and species**: Dodonaea angustifolia*
***Collection No**: Z03*

Transverse plane (TS)
•there are no distinctive growth rings
•diffuse ring porous
•solitary and radial multiples (2-4) vessel arrangement
•rays are 1-2 seriate
•there are amorphous deposits in vessels
•the paratracheal axial parenchyma is vasicentric and radial
•Mean tangential vessel diameter=45 µm
•Vessel per millimetre square=63

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 cells wide
•are predominantly uniseriates, weakly heterocellular and have sections that are homocelluar
•are short and heterocellular
•there are horizontal perforation plates.

Radial longitudinal plane (RLS)

•mixed procumbent and square cells
•the rays are heterocellular

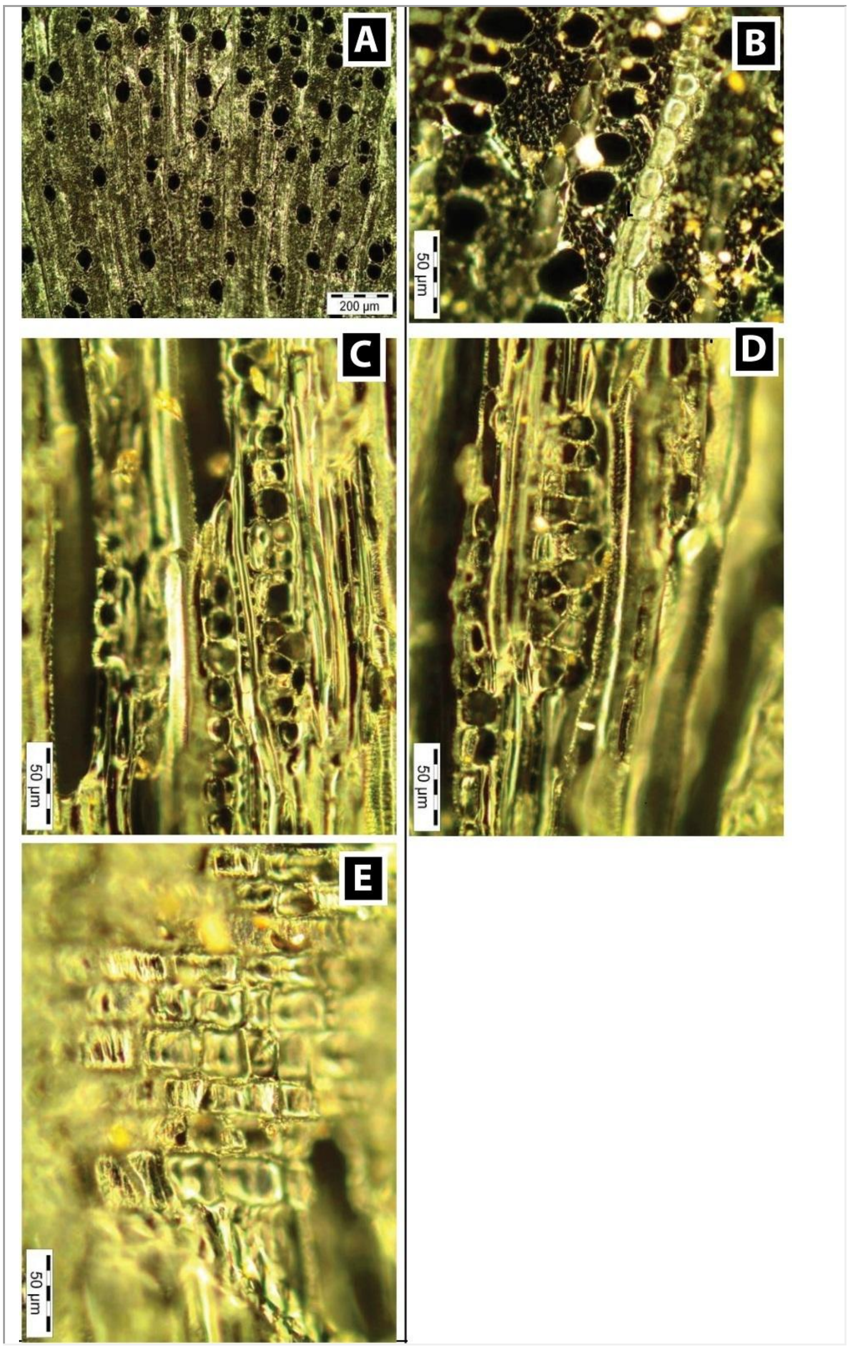


Figure 10: SAPINDACEAE *Dodonaea angustifolia* (Z03).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family*: ASTERACEAE** ***Genus and species*: *Brachylaena rotundata ***Collection No*: *Z04***

Transverse plane (TS)

•growth rings are present
•diffuse ring porous
•radial multiples (2-12) vessel arrangement
•1-3 seriate
•the rays are predominantly biseriates
•amorphous deposits are found in vessels
•scanty parenchyma
Mean vessel diameter = 42.87 µm
•vessel per millimetre square=155

Tangential longitudinal plane (TLS)

Rays:
•are 2-3 cells wide
•are heterocellular
•are heterogenous
•are crystalliferous
• some are idioblasts
•horizontal and oblique perforation plates
Fibres have tiny pits (this is rare though

Radial longitudinal plane (RLS):

•mixed arrangement of upright and square cells
•rays are heterocellular

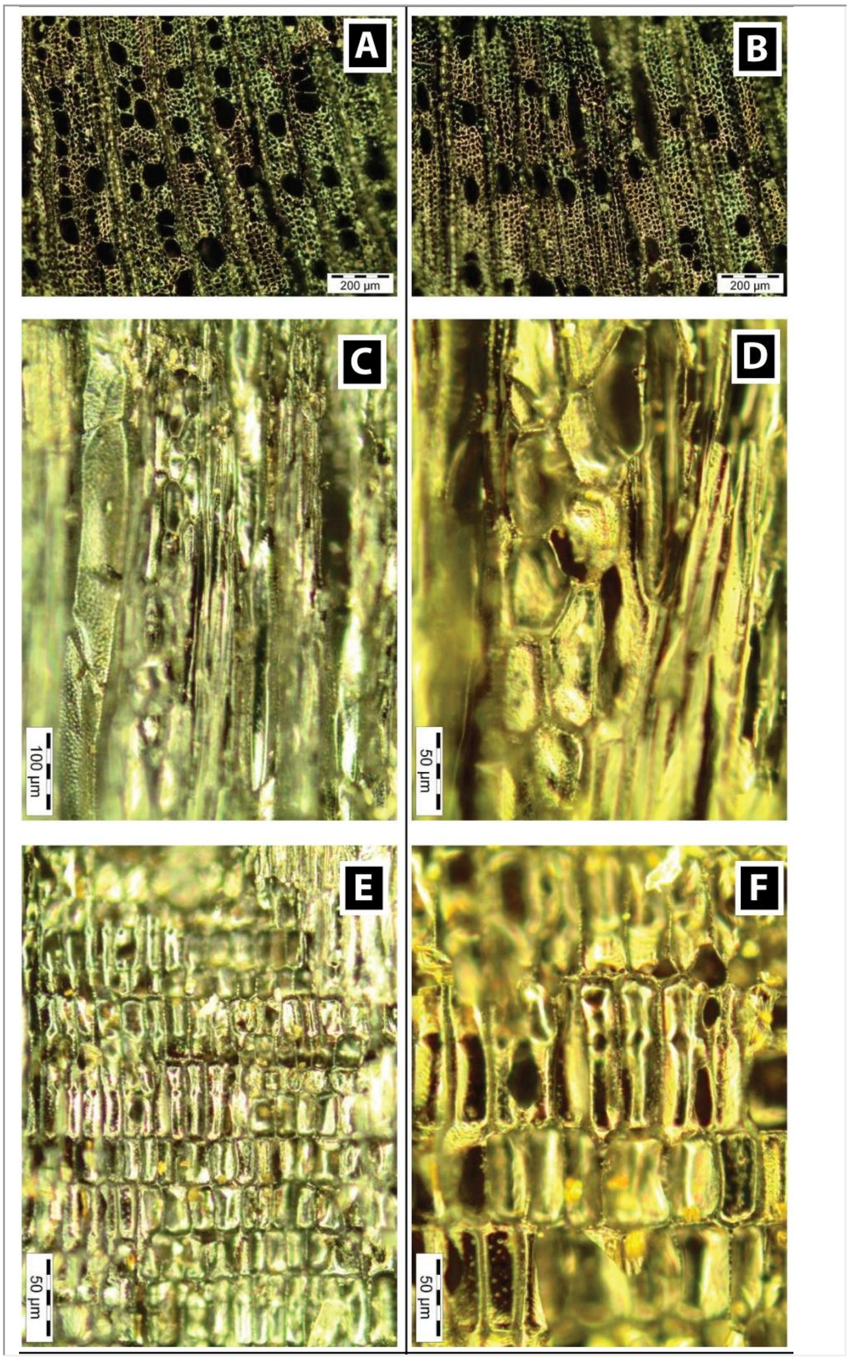


Figure 11: ASTERACEAE *Brachylaena rotundata* (Z04).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection - no data

Family: LEGUMINOSAE MIMOSOIDEAE **Genus and species**: *Dichrostachys cinerea* **Collection No**:*Z06*

Transverse plane (TS)

- vessel arrangements are predominantly solitary
- radial multiples (2-8) also occur
- angular vessel outlines

The rays are 1-3 seriate

- Axial parenchyma, paratracheal- aliform to banded or aliform to and banded
- Irregular bands of parenchyma, 4 bands per millimetre square
- parenchyma is also radial, vasicentric, lozenge, confluent
- Tyloses are present
- Amorphous deposits and gums are found in vessels
- no distinctive growth rings
- Ray cells are procumbent and crystalliferous
- Thick walled narrow diameter fibres

Mean tangential vessel diameter=75 µm

Vessel per square millimetre=25

Tangential longitudinal plane (TLS)

Rays are 3 cells wide

- some rays are heterocellular and others are weakly heterocellular
- have idioblasts
- the widest part of the ray is 2-3 cells wide
- have parenchyma
- mixture of short and long rays
- short tracheids
- horizontal perforation plates are present

Radial longitudinal plane (RLS):

- Mixed procumbent, square and upright cells that are polygonal
- More than 6 layers of procumbent cells
- Procumbent cells have the tendency of tapering
- Long/big procumbent cells are 2.5 times their width and others are 1.5 times their width
- Alternating procumbent and square cells,

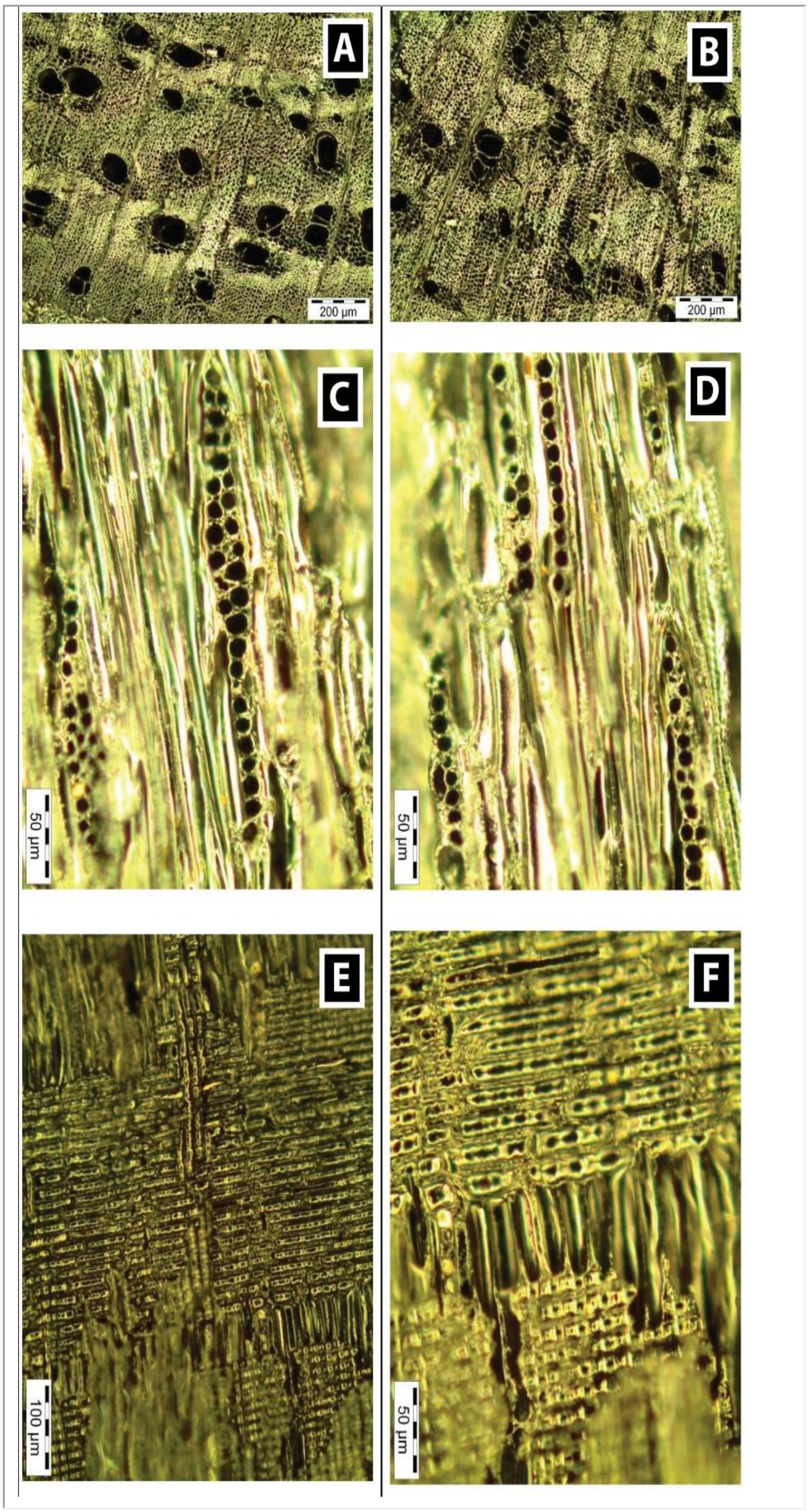


Figure 12: LEGUMINOSAE MIMOSOIDEAE *Dichrostachys cinerea* (Z06).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth rings distinct, -intervessel pits alternate, -shape of alternate pits polygonal, -small-4-7 µm, -Vestured pits, -vessel pits with distinct borders; similar to intervessel pits in size and shape through cell, -fibres with simple to minutely bordered pits, -axial parenchyma vasicentric, -axial parenchyma unilateral paratracheal, -prismatic crystals present, -prismatic crystals in chambered axial parenchyma cells

***Family**: PHYALLANTHACEAE EUPHORBIACEAE* ***Genus and species**: Bridelia micrantha* ***Collection No**:Z08*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-8) predominant
•solitary
•there are vessel clusters of between 3 and 6
•1-2 seriate, the rays can be as high as 6 near the pith
•amorphous deposits in vessels are present
•tyloses are present
•Mean tangential diameter=56 µm •Vessels per millimetre square = 78

Tangential longitudinal plane (TLS)
Ray s:
•are 1-3 cells wide
• have sections that are biseriate and uniseriate
•are uniseriate sections are more weakly heterocellular
• biseriate sections are heterocellular
•parenchyma along vessels
•there are horizontal and oblique perforation plates
•Fibres have simple pits
•Fibres with septa (rare)

Radial longitudinal plane (RLS):
•mixed cells
•square to upright and then upright
•square and upright

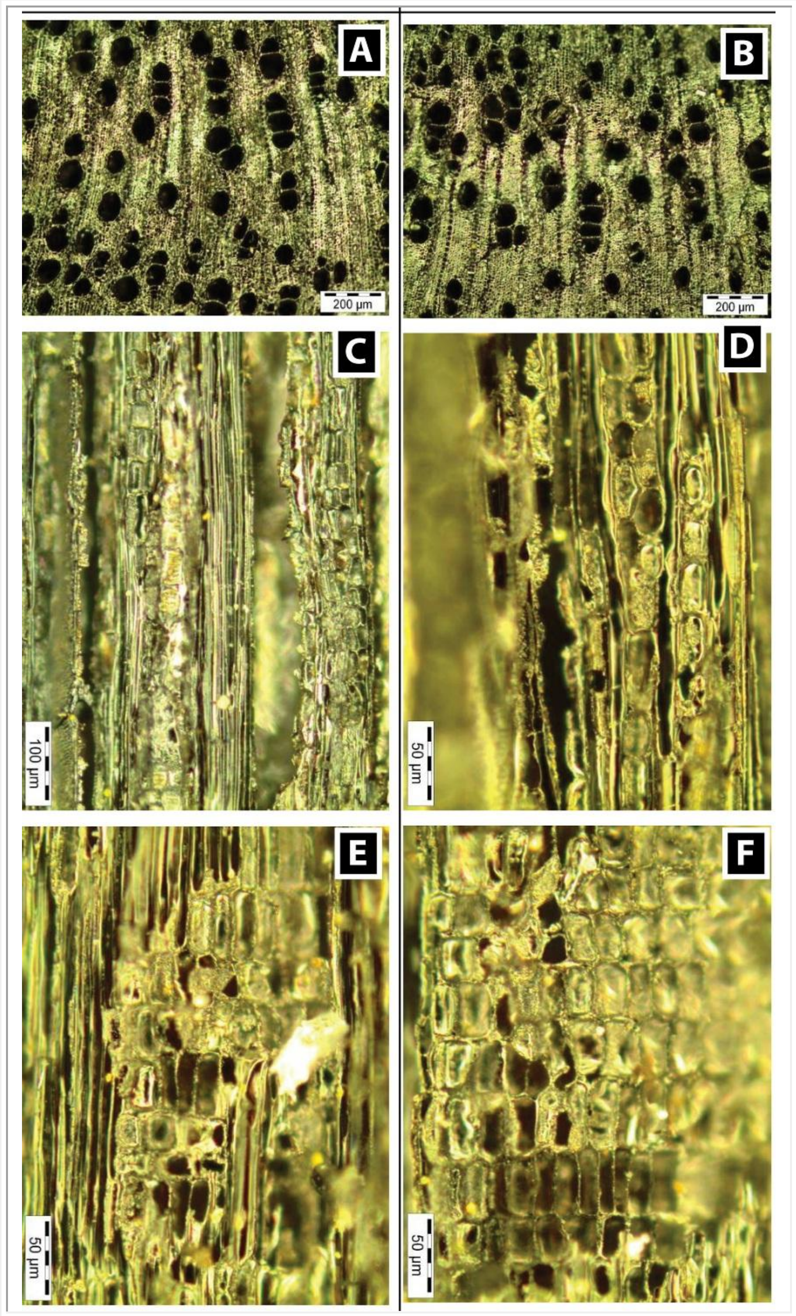


Figure 13:
PHYALLANTHACEAE (EUPHORBIACEAE) *Bridelia micrantha* (Z08).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -reticulate, foraminate, and other types of multiple perforation plates, -intervessel pits alternate, -shape of alternate pits polygonal, -vessel ray pits with distinct borders, -vessel ray pits of two distinct types or sizes in the same ray cell, -vessel ray pits unilaterally compound and course, -vessel ray pits restricted to marginal rows, -fibres with thin - to thick walled, -axial parenchyma diffuse, vasicentric, scanty paratracheal, -ray height> 1mm, -perforated ray cells, -prismatic crystals present.

Family: PHYLLANTHACEAE **Genus and species**: *Antidesma venosum* **Collection No**: *Z09*

Transverse plane (TS)

•there are no distinctive growth rings
•diffuse ring porous
•amorphous deposits
•radial multiples (2-7)
•solitary
•1-3 seriate (mixture of upright and square cells)
•scanty paratracheal

Mean tangential vessel diameter =47 µm
Vessels per millimetre square = 67

Tangential longitudinal plane (TLS)

Rays:
• are 2-4 cells wide
•are crystalliferous cells
•are heterocellular, the outlying cells are angular and polygonal
•they have parenchyma
• simple perforation plate

Radial longitudinal plane (RLS):

•mixture of upright and square cells
•upright cells appear to be predominant
•rays heterocellular

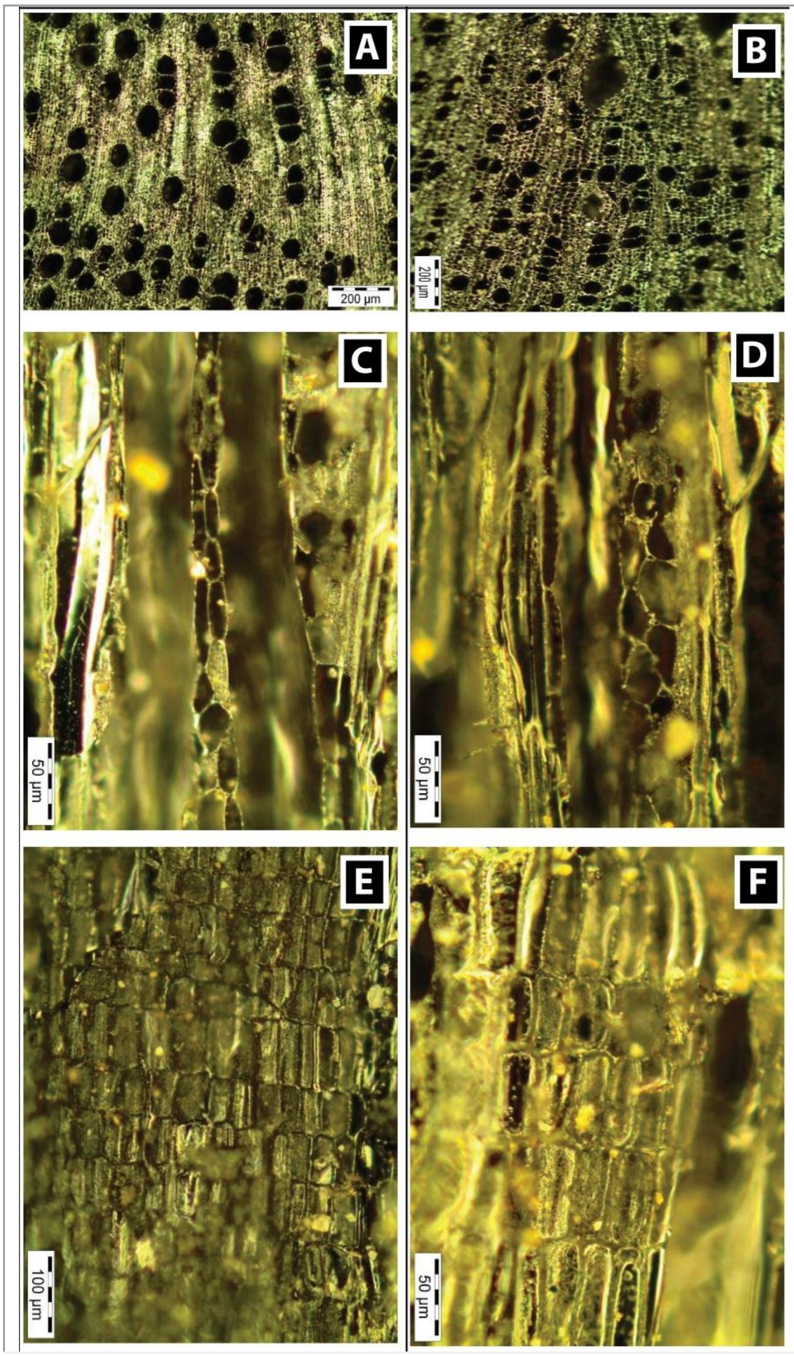


Figure 14: PHYLLANTHACEAE - *Antidesma venosum* (Z09).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -simple perforation plates, -intervessel pits alternate, -shape of alternate pits polygonal, -vessel ray pits with reduced borders to apparently simple:pits rounded, angular, horizontal to vertical, -vessel ray pits restricted to marginal rows, -fibres with simple to minutely bordered pits, -septate fibres present, -ray height>1mm, -rays of two distinct sizes, -Perforated ray cells, -disjunctive ray parenchyma, -sheath cells

Family: SAPOTACEAE	*Genus and species*: *Mimusops zeyheri*	*Collection No*:*Z11*

Transverse plane (TS)

•no distinctive growth rings
•diffuse ring porous
•amorphous deposits
•radial multiples (2-10)
•1-2 seriate (predominantly uniseriate)
•axial parenchyma – confluent to banded (2 layers of cells)
•radial parenchyma present
•Mean tangential vessel diameter= 55µm
Vessels per millimetre square = 95

Tangential longitudinal plane (TLS)

Rays:
•are 1-2 seriate
•biseriates have tails that are uniseriate composed of cells that are large and oval, and the biseriate section is composed of smaller cells when compared to those found in the biseriate section
•are heterocellular
•Tracheids are present

Radial longitudinal plane (RLS):

•Mixed procumbent, upright and square cells
•Some sections have upright to square cells only

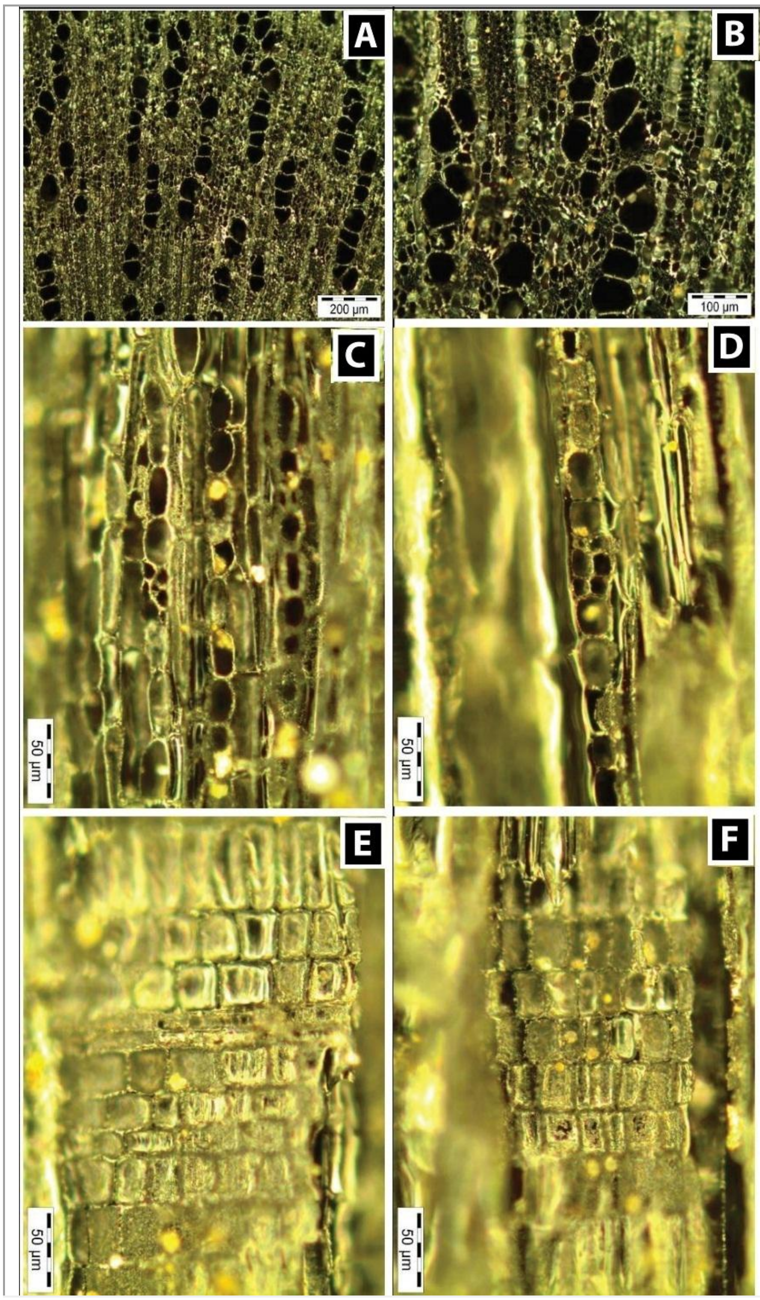


Figure 15: SAPOTACEAE - *Mimusops zeyheri* (Z11).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE MIMOSOIDEAE **Genus and species**: *Acacia ataxacantha* **Collection No**: *Z12*

Transverse plane (TS)
•vessels are exclusively solitary (more than 90%)
•no distinctive growth rings
•semi-diffuse ring porous
•round vessel outlines
•axial paratracheal- vasicentric, banded, aliform- banded, apotracheal forming bands, confluent
•uniseriate
•crystallised procumbent ray cells
•some of the ground cells have crystals
•Tyloses
•Mean tangential vessel diameter=60µm
Vessels per millimetre square=39

Tangential Longitudinal palne (TLS)
•have crystallised cells
•have idioblasts
•are 1-3 cells wide
•uniseriate rays are homocellular (2-16 cells long)
•biseriates have a fat end that is 2 cells wide and a tail that is 1 cell wide and they heterocellular
•Have thick cell walls
Vessels:
•have pits
•have parenchyma along vessels
•have mixture of long and short vessels
•simple perforation plates
Fibres:
•have septa
•have simple alternate pits

Radial longitudinal plane (RLS):
•upright to square cells, generally appear to be square
•upright to procumbent cells
•Predominantly square cells
•weakly heterocellular
•two rows procumbent and then upright

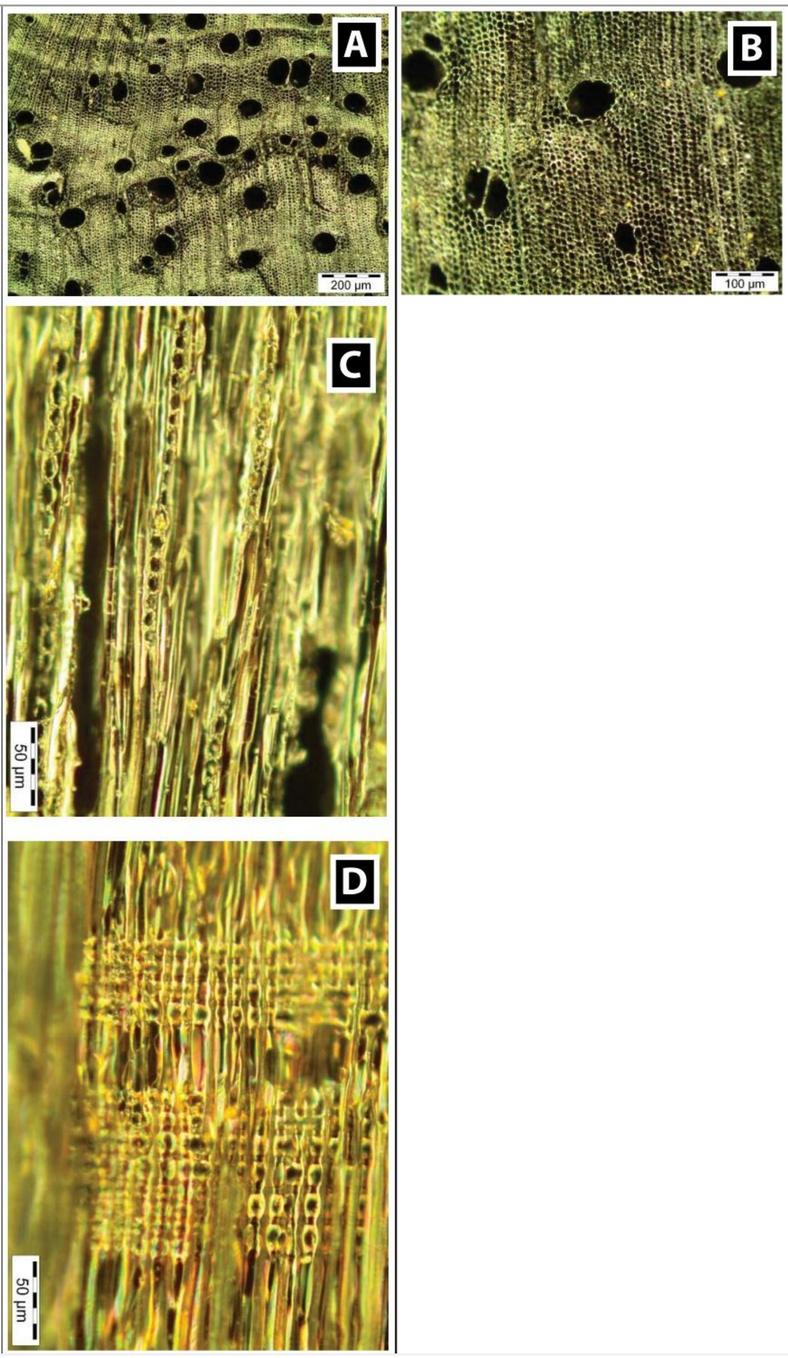


Figure 16: LEGUMINOISAEMIMOSOIDEAE - *Acacia ataxacantha* (Z12).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -Vestured pits, -Vessel ray pits with distinct borders, -fibres thin – to thick walled, -axial parenchayma in marginal, -Prismatic crystals in chambered axial parenchyma cells.

Family: LEGUMINOSAE PAPILIONOIDEAE ***Genus and species**: Pericopsis angolensis* **Collection No**: *Z13*

Transverse plane (TS)

•no distinctive growth rings
•semi-diffuse ring porous
•solitary
•radial multiples (2-7)
•amorphous deposits
•round/ angular vessel outlines
•ray cells square and /procumbent
•some ray cells contain crystals
•there are varying sizes of ray cells
•1-3 seriate
•paratracheal axial parenchyma-vasicentric
•aliform to confluent
•parenchyma cells contain crystals in them
•Scanty parenchyma
•apotracheal
•Tyloses
•Mean tangential vessel diameter=47 µm
Vessels per millimetre squar = 34

Tangential longitudinal plane (TLS)

Rays:
•are 1-3 cells wide
•have crystalliferous cells
•have idioblasts
•are heterocellular
•some ray cells are angular, round and polygonal
•There is parenchyma along vessels
•horizontal perforation plate
Vessels:
•there is a combination of short and long vessels
Fibres
•have alternate pits

Radial longitudinal plane (RLS):

•mixed ray cells
•ray cells are sometimes separated by fibres that have simple pits.
•two rows of upright cells and then at least 7 rows of procumbent cells that are mixed with square cells.

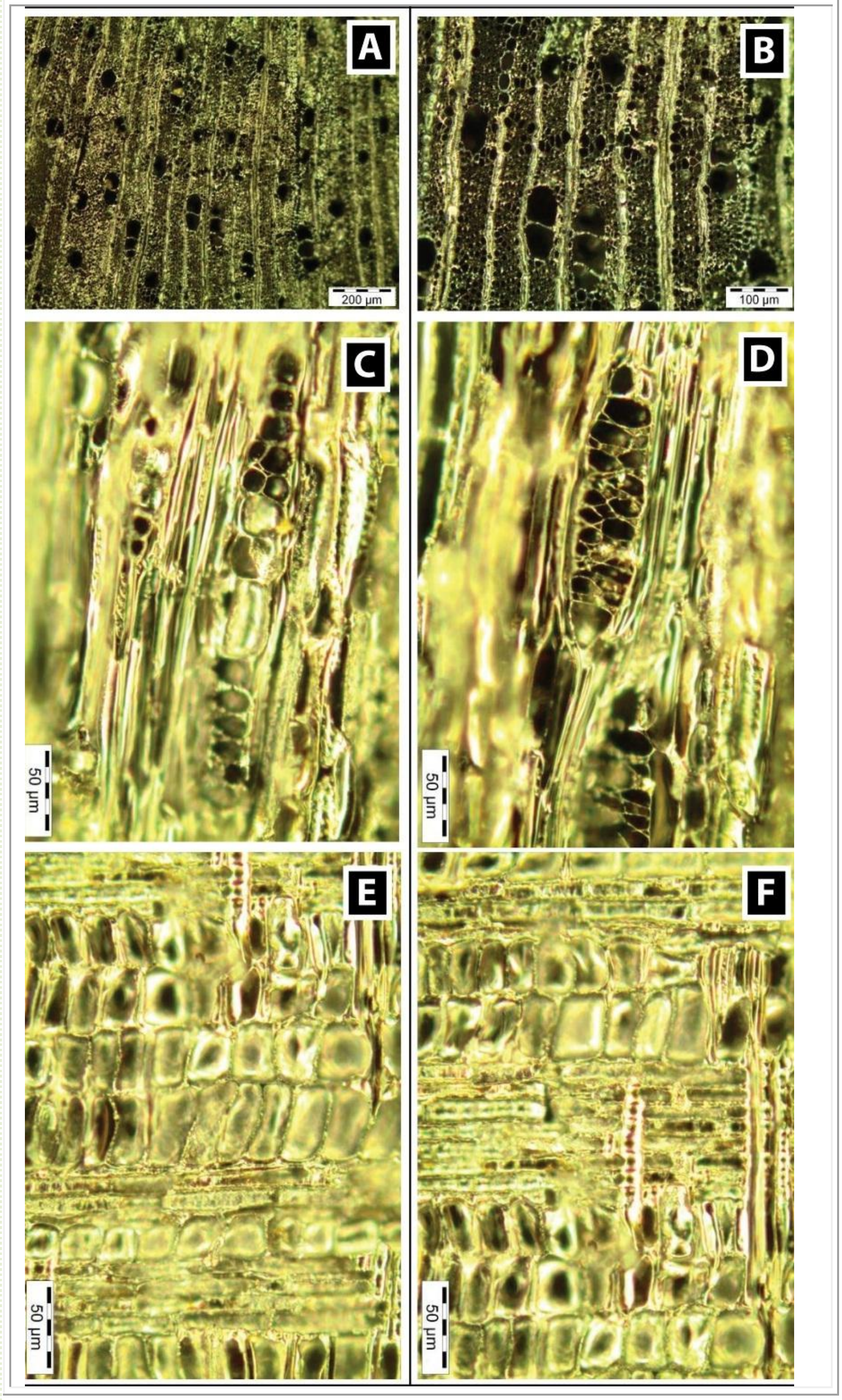


Figure 17: LEGUMINOSAE PAPILIONOIDEAE - *Pericopsis angolensis* (Z13).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -vestured pits, -Vessel pits with distinct borders, similar to intervessel pits in size and shape through cell, -fibres very thick walled, -axial parenchyma winged-aliform, square marginal cells, low rays storied, high rays non-storied, -axial parenchyma and / or vessel elements storied, -prismatic crystals in chambered axial parenchyma cells,

Family: RUBIACEAE	***Genus and species***: *Gardenia volkensii*	***Collection No***: *Z14*

Transverse plane (TS)
•no distinctive growth rings
•semi-diffuse ring porous
•tyloses
•1-3 seriate
•exclusively solitary
•scanty parenchyma
•Mean tangential diameter=27µm
Vessels per millimetre square=166

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 cells wide
•biseriates have tails that are uniseriate composed of large oval cells and the biseriate section has smaller cells as compared to those found in the biseriate section
•are heterocellular
Tracheids are present

Radial longitudinal plane (RLS):
•mixed procumbent, upright and square cells
•Some sections have upright to square cells only

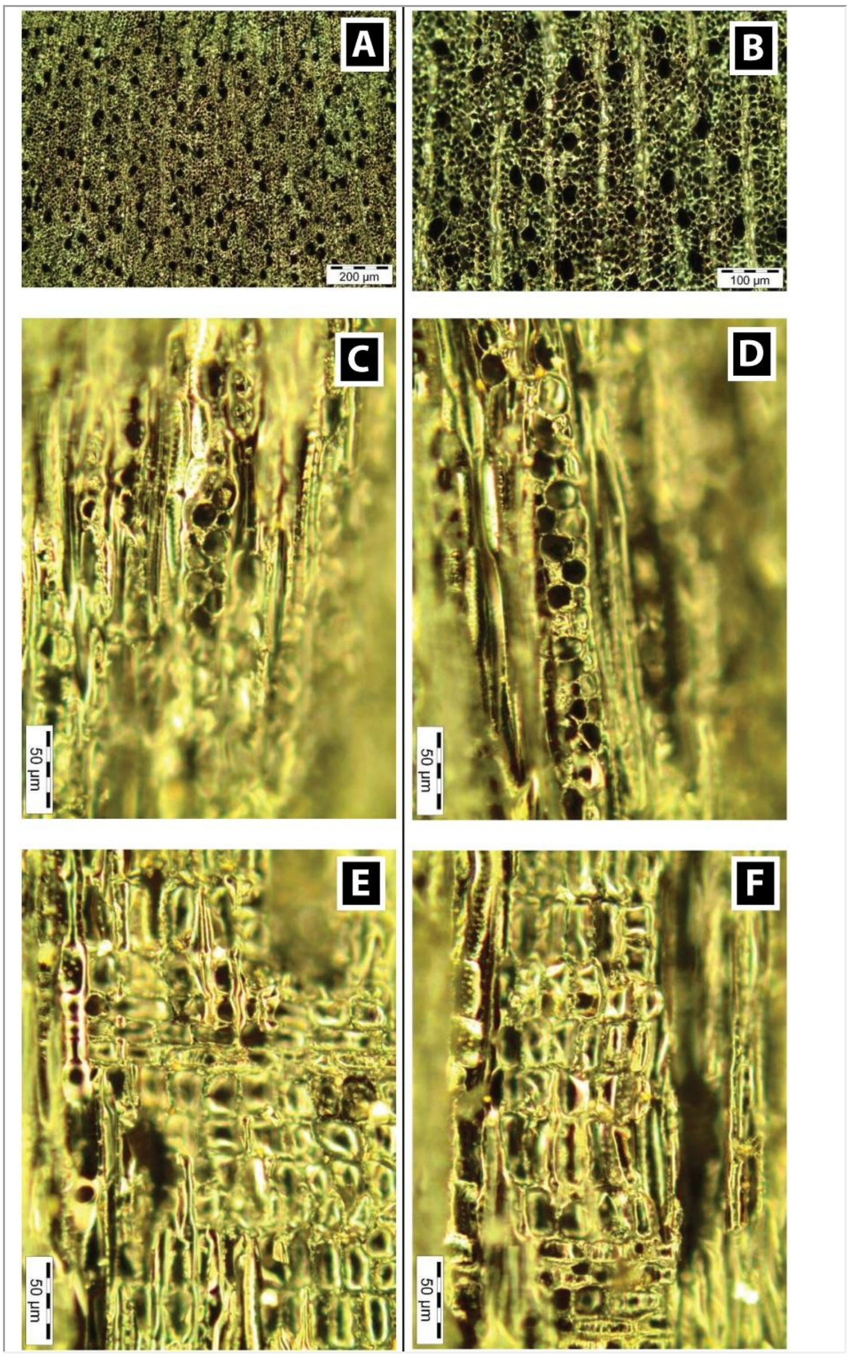


Figure 18: RUBIACEAE - *Gardenia volkensii*

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE MIMOSOIDEAE **Genus and species**: *Acacia sieberiana* **Collection No**: *Z16*

Transverse plane (TS)
•growth rings are present (there regions with high density of vessels)
•semi- diffuse ring porous
•solitary
•radial multiples (2-3)
•vessel arrangements are also tangential and diagonal (haphazard)
•1-3 seriate
•axial paratracheal - confluent
Mean tangential diameter = 73.45µm
Vessels per millmetre square=19

Tangential longitudinal plane (TLS)
Rays:
•are 1-4 cells wide
•the commonest being 1-3 seriates
•uniseriates are weakly heterocellular
•2-4 seriates are heterocellular
•have cell outlines that are either round or angular.
•simple perforation plates
Fibres have septa and simple pits

Radial longitudinal plane (RLS):
•homocellular rays
•all procumbent cells

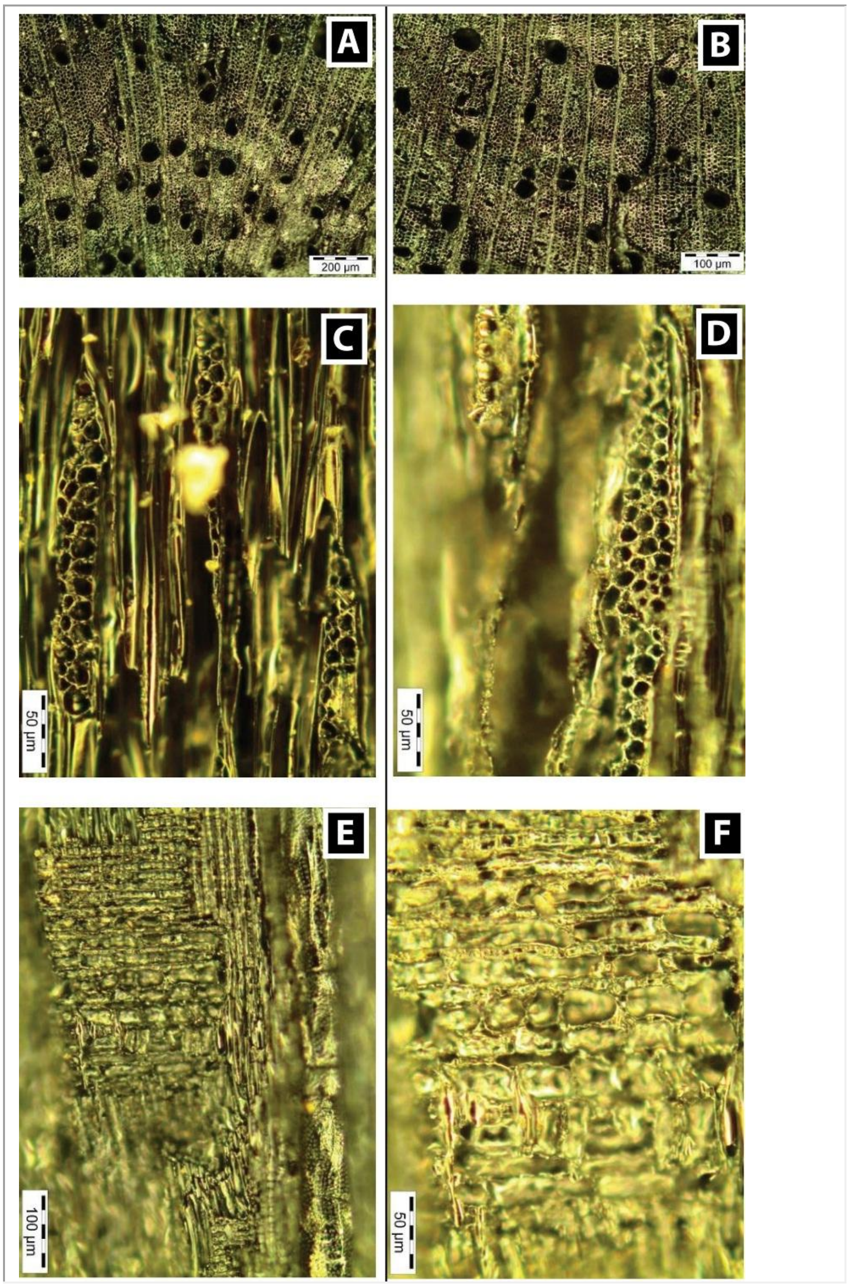


Figure 19: LEGUMINOSAE MIMOSOIDEAE - *Acacia sieberiana* (Z16).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries indistinct or absent, shape of alternate pits polygonal, -vestured pits, Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape through cell, -<=5 vessels per square millimeter, fibres thin- thick walled, -axial parenchyma diffuse, aliform, lozenge-aliform, -axial parenchyma in marginal -prismatic crystals present.

Family: CELTIDACEAE	**Genus and species**: *Celtis africana*	**Collection No**: *Z17*

Transverse plane (TS)
•no distinctive growth rings
•ring porous
•exclusively solitary
•amorphous deposits
1-6 seriate- the ray cells are mixed that is square, procumbent and upright. There is also a mixture of big and small cells.
•Paratracheal axial parenchyma – confluent to banded, festooned
Mean tangential diameter = 13.23µm
Vessels per millimetre square= 61

Tangential longitudinal plane (TLS)
Rays:
•are 1-6 seriate
•are heterocellular
•are fat (mostly triseriates)
•have crystalliferous cells
•cells in some of the five-seriate rays are polygonal
•tetra-seriates have upright and procumbent cells on the margins
•have idioblasts
•simple perforation plates

Radial longitudinal plane (RLS):
•procumbent to square cells
•upright cells on the margins
•crystalliferous cells
•heterocellular

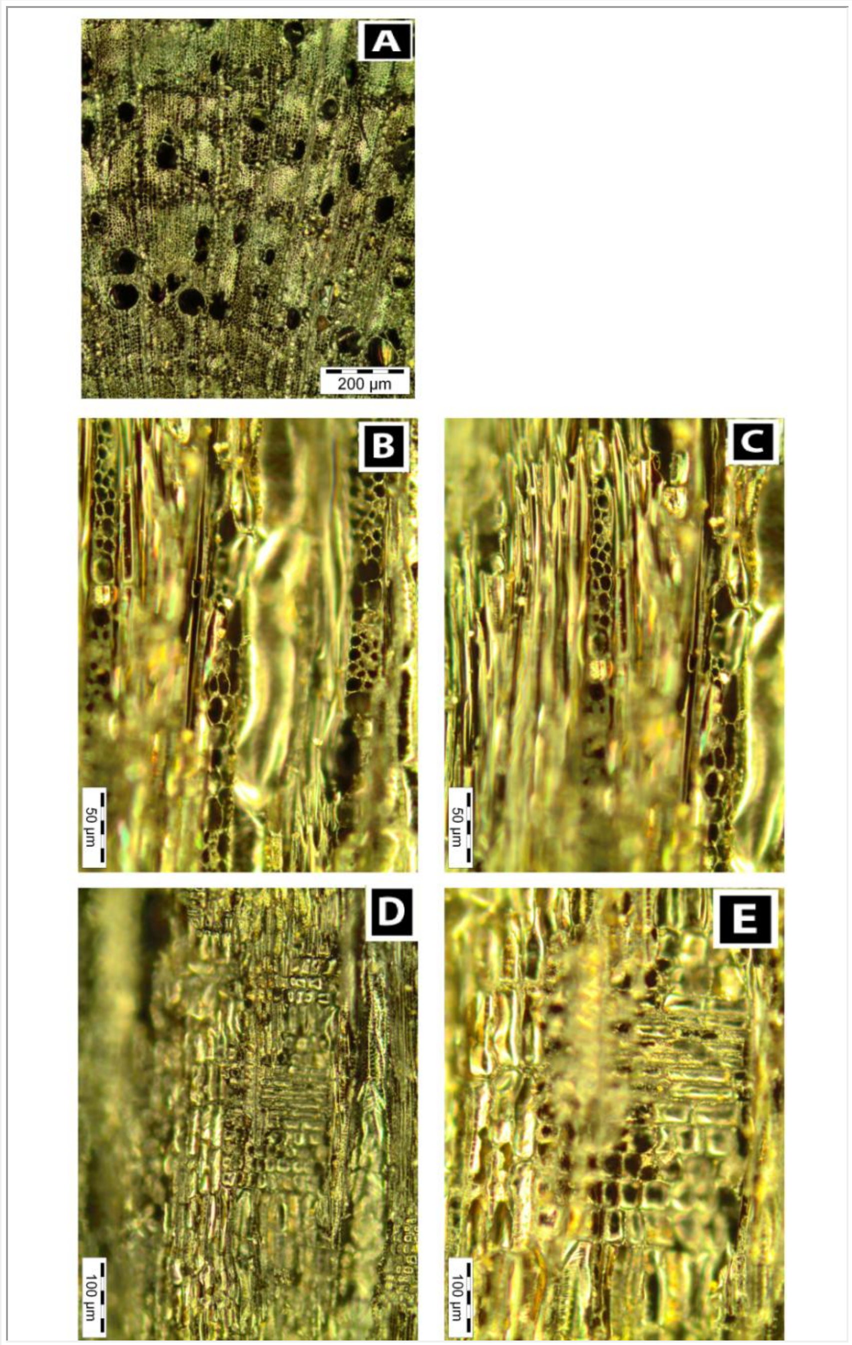


Figure 20: CELTIDACEAE *Celtis africana* (Z17).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -intervessel pits alternate, -vessel-ray pits with distinct borders, -vessel-ray pits with much reduced borders to apparently simple pits rounded or angular, scalariform to palisade, -vessel ray pits restricted to marginal rows, -helical thickenings throughout body of vessel elements,-fibres with simple to minutely bordered pits, -non -septate fibres present, -druses present, -prismatic crystals present

Family: MALVACEAE GREWIOIDEAE ***Genus and species***: *Grewia flavescens* ***Collection No***: *Z18*

Transverse plane (TS)

- no distinctive growth rings
- semi-diffuse ring porous
- solitary
- radial multiples (2-3),
- clusters of 3-4
- amorphous deposits
- 1-4 seriate
- scanty parenchyma

Mean tangential vessel diameter= 46.47 µm
Vessels per millimetre square=53

Tangential longitudinal plane (TLS)

Rays are:

- are 3-4 cells wide
- have cells of varying shapes and outlines that are round to irregular polygonal
- Some of the ray cells are crystalliferous
- have parenchyma also present
- are long triseriates with varying width ranging from 2-3 cells along the ray length
- have idoiblasts

Vessels have alternate pits
Fibres have simple pits

Radial longitudinal plane (RLS):

- mixed cells that are square, upright and procumbent
- heterocellular

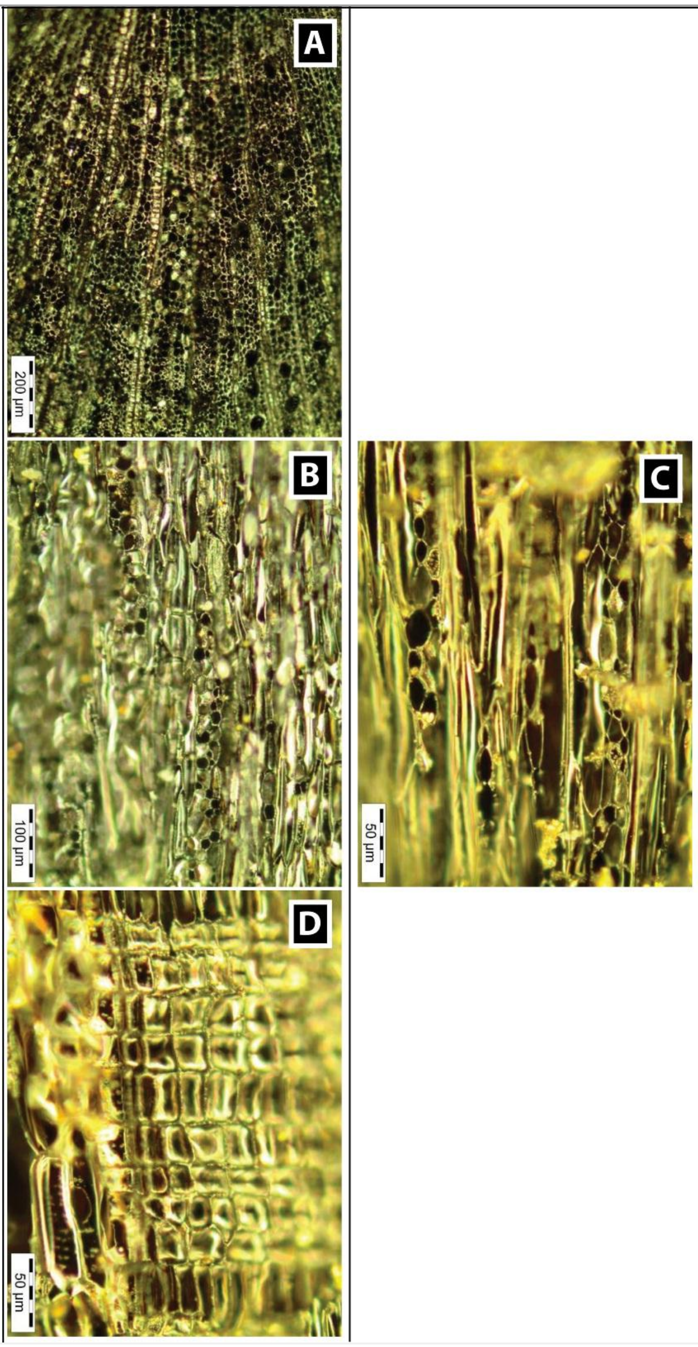


Figure 21: MALVACEAE GREWIOIDEAE - *Grewia flavescens* (Z18).

Extra features from the Inside Wood Online database that are not visible in charcoal reference collection: no data

Family: LEGUMINOSAE MIMOSOIDEAE **Genus and species**: *Albizia amara* **Collection No**: *Z20*

Transverse palne (TS)

•no distinctive growth rings
•diffuse ring porous
•solitary
•Isolated cases of radial multiples (2-3) and diagonal vessel arrangements
•1-2 seriate, predominantly uniseriate
•some ground tissue cells contain crystals and parenchyma as well
•axial paratracheal- confluent, confluent to banded and dendritic
•the vessels are oval in shape
•amorphous deposits

Mean tangential diameter = 70.15 µm
Vessels per millimetre square= 12

Tangential longitudinal plane (TLS)

Rays:
•are 1-3 cells wide
•uniseriates are homocellular, weakly heterocellular and heterocellular
•2-3 seriates are heterocellular
•Some biseriates are weakly heterocellular
•Have idioblasts in biseriates and triseriates
•have parenchyma that are up to three layers of cells along them
•Fibres have septa
•have simple pits
•simple perforation plates

Radial longitudinal plane (RLS):

•mixed upright and square cells
•square cells mixed with procumbent cells
•square cells found on the margins

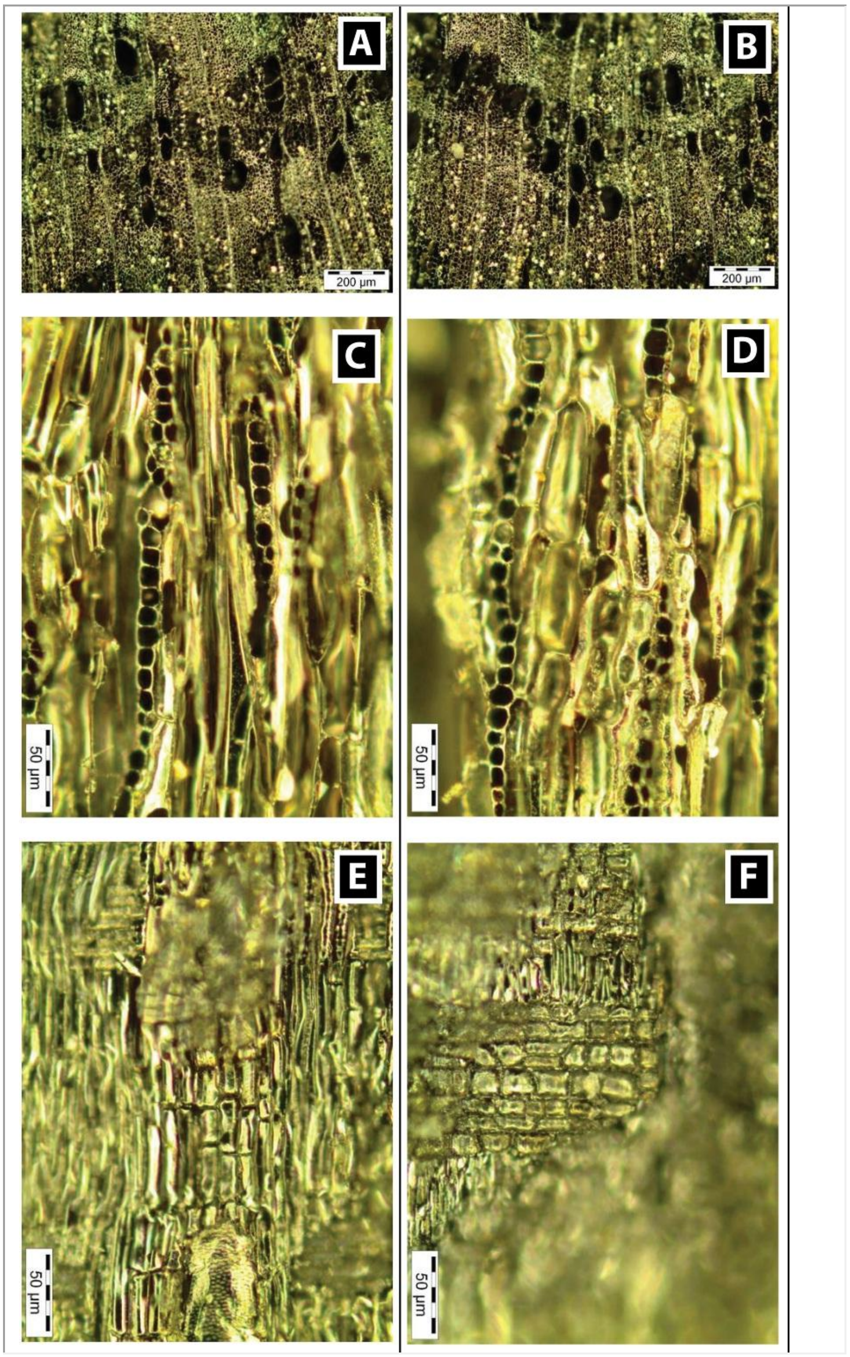


Figure 22: LEGUMINOSAE MIMOSOIDEAE *Albizia amara* (Z20).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct,, -intervessel pits alternate, -shape of alternate pits polygonal, -vestured pits, -vessel ray pits with distinct borders similar to intervessel pits in size and shape through cell, -prismatic crystal present

***Family**: PAPILIONACEAE CAESALPINIOIDEAE **Genus and species** :Bauhinia sp (lilac flowers): **Collection No**: Z27*

Transverse plane (TS)

•solitary
•radial multiples (2-5)
•1-2 seriate (predomoinantly uniseriate)
•diffuse ring porous
•no distinctive growth rings
•paratracheal axial parenchyma – confluent to dendritic?
•narrow rays
•sinus rays
•Tylose
Mean tangential daimeter= 47.69 μm
Vessels per millimetre square = 5

Tangential longitudinal plane (TLS)

Rays:
• 1-2 cells wide
•long and thin rays, 2 cells wide
•biseriates are heterocellular
•Uniseriates are weakly heterocellular
•some of the uniseriate are heterocellular

Fibres have septa

Radial longitudinal plane (RLS):

The ray cells are mixed that is upright to square, square, upright and procumbent
•in some instances procumbent cells occur along the margins
•rays are heterocellular

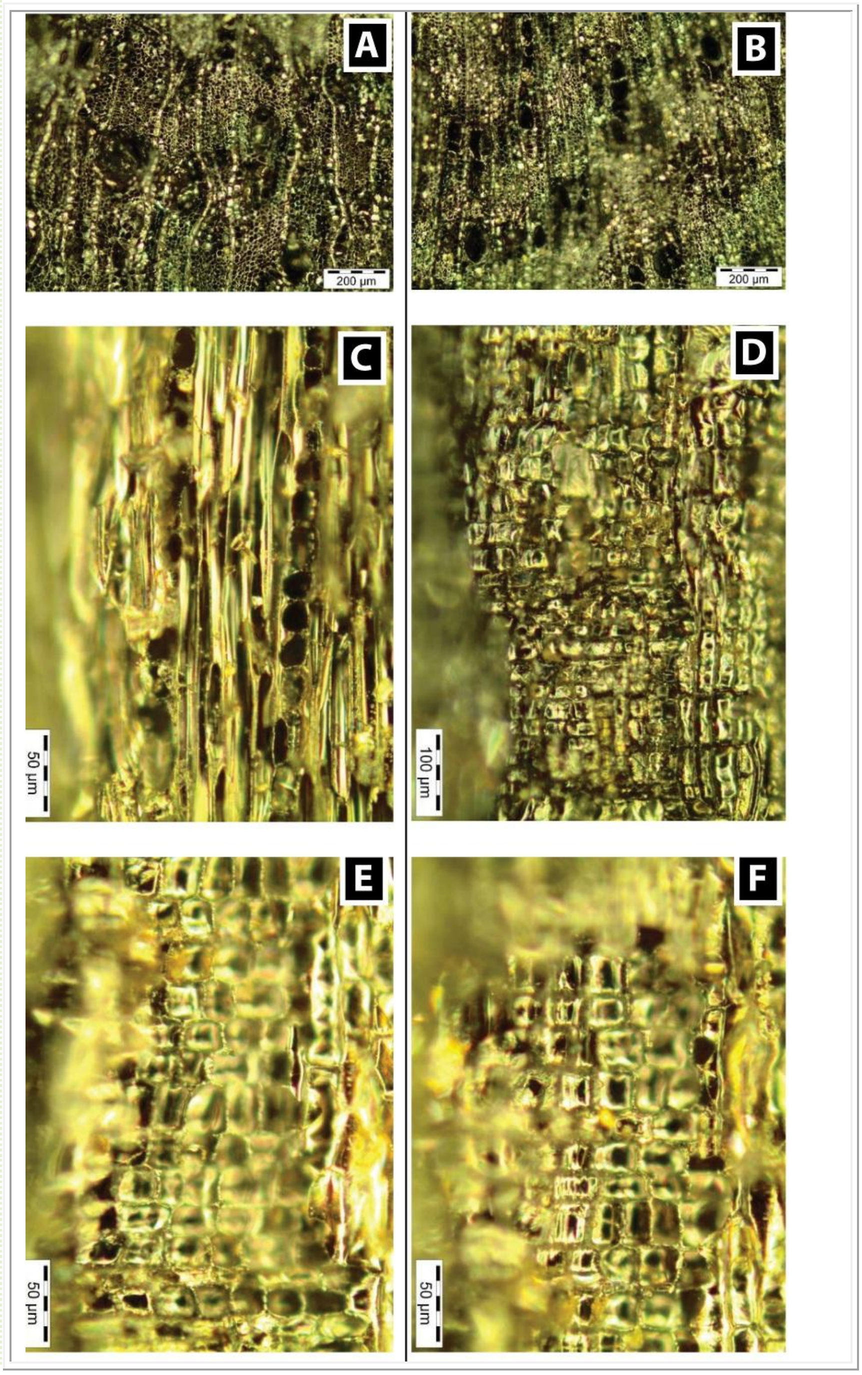


Figure 23: PAPILIONACEAE CAESALPINIOIDEAE *Bauhinia sp (lilac flowers)*

Extra features from the Inside Wood Online database that are not in the charcoal reference collection: no data

Family: COMBRETACEAE **Genus and species**: *Combretum erythrophyllum* **Collection No**: *Z28*

Transverse palne (TS)

- no distinctive growth rings
- diffuse ring porous
- 1-2 seriate (uniseriates are predominant and biseriates are rare)
- exclusively solitary
- axial aliform lozenge, confluent to banded
- banded parenchyma in the ground tissue
- interxylral foraminate phloem

Mean tangential diameter= 43.25 µm
Vessels per millimetre square= 13

Tangential longitudinal plane (TLS)

Rays:

- are 1-2 cells wide
- some uniseriates are weakly heterocellular, and have a length ranging from 2-11 cells
- biseriates with uniseriate tails
- are heterocellular

Vessels:

- have alternate pits
- are short
- have parenchyma

Radial longitudinal plane (RLS):

- mixed procumbent, square and upright
- heterocellular
- heterogenous

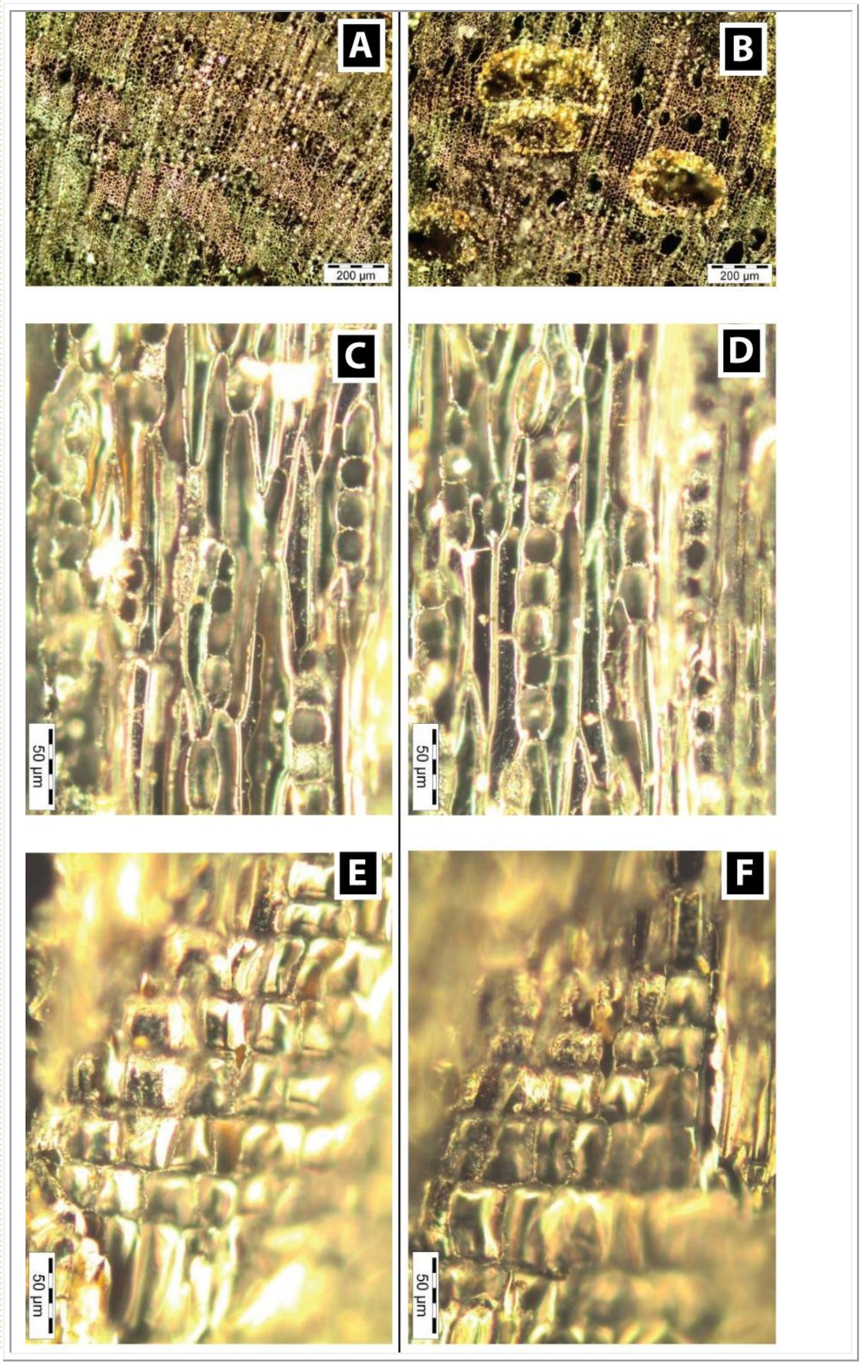


Figure 24: COMBRETAECE *Combretum erythrophyllum* (Z28).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: RHAMNACEAE	**Genus and species**: *Ziziphus mucronata*	**Collection No**: *Z29*

Transverse palne (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary
•radial multiples (2-5)
•uniseriate
•amorphous deposits
•Mixed procumbent, square and upright
•vasicentric parenchyma

Mean tangential vessel diameter = 56.53 µm
Vessels per millimetre square= 83

Tangential longitudinal plane (TLS)
Rays:
•are uniseriates
•weakly heterocellular
•have lengths that are at least 2 cells and up to 15 cells or more
•have crystalliferous cells

Vessels:
•have alternating pits
•have parenchyma

Radial longitudinal plane (RLS):
•mixed upright and square cells
•crystalliferous cells
•heterocellular

•simple perforation plates

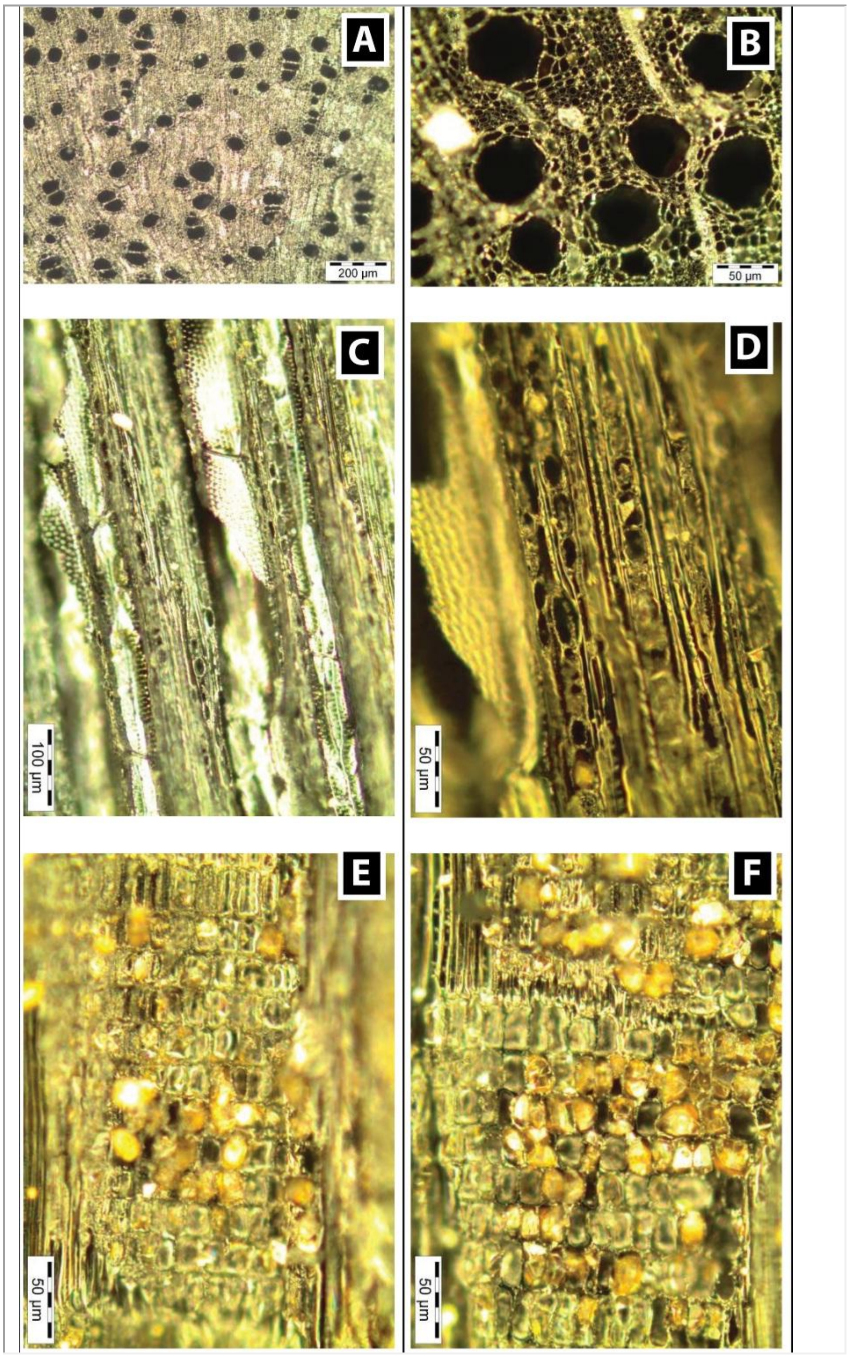


Figure 25: RHAMNACEAE *Ziziphus mucronata* (Z29).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: sclariform perforation plates with <= 10, 10-20 bars, -intervessel pits alternate, -shape of alternate pits polygonal, -vessel pits with distinct borders, similar to intervessel pits in size and shape throughout ray cells, -fibres with simple to minutely bordered pits, -non-septate fibres present, -fibres thin – to thick-walled, aliform, lozenge –aliform, winged aliform, marginal or in seemingly marginal bands, prismatic crystals in upright and or square cells, prismatic crystals in non-chambered axial parenchyma cells

Family: VERBENACEAE	*Genus and species*: *Vitex payos*	*Collection No*: *Z30*

Transverse plane (TS)
•no distinctive growth rings
•ring porous
•solitary
•1-2 seriate
•amorphous deposits (rare)
•Mean tangential vessel diameter = 50 µm

Vessels per millimetre square = 18

Tangential longitudinal plane (TLS)
Rays:
•are 2-3 cells wide
•have idioblasts
•are short, fat and long
•have crystalliferous cells
•are heterocellular

Vessels have parenchyma

Fibre: rare fibres with septa

Radial longitudinal plane (RLS):
•mixed procumbent, square and upright cells
•square –procumbent- square arrangement
•heterocellular

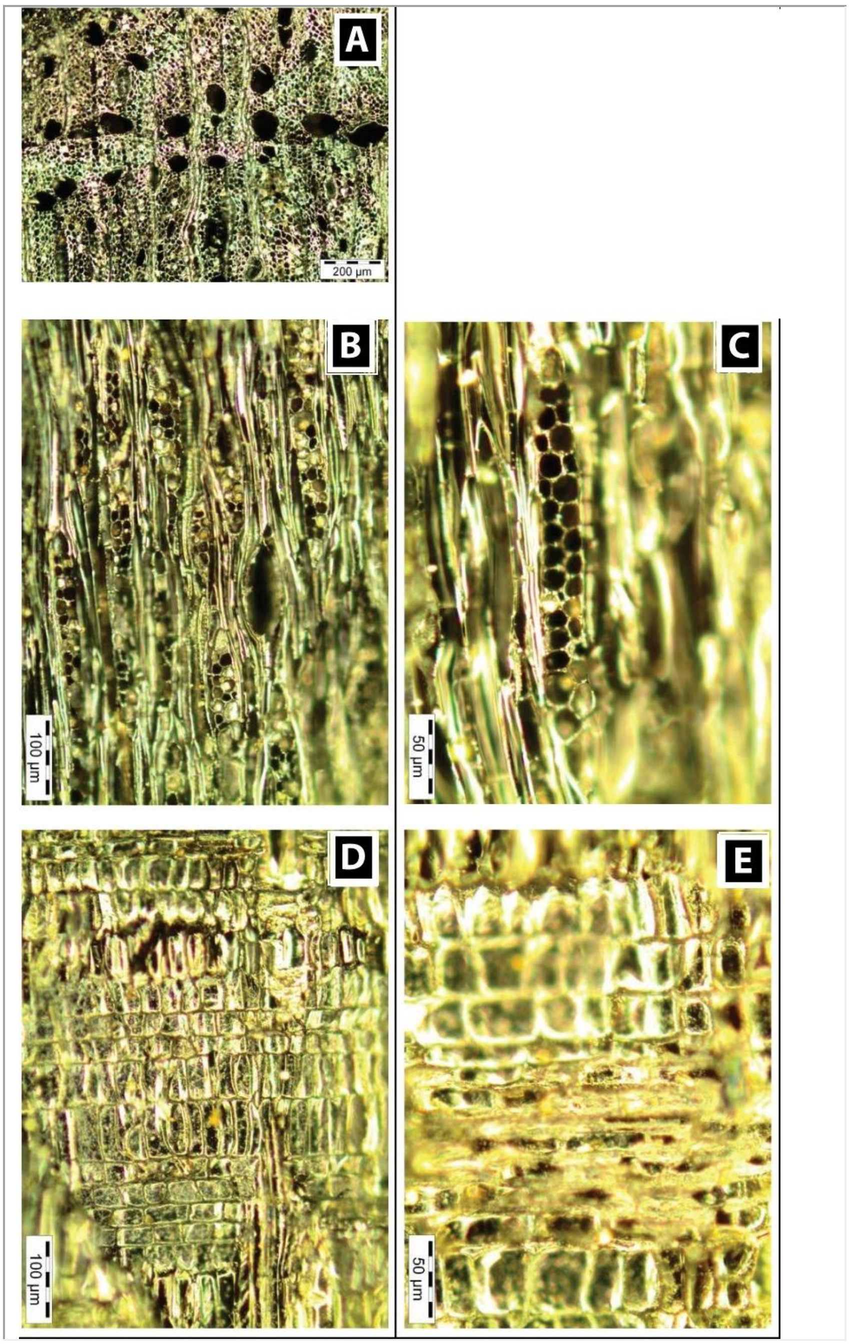


Figure 26: VERBENACEAE *Vitex payos*

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: CHRYSOBALANACEAE	**Genus and species**: *Parinari curatellifolia*	**Collection No**: *Z32*

Transverse plane (TS)
- no distinctive growth rings
- Diffuse ring porous
- solitary (predominant)
- radial multiples
- 1-2 seriate (biseriates are very rare)
- rare tyloses
- amorphous deposits
- axial parenchyma intermediate between reticulate and scalariform

Mean tangential vessel diameter= 77.96 µm
Vessels per millimetre square= 41

Tangential longitudinal plane (TLS)
Rays:
- are 1-4 cells wide (though 4 cells wide are extremely rare)
- uniseriates are at least 3cells and can be up to 14 cells or more long
- are heterocellular
- have crystalliferous cells

- Fibres have simple pits

Radial longitudinal plane (RLS):
- mixed procumbent and square cells
- predominantly square cells

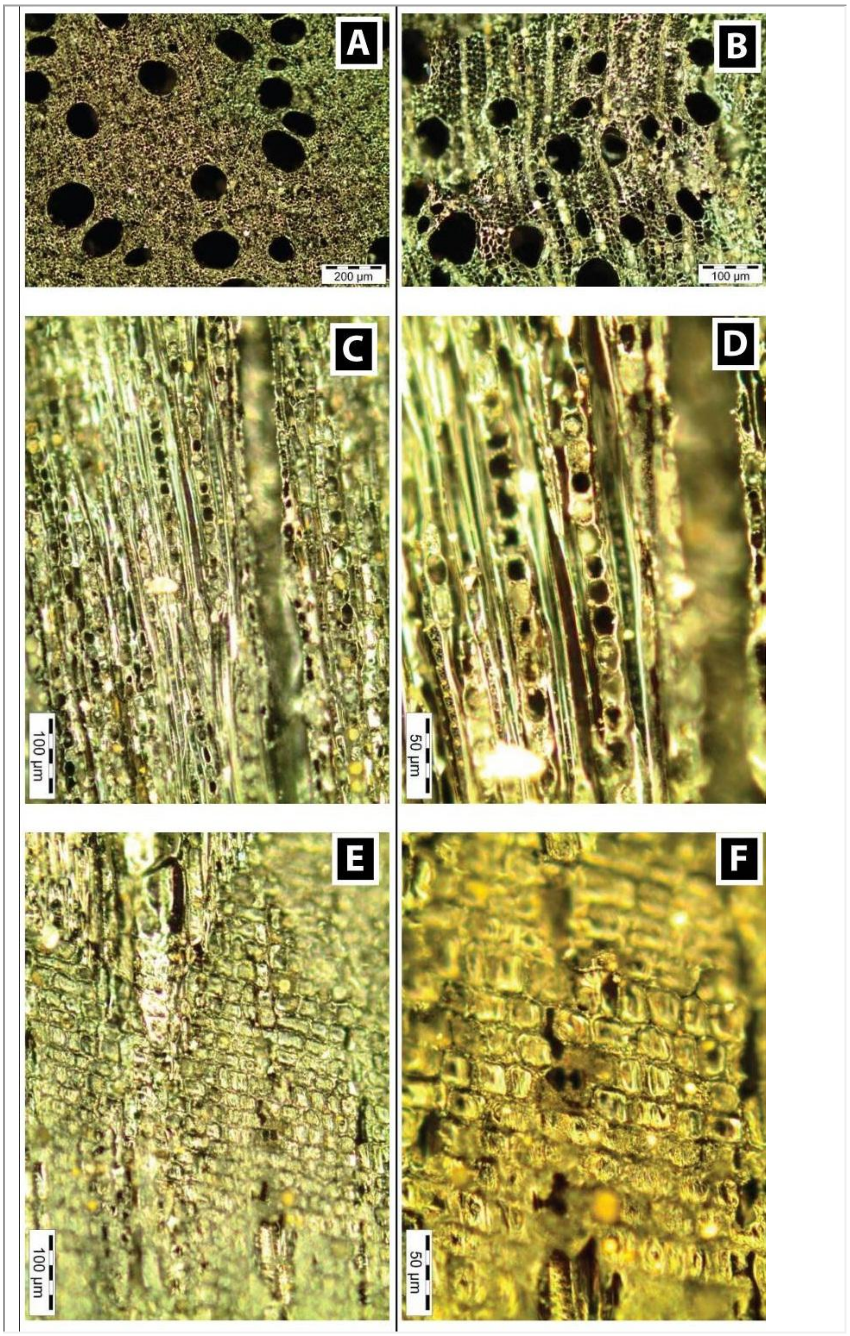


Figure 27: CHRYSOBALANACEAE *Parinari curatellifolia* (Z32).

Extra features from the Inside Wood Online database that are not visible the charcoal reference collection: -vessel ray pits with much reduced borders to apparently simple: pits horizontal to vertical (palisade), -vessels of two distinct diameter classes, -fibres with distinctly bordered pits, fibre pits common in both radial and tangential walls, non -septate fibre present, fibres thin-to thick walled, -axial parenchyma in narrow bands or lines up to three cells wide, ->=12 /mm, -silica bodies present, -silica bodies present in ray cells.

Family: ANACARDIACEAE **Genus and species**: *Protorhus longifolia* **Collection No**: *Z34*

Transverse plane (TS)

•no distinctive growth rings
•diffuse ring porous
•solitary
•radial multiples (2-3)
•amorphous deposits
•uniseriate
•Mean tangential vessel diameter = 51.03 µm

Vessels per millimetre square = 59

Tangential longitudinal plane (TLS)

Rays:
•are 1-2 seriate
•uniseriates are 3 to 9 or more cells long and they are weakly heterocellular
•biseriates are heterocellular, they have sections that are uniseriate and the uniseriate sections are sometimes up to 18 cells long.

Vessels have alternate pits

Radial longitudinal plane (RLS):

•mixed procumbent and square cells
•rays are homocellular and homogenous

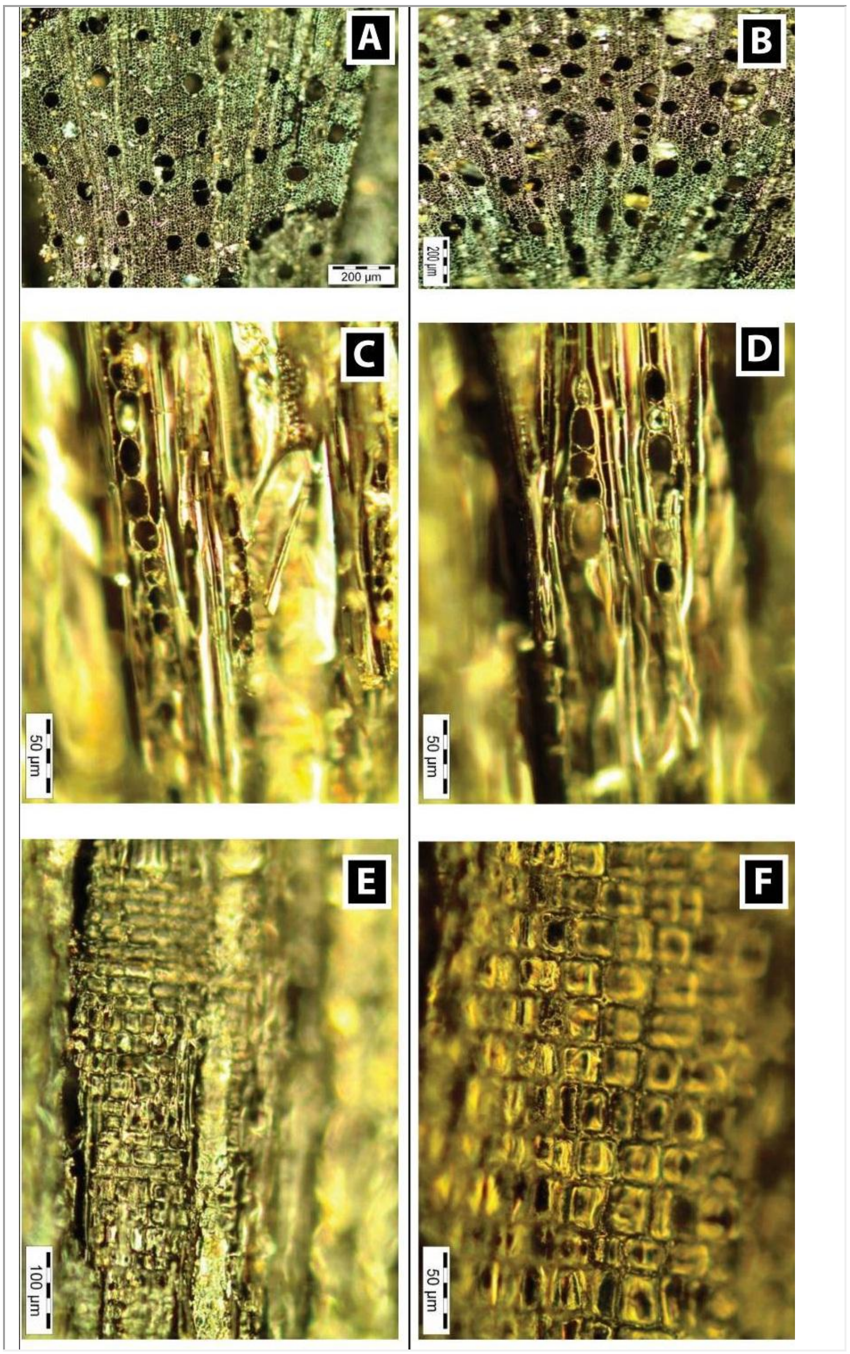


Figure 28: ANACARDIACEAE *Protorhus longifolia* (Z34).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: PHYLLANTHACEAE UAPACEAE **Genus and species**: *Uapaca kirkiana* **Collection No**: *Z35*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•vessels are in radial multiples (2-8)
•vessels are solitary
•1-4 seriate
Mean tangential vessel diameter= 49.59 µm
Vessels per millimetre square = 94

Tangential longitudinal plane (TLS)
Rays:
•are 3-6 cells wide
•are long , big and up to 6 cells wide
•sometimes they have uniseriate tails that are 6 cells long
•are heterocellular

Vessels have opposite pits

Radial longitudinal plane (RLS):

•mixed upright, square and procumbent cells
•heterocellular

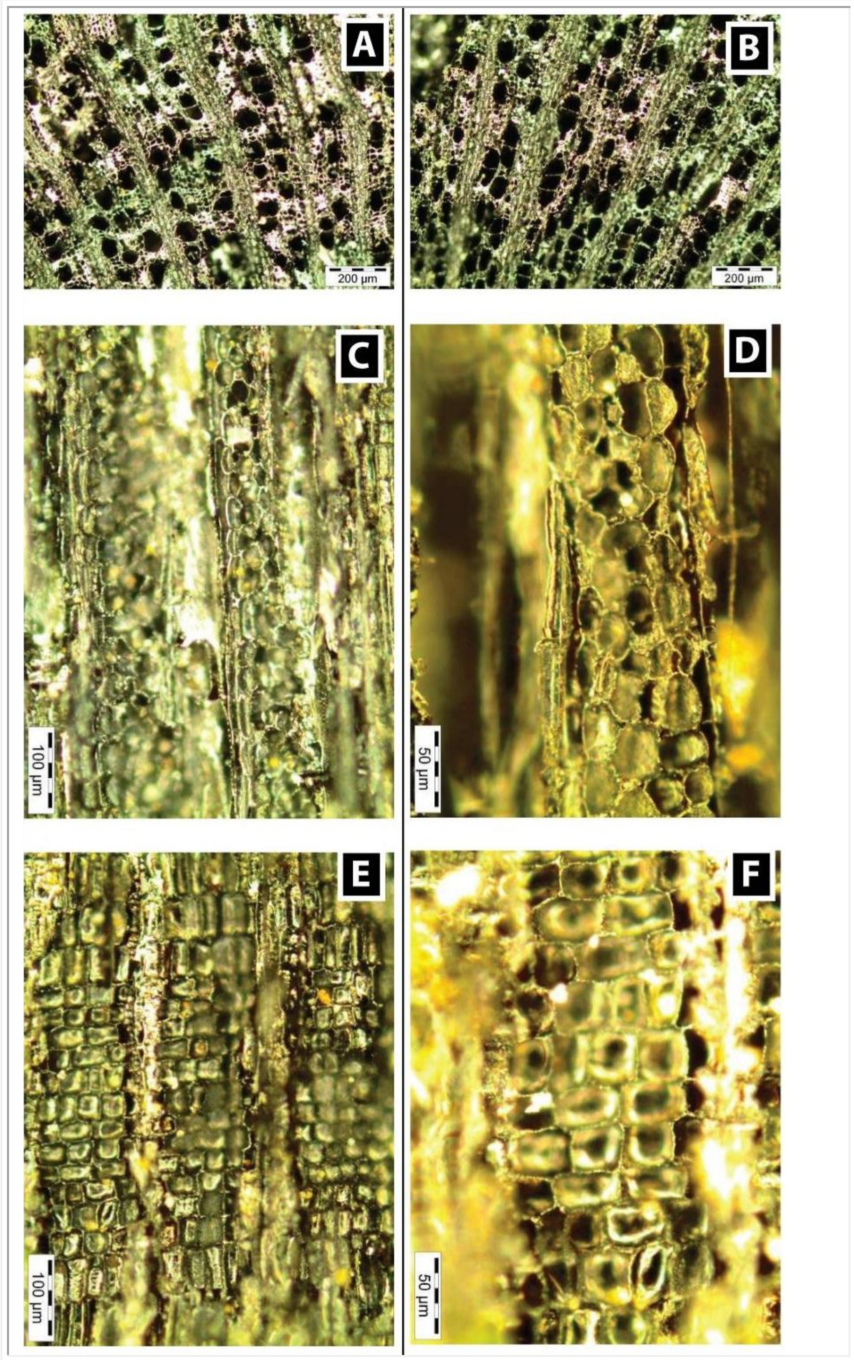


Figure 29: PHYLLANTHACEAE UAPACEAE - *Uapaca kirkiana* (Z35).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: vessel ray pits with much reduced borders to apparently simple :pits rounded or angular, horizontal (scalariform like) to vertical (palisade), -fibres with simple to minutely bordered pits, fibre pits common in both radial and tangential walls, non-septate fibre present, fibres very thick –walled, -axial parenchyma diffuse, scanty paratracheal, vasicentric, unilateral paratracheal, parenchyma in narrow bands 3-8 cells in a strand, -rays 4-to 10 seriate, -ray height> 1mm, -rays of two distinct, sizes, -perforated ray cells, -disjunctive ray parenchyma cells.

Family: EUPHORBIACEAE	***Genus and species***: *Pseudolachnostylis maprouneifolia*	***Collection No***: *Z36*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-7)
•solitary
•1-3 cells wide
•amorphous deposits
Mean tangential vessel diameter= 47.79 µm
Vessels per millimetre square= 72

Tangential longitudinal plane (TLS)
Rays:
•are 1-3 cells wide
•are large and long rays that are heterocellular
•some sections of the rays are weakly heterocellular
•biseriate and triseriate rays have tails that are uniseriate
•uniseriate rays have lengths from 7- 15 cells or more

Radial longitudinal plane (RLS):
•mixture of procumbent and square cells
•heterocellular
Vessels have alternating pitS

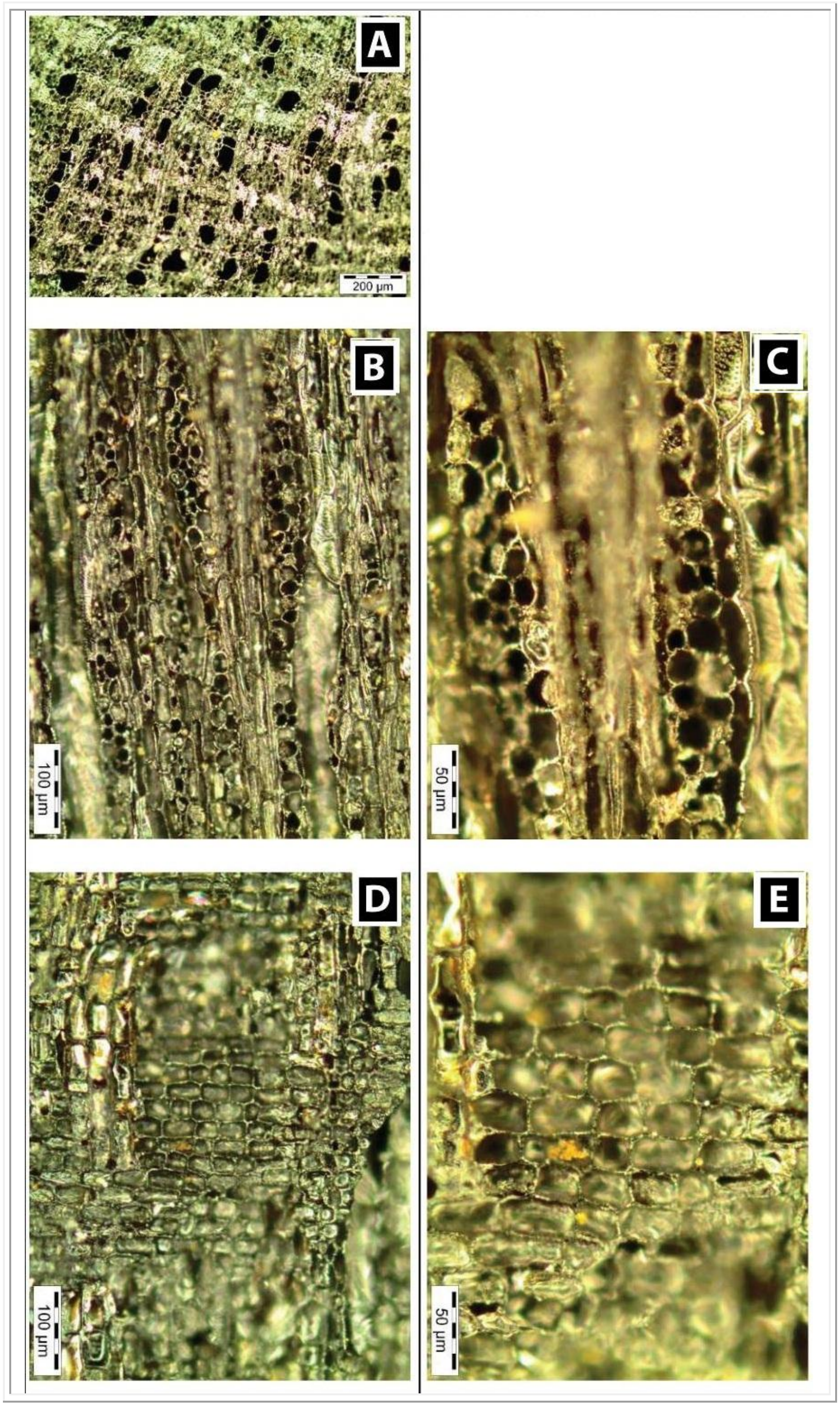


Figure 30: EUPHORBIACEAE *Pseudolachnostylis maprouneifolia* (Z36).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

***Family**:* ANACARDIACEAE ***Genus and species**: Rhus chirindensis* ***Collection No**: Z37*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-3)
•solitary
•1-2 seriate (biseriates extremely rare)
•amorphous deposits
•Tyloses

Mean tangential vessel diameter = 48.36 µm
Vessels per millimetre square = 38

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 seriate
•uniseriates are varied in that some are homocellular to weakly heterocellular whilst others are heterocellular
•biseriates are heterocellular, they however, have sections that are homocellular to weakly heterocellular
•have idioblasts

Fibres have septa and alternate pits

Radial longitudinal plane (RLS):
•mixed cells
•upright cells
•upright to square cells
•mixed square and procumbent cells

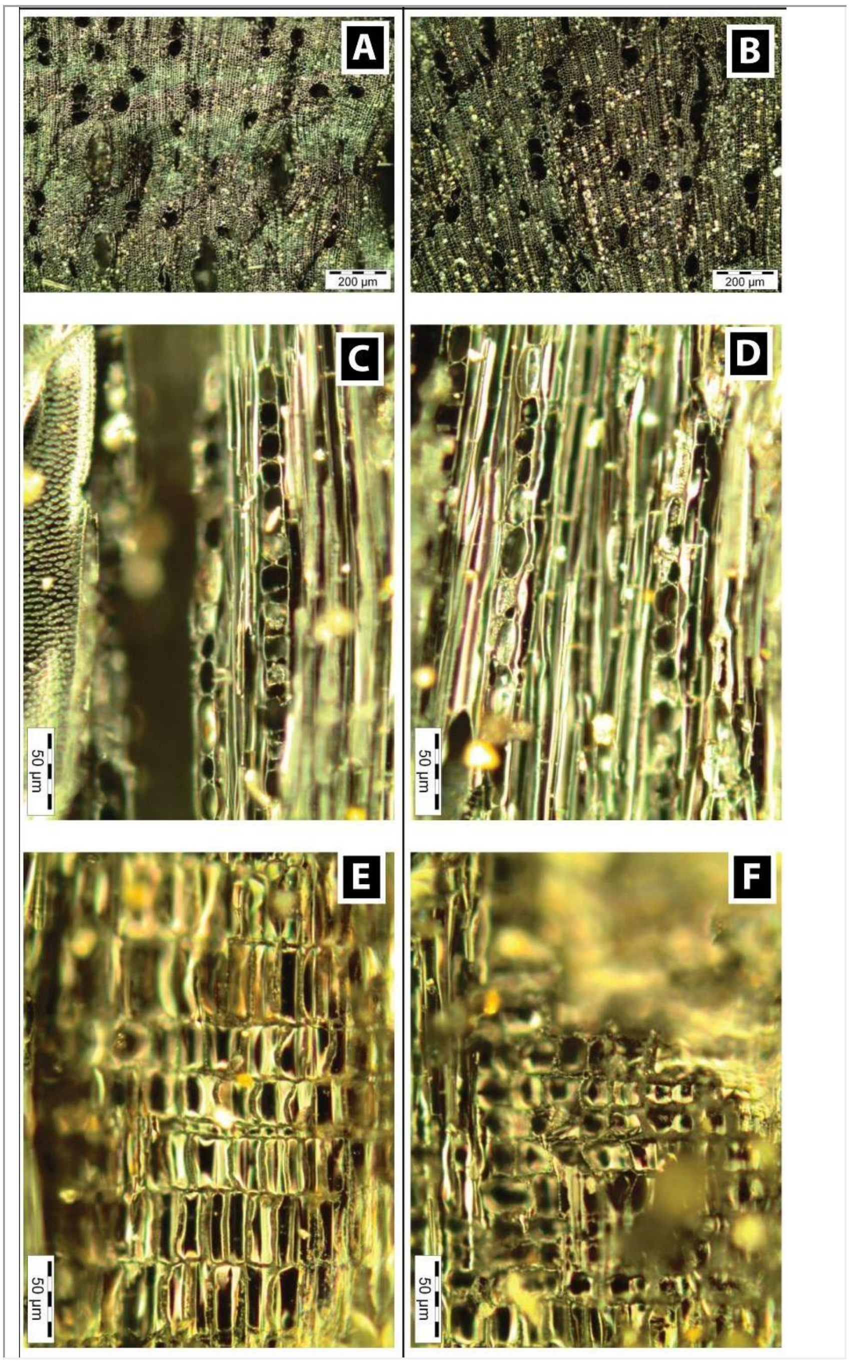


Figure 31: ANACARDIACEAE *Rhus chirindensis*

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: PROTEACEAE	*Genus and species*: *Faurea saligna*	*Collection No*: *Z38*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•mixed – solitary, tangential, and diagonal (the tangential distribution appear to be dominant)
•1-13 seriate
•confluent, confluent to banded parenchyma
•amorphous deposits
Mean tangential vessel diameter= 36.53 µm
Vessels per millimetre square= 133

Tangential longitudinal plane (TLS)
Rays:
•are 1-18 cells wide
•are very fat
•Aggregate rays
•are heterocellular
•have simple pits

Radial longitudinal plane (RLS):
Ray cells are mixed that are procumbent, and square to uprigh

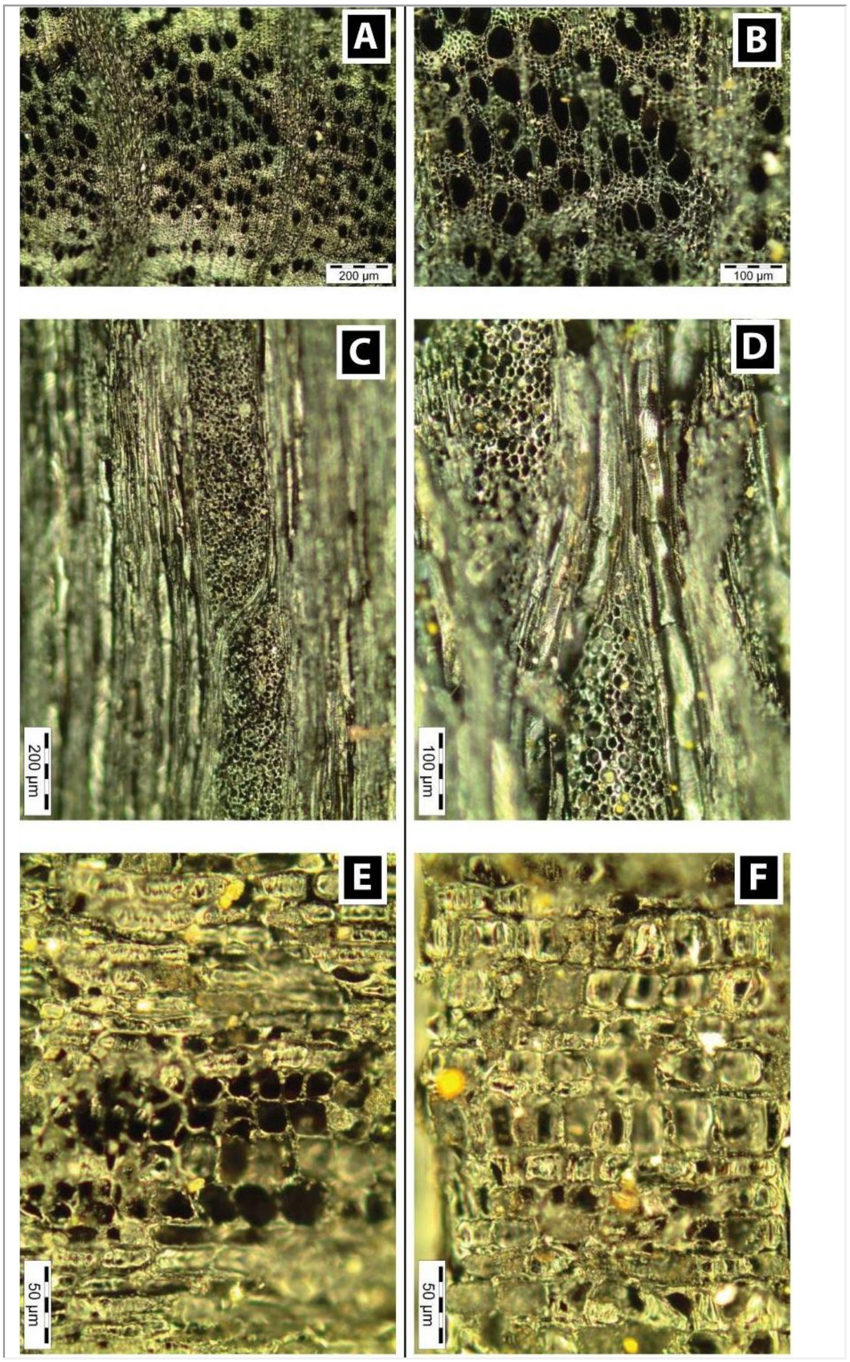


Figure 32: PROTEACEAE *Faurea saligna* (Z38).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE PAPILIONOIDEAE ***Genus and species***: *Pterocarpus angolensis* **Collection No**: *Z41*

Transverse plane (TS)
•solitary
•radial multiples (2-3)
•amorphous deposits
•no distinctive growth rings
•ring porous
•uniseriate
•Tyloses
•axial parenchyma- paratracheal-banded, confluent, confluent to banded
•parenchyma cells look much bigger than the fibre/ground tissue cells

Mean tangential vessel diameter = 80.41µm
Vessels per millimetre square =17

Tangential longitudinal plane (TLS)
Rays:
•are uniseriates
•are weakly heterocellular and homocellular
•have crystals in 1 or 2 cells
•are 3-11 cells long
•Vessel ray pits
Vesselsl ray pits approximately 5 µm probably the same with intervessel pits
Fibres have septa

Radial longitudinal plane (RLS):
•mixed procumbent and square cells
•marginal square cells

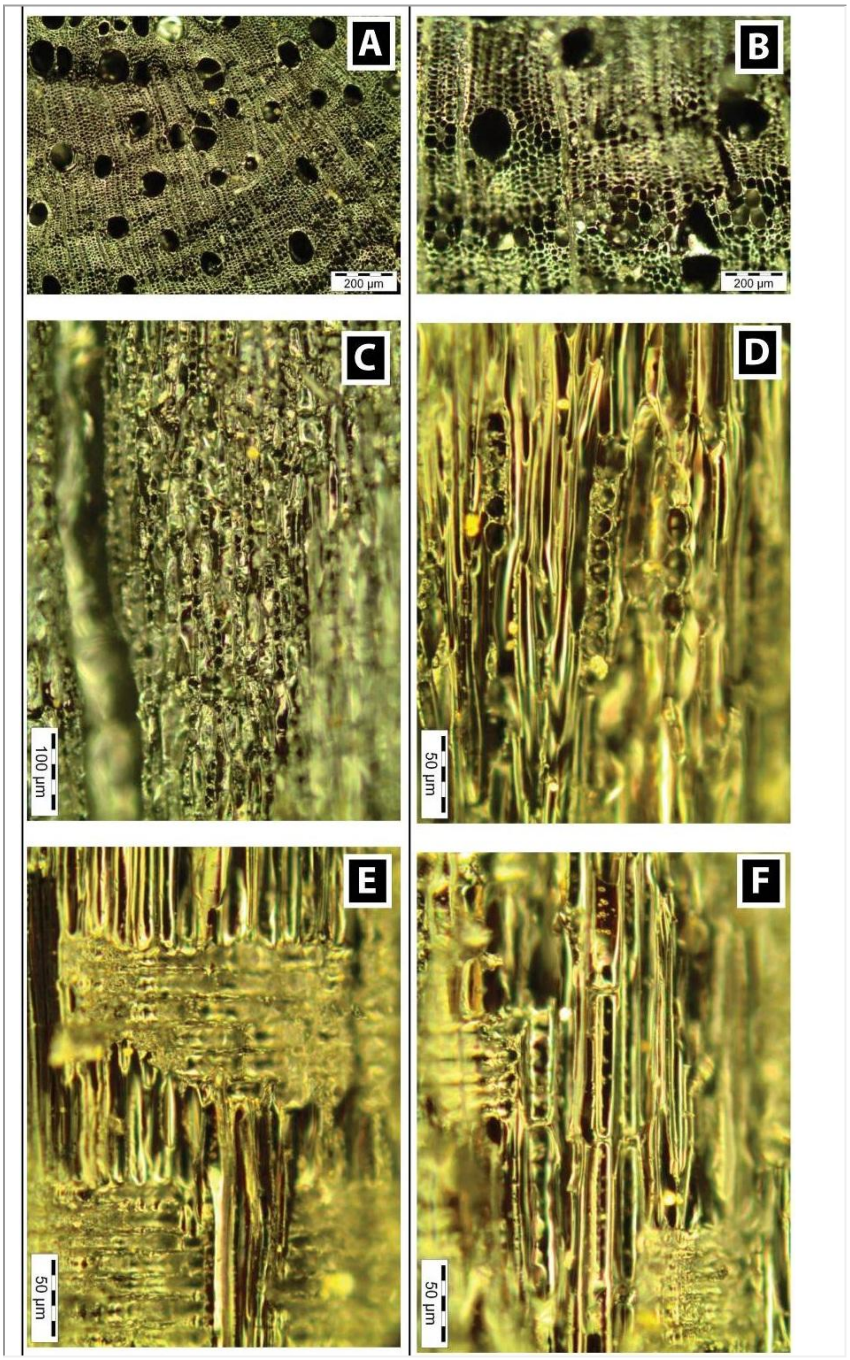


Figure 33: LEGUMINOSAE PAPILIONOIDEAE *Pterocarpus angolensis* (Z41).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE CAESALPINIOIDEAE **Genus and species**: *Brachystegia spiciformis* **Collection No**:*Z42*

Transverse plane (TS)
•growth rings
•diffuse ring porous
•solitary
•radial multiples (2-3)
•axial paratracheal- confluent, aliform winged, vasicentric
•aliform to confluent paratracheal
•radial parenchyma,marginal parenchyma
•uniseriate
•Vessel outlines are round and / angular
•there crystals in ground tissue and parenchyma cells
•Mean tangential vessel diameter = 60.47 μm
Vessels per millimetre square=22

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 seriates
•uniseriates are homocellullar to weakly heterocellular
•uniseriate have lengths that are 4- 20 cells
•are predominantly uniseriate
•biseriates are rare and heterocellular
•have idioblasts
•hre crystalliferous
•there are rows of square crystals (very square)
Vessels:
•have intervessel pits that are alternate about 2-4 μm wide
Fibres have simple pits

Radial longitudinal plane (RLS):
•mixed procumbent and upright to square cells on the margins
•mixture of square to procumbent cells on the margins and then a column of upright to square cells in the middle

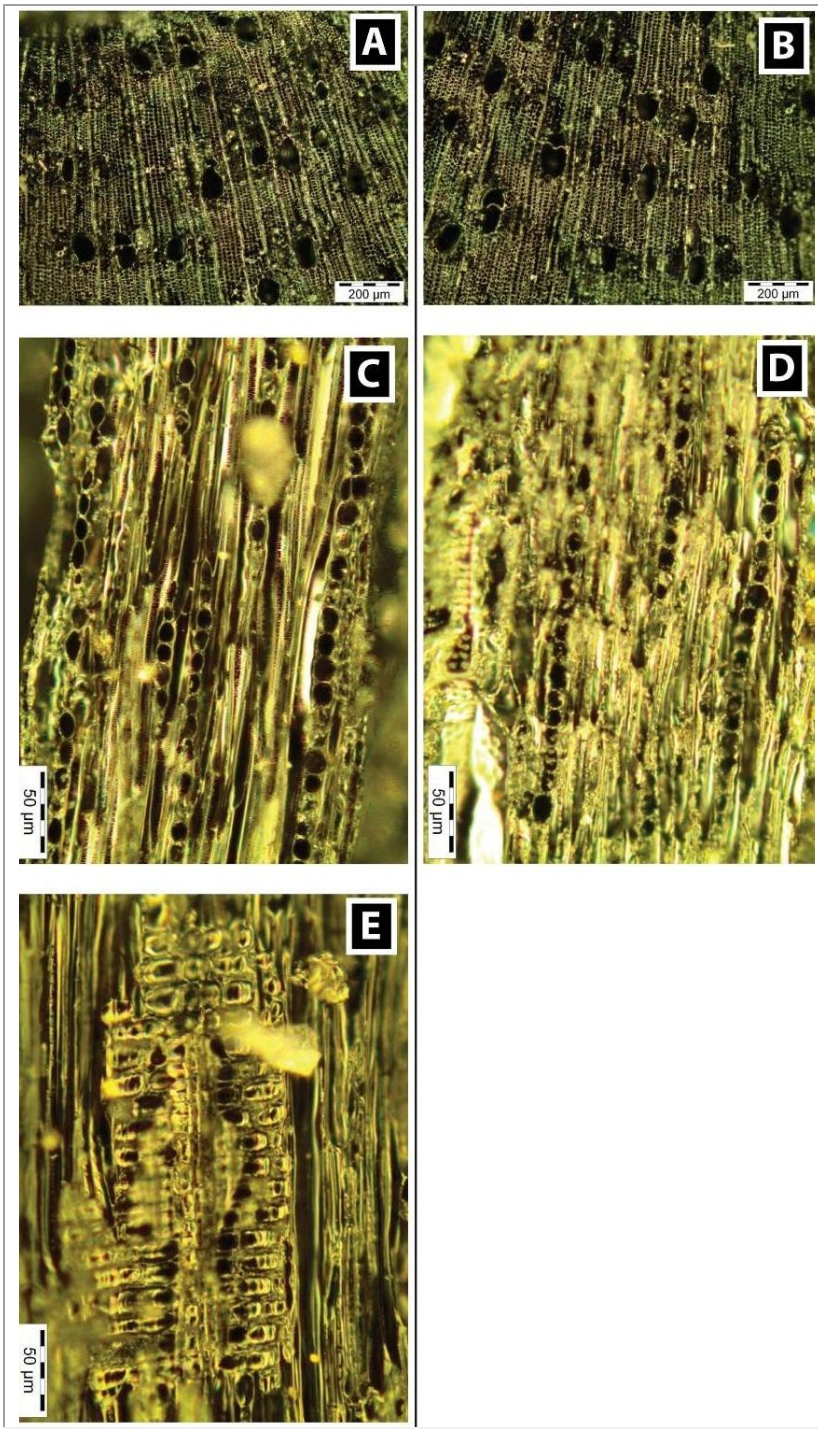


Figure 34: LEGUMINOSAE CAESALPINIOIDEAE - *Brachystegia spiciformis* (Z42).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: COMBRETACEAE	*Genus and species*: *Combretum molle*	*Collection No*: *Z43*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•exclusively solitary
•intraxylral foraminate phloem
•axial parenchyma- confluent, confluent to banded
•Tyloses
•uniseriate

Mean tangential vessel diameter = 50.18 µm
Vessels per millimetre square= 22

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 cells wide
•have idioblasts
•uniseriates are weakly heterocellular
•some uniseriates are up 19 cells long

Fibres have septa

Radial longitudinal plane (RLS):
•mixed procumbent and square cells
•have idioblasts

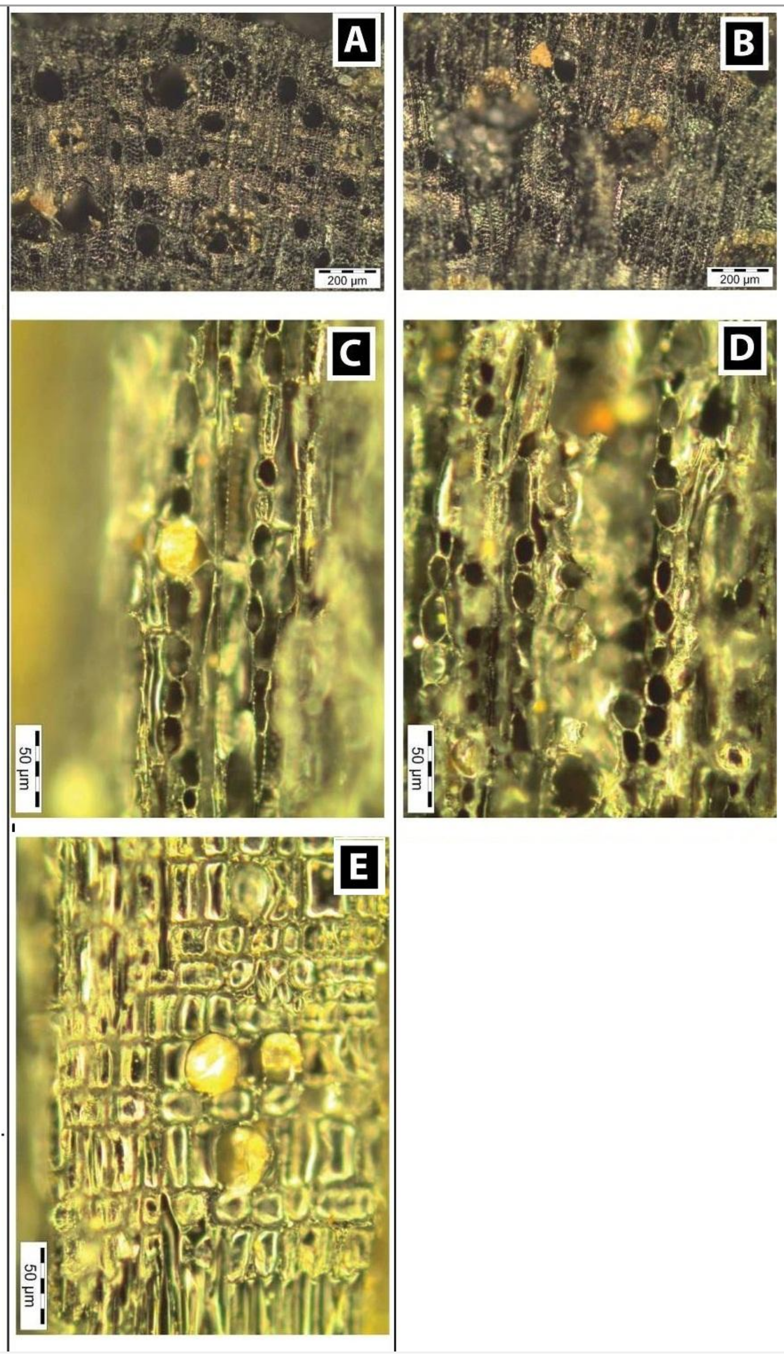


Figure 35: COMBRETACEAE - *Combretum molle* (Z43)

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: ANACARDIACEAE	Genus and species: *Lannea discolor*	Collection No: *Z47*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary
•radial multiples (2-4)
•uniseriate
•amorphous deposits
•scanty to vasicentric parenchyma

Mean tangential vessel diameter= 67.31 µm
Vessels per millimetre square=90

Tangential longitudinal section (TSL)
Rays:
•are 1-2 cells wide
•some uniseriates are heterocellular whilst others are weakly heterocellular
•uniseriates can be up to 15 cells and can be as short as 2 cells
•uniseriates are heterocellular and long
•biseriates have idioblasts

Vessels have alternate pits

Fibres have septa

Radial longitudinal plane (RLS):
•mixed cells that are square, upright and procumbent
•heterocellular

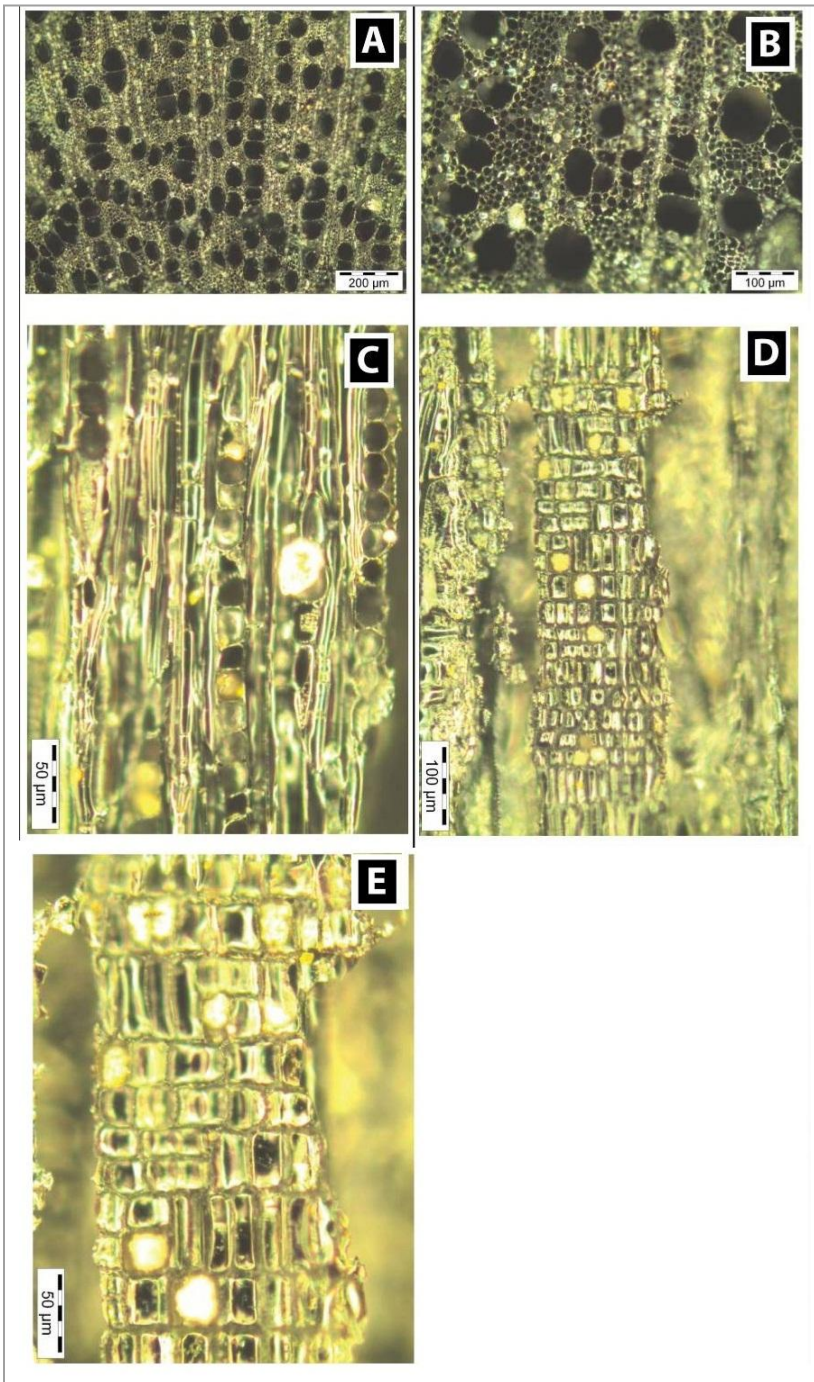


Figure 36: ANACARDIACEAE *Lannea discolour* (Z47).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE MIMOSOIDEAE ***Genus and species***: *Albizia gummifera* ***Collection No***: *Z48*

Transverse plane (TS)
•growth ring boundaries distinctive
•diffuse ring porous
•exclusively solitary
•radial multiples (2-4)
•uniseriate
•amorphous deposits
•confluent, confluent to banded paratracheal axial parenchyma
•Tyloses
Mean tangential vessel diameter = 81.62 µm
Vessels per millimetre square = 16µm

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 seriate
•Short uniserites are weakly heterocellular to homocellular
•that are 2 cells wide have a short biseriate section and a tail section that is 1 cell wide (rare)
•have crystals in one or two cells
•cells are oval with round outline
•have idioblasts
•have parenchyma strands along them
Fibres have simple pits
•are occasionally septate

Radial longitudinal plane (RLS):
•mixed cells
•mostly procumbent cells
•body cells procumbent
•upright square cells occur along the margins
•square cells
•wekly heterocellular
•simple perforation plates

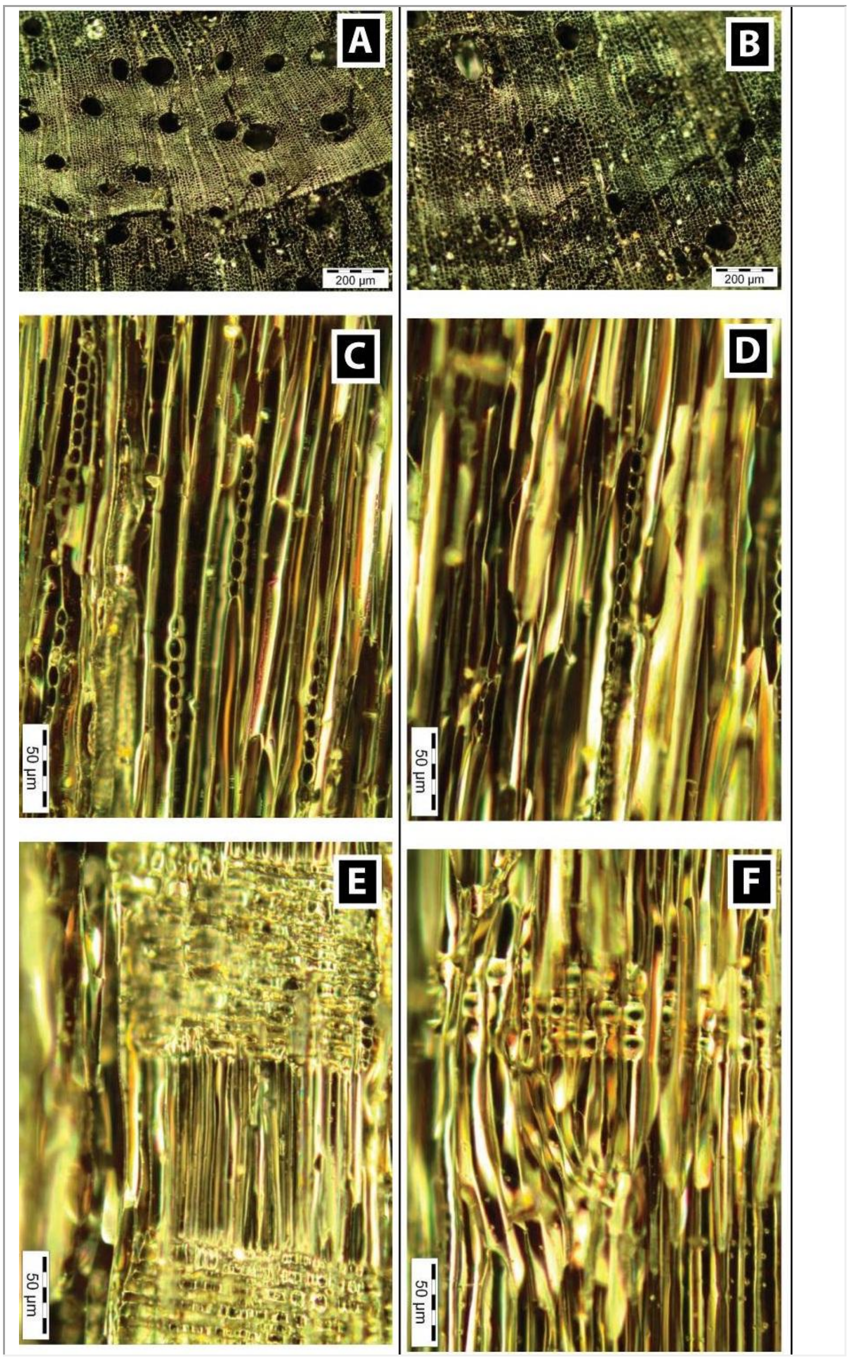


Figure 37: LEGUMINOSAE MIMOSOIDEAE *Albizia gummifera* (Z48).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -intervessel pits alternate, -shape of alternate pits polygonal, -vestured pits, -vessel ray pits with distinct borders similar to intervessel pits in size and shape, -fibres with simple to minutely bordered pits, septate fibres present, fibres thin – to thick-walled, -axial parenchyma diffuse, vasicentric, aliform, lozenge-aliform, fusiform parenchyma, 2-4 cells per parenchyma strand, -4-12 /mm, -prismatic crystals in chambered axial parenchyma cells

Family: LEGUMINOSAE PAPILIONOIDEAE **_Genus and species_**: *Pterocarpus rotundifolius* **_Collection No_**: *Z50*

Transverse plane (TS)
- no distinctive growth rings
- semidiffuse ring porous
- solitary
- radial multiples (2-3)
- uniseriate
- amorphous deposits
- Tyloses
- irregular banding of apotracheal and paratracheal (aliform)

Mean tangential vessel diameter= 58.5 µm
Vessels per millimetre square = 44

Tangential longitudinal plane (TLS)

Rays:
- are 1-2 seriate
- have idioblasts
- Biseriates are heterocellular
- uniseriates are weakly heterocellular to homocellular

Vessels have parenchyma

Fibres:
- have simple pits
- have rare septa

Radial longitudinal plane (RLS):
- mixed procumbent and square cells
- square cells also occurring along the margins

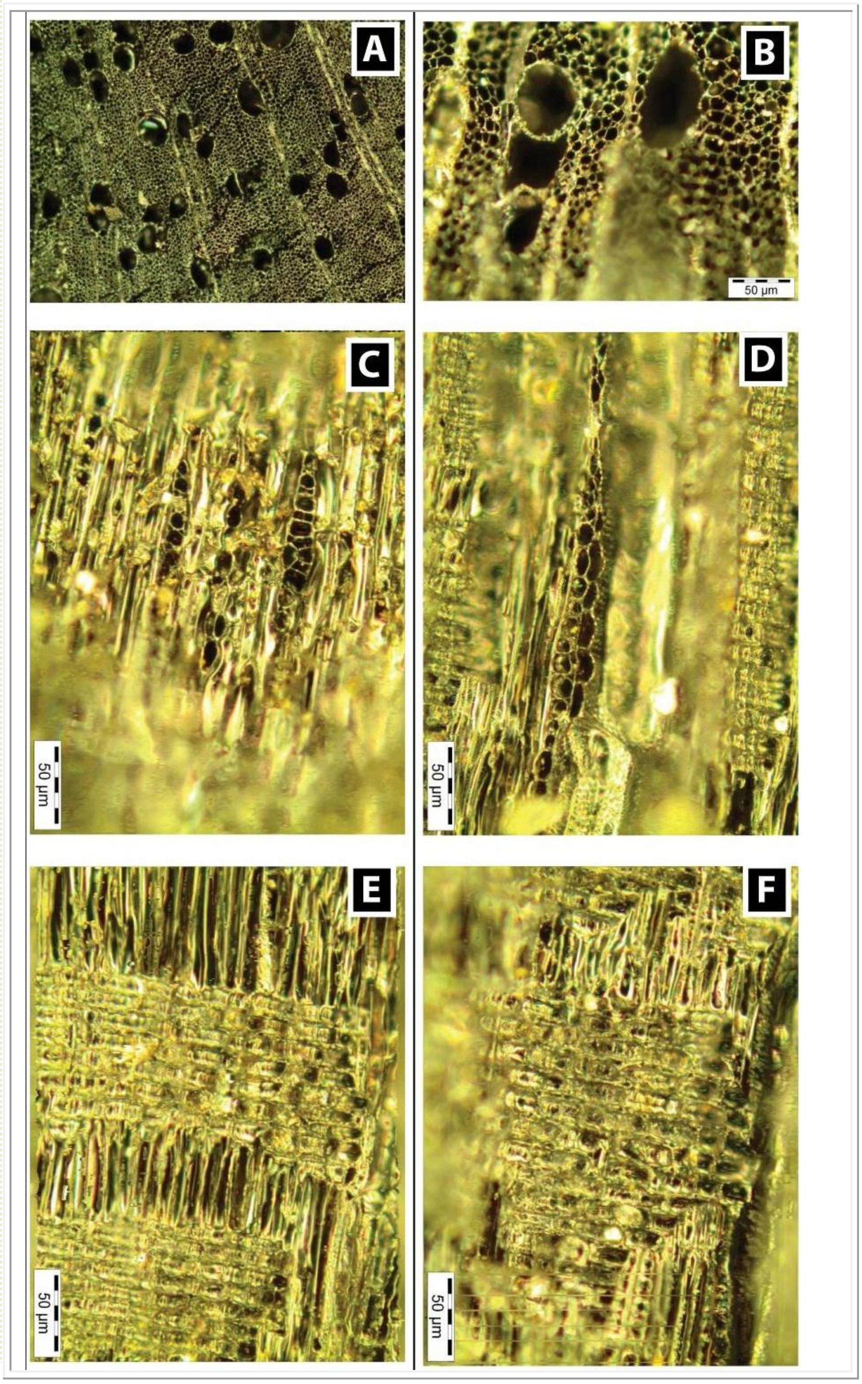


Figure 38: LEGUMINOSAE PAPILIONOIDEAE *Pterocarpus rotundifolius* (Z50).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: data not complete, only images are available

Family:LEGUMINOSAE CAESALPINIOIDEAE ***Genus and species***: *Burkea africana* ***Collection No***: *Z53*

Transverse plane (TS)
•no distinctive growth rings
•semi diffuse ring porous
•exclusively solitary
•1-2 seriate, but predominantly uniseriate and biseriates are rare
•amorphous deposits
•axial paratracheal – confluent, confluent to banded, winged, confluent to aliform

Mean tangential vessel diameter = 83.67 µm

Vessels per millimetre square = 18

Tangential longitudinal plane (TLS)
Rays:
•are 1-3 seriate
•uniseriates are 2-23 cells long and some of them are weakly heterocellular
•uniseriates that are heterocellular have sections that have big and small cells and each of these sections looks weakly heterocellular
•biseriates and triseriates are short, fat and heterocellular
•sometimes biserite have tails that are weakly heterocellular
•have parenchyma strands (1-2 cells wide)
•crystals like
Fibres:
•have simple pits
•have septa

Radial longitudinal plane (RLS):
•mixed- procumbent, and square cells
•square cells are found along the margins as well

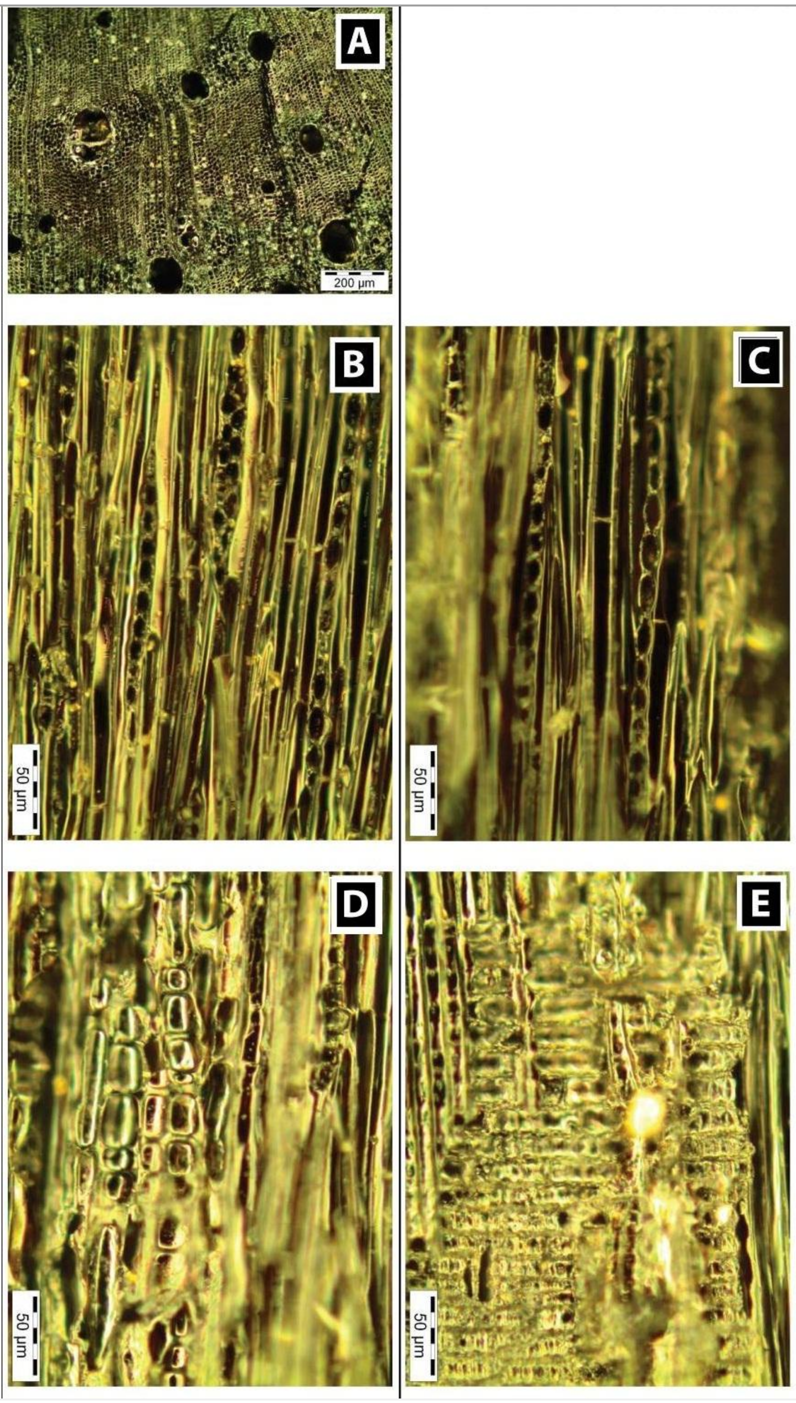


Figure 39: LEGUMINOSAE CAESALPINIOIDEAE *Burkea africana* (Z53).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: COMBRETACEAE ***Genus and species***: *Terminalia sericea* ***Collection No***: *Z54*

Transverse plane (TS)

- no distinctive growth rings
- ring porous
- Solitary
- radial multiples (2-7)
- 1-2 seriate
- scanty to vasicentric parenchyma
- banded axial parenchyma that are more than 3 cells wide
- amorphous deposits
- crystalliferous in some of the parenchyma cells

Mean tangential vessel diameter= 57.58 µm
Vessels per millimetre square

Tangential longitudinal plane (TLS)

Rays:

- are 1-3 seriate
- uniseriates are weakly heterocellular
- uniseriates are 3-16 cells long or more
- biseriates and triseriates are heterocellular

Fibres have pits

Radial longitudinal plane (RLS):

- mixed procumbent, square and square to upright cells

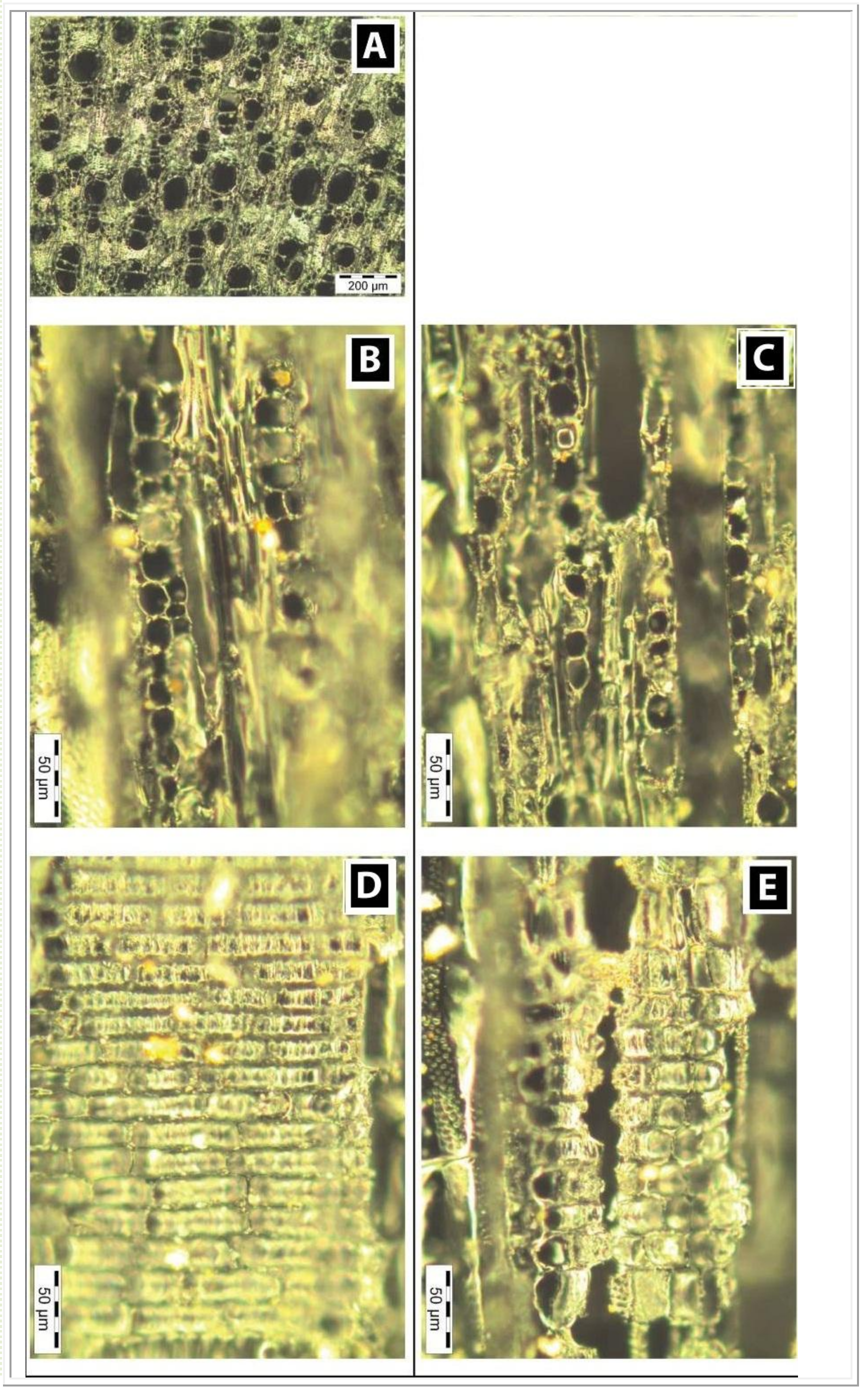


Figure 40: COMBRETACEAE *Terminalia sericea* (Z54).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family:LEGUMINOSAE CAESALPINIOIDEAE ***Genus and species***: *Julbernardia globiflora* ***Collection No***: *58*

Transverse plane (TS)

•distinctive growth rings
•diffuse ring porous
•solitary
•uniseriate
•radial mulptiples (2-4)
•amorphous deposits
•paratracheal axial parenchyma- vasicentric, confluent, confluent to banded, aliform to banded
Mean tangential vessel diameter= 64.54µm
Vessels per millimetre square = 40

Tangential longitudinal plane (TLS)

Rays:
•are 1-3 seriate
•are weakly heterocellular to heterocellular
•some of the rays that are uniseriate are homocellular to weakly heterocellular
•have paratracheal parenchyma
•have crystals

Radial longitudinal plane (RLS):

•mixed upright, square and procumbent
•heterocellular

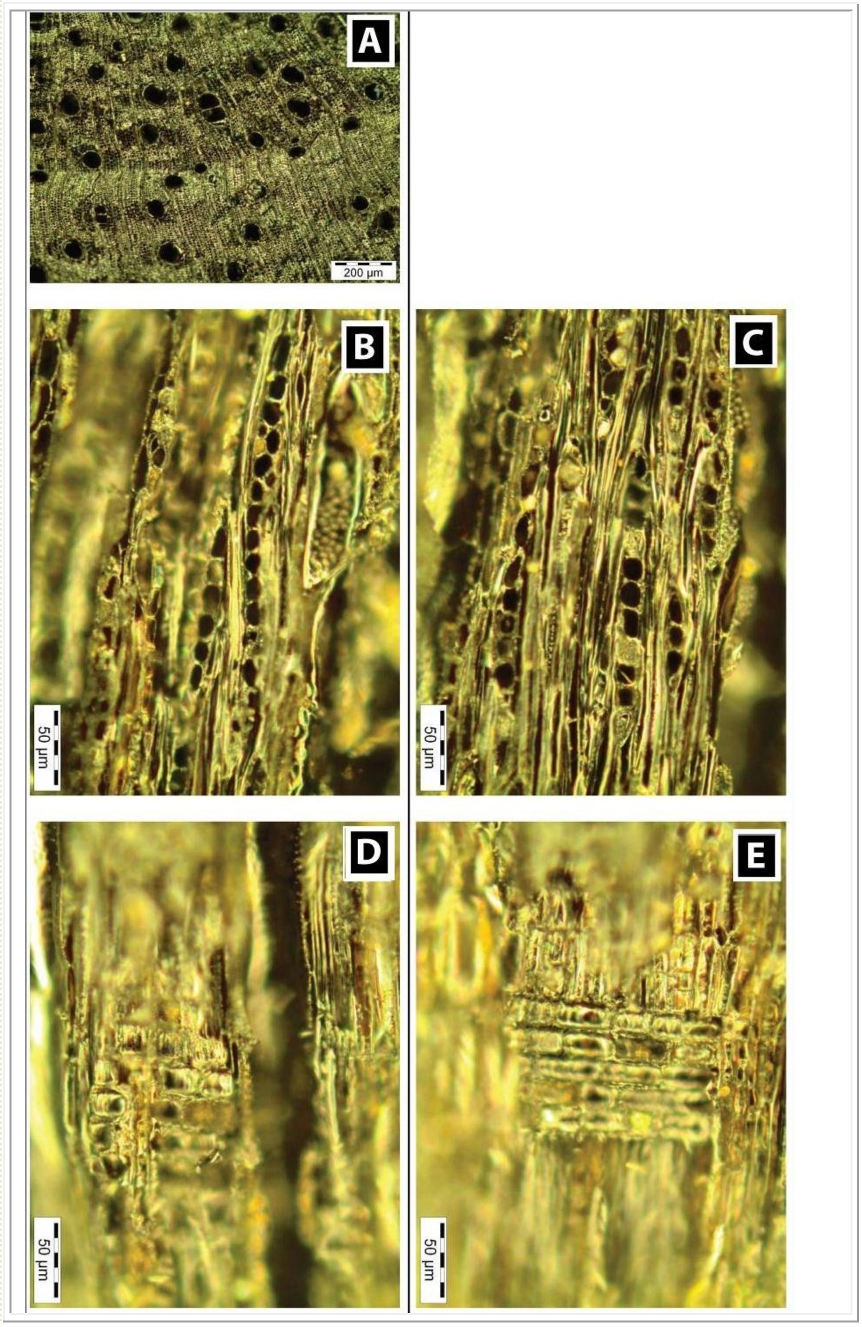


Figure 41: LEGUMINOSAE CAESALPINIOIDEAE - *Julbernardia globiflora* (Z58).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries indistinct or absent,-intervessel pits alternate, -Vestured pits, -Vessel ray pits with distinct borders similar to intervessel pits in size and shape, -fibres with simple to minutely bordere pits, non- septate fibres present, fibres with thin –to thick-walled, -4- 12 /mm, -prismatic crystals in chambered axial parenchyma cells.

Family: APOCYNACEAE **Genus and species**: *cf Diplorhynchus condylocarpon* **Collection No**: *Z60*

Transverse plane (TS)

•no distinctive growth rings
•semi diffuse ring porous
•solitary
•radial multiples (2-5)
•amorphous deposits
•1-3 seriate
•scanty to vasicentric

Mean tangential vessel diameter= 47.00 µm
Vessels per millimetre square = 91

Tangential longitudinal plane (TLS)

Rays:

•are 2-4 seriate

•are big and long

•are heterocellular, some are weakly heterocellular

•have idioblasts

Radial longitudinal plane (RLS):

•Mixed square, procumbent and upright cells

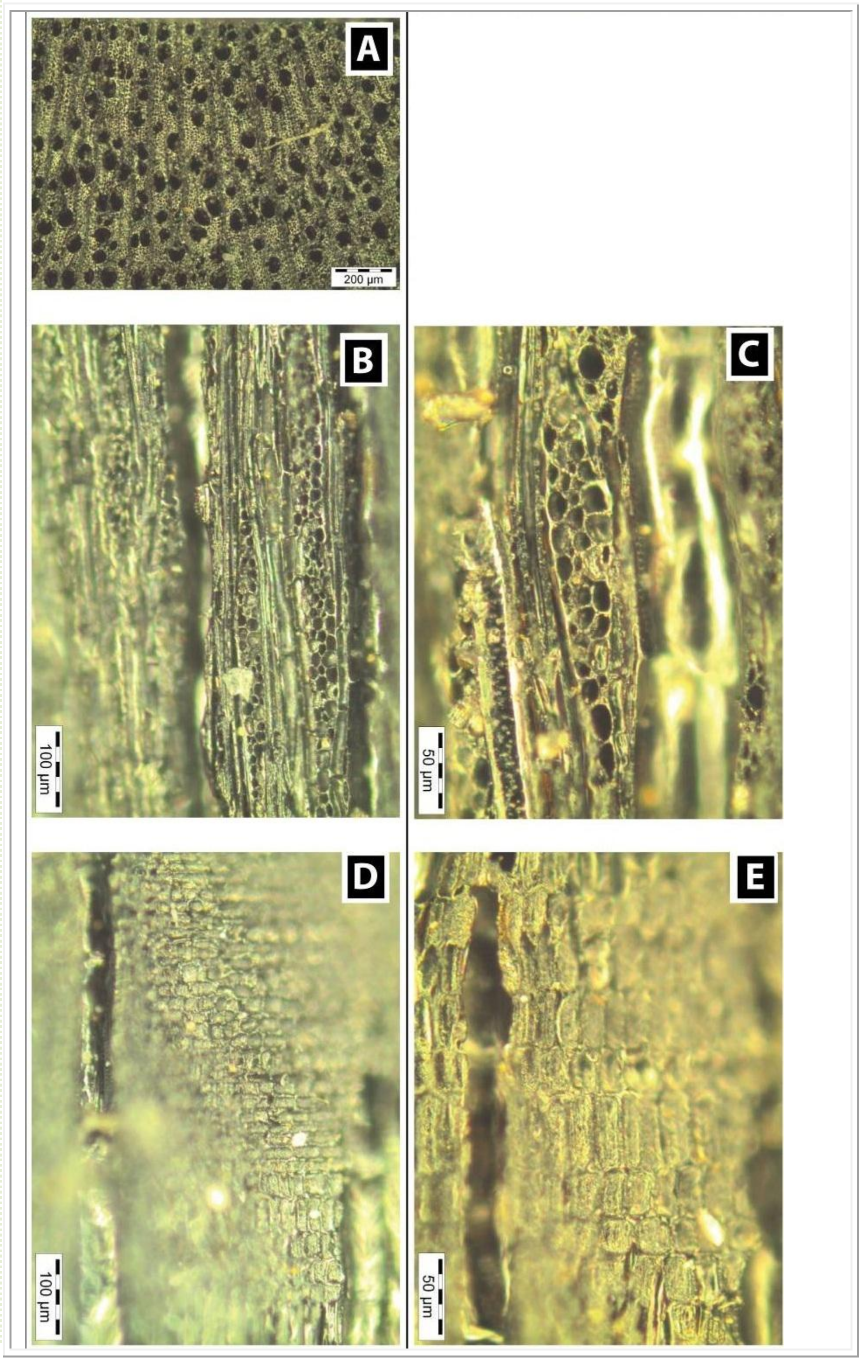


Figure 42: APOCYNACEAE *cf Diplorhynchus condylocarpon* (Z60).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

***Family**:* MALVACEAE	***Genus and species**:Azanza garckeana*	***Collection No**: Z63*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-5)
•solitary
•1-3 seriate
•Amorphous deposits

Mean tangential vessel diameter = 73.68 µm
Vessels per millimetre square = 35

Tangential longitudinal plane (TLS)
Rays:

•have a width of 1-4 cells

•are heterocellular
•have idioblasts
•are Crystalliferous
•some of the uniseriates are weakly heterocellular

Fibres have alternate pits

Radial longitudinal plane (RLS):
•mixed upright, procumbent and square cells
•crystalliferous

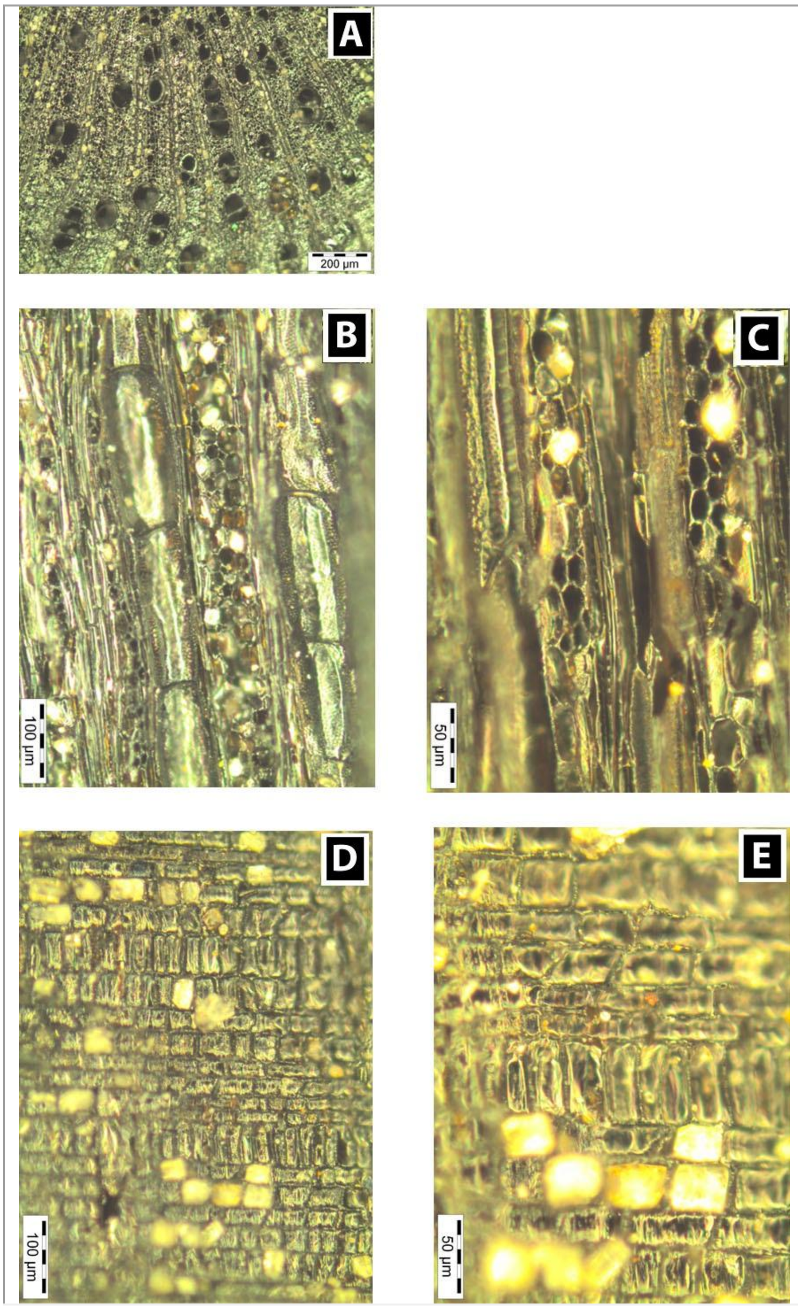


Figure 43: MALVACEAE *Azanza garckeana* (Z63).

Extra features from the Inside Wood Online database thata are not visible in the charcoal reference collection: no data

Family: MYRTACEAE ***Genus and species***: *Syzygium guineense* ***Collection No***: *Z71*

Transverse plane (TS)

•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-7)
•solitary
•1-2 seriate
•scanty to vasicentric parenchyma

Mean tangential vessel diameter= 63.36 µm
Vessels per millimetre square = 111

Tangential longitudinal plane (TLS)

Rays:
•are 1-3 cells wide
•are long biseriates
•uniseriates are at least 3-7 cells long or more
•are heterocellular

Vessels have alternate pits

Radial longitudinal plane (RLS):

•mixed procumbent, upright and square cells
•mixed upright and square cells

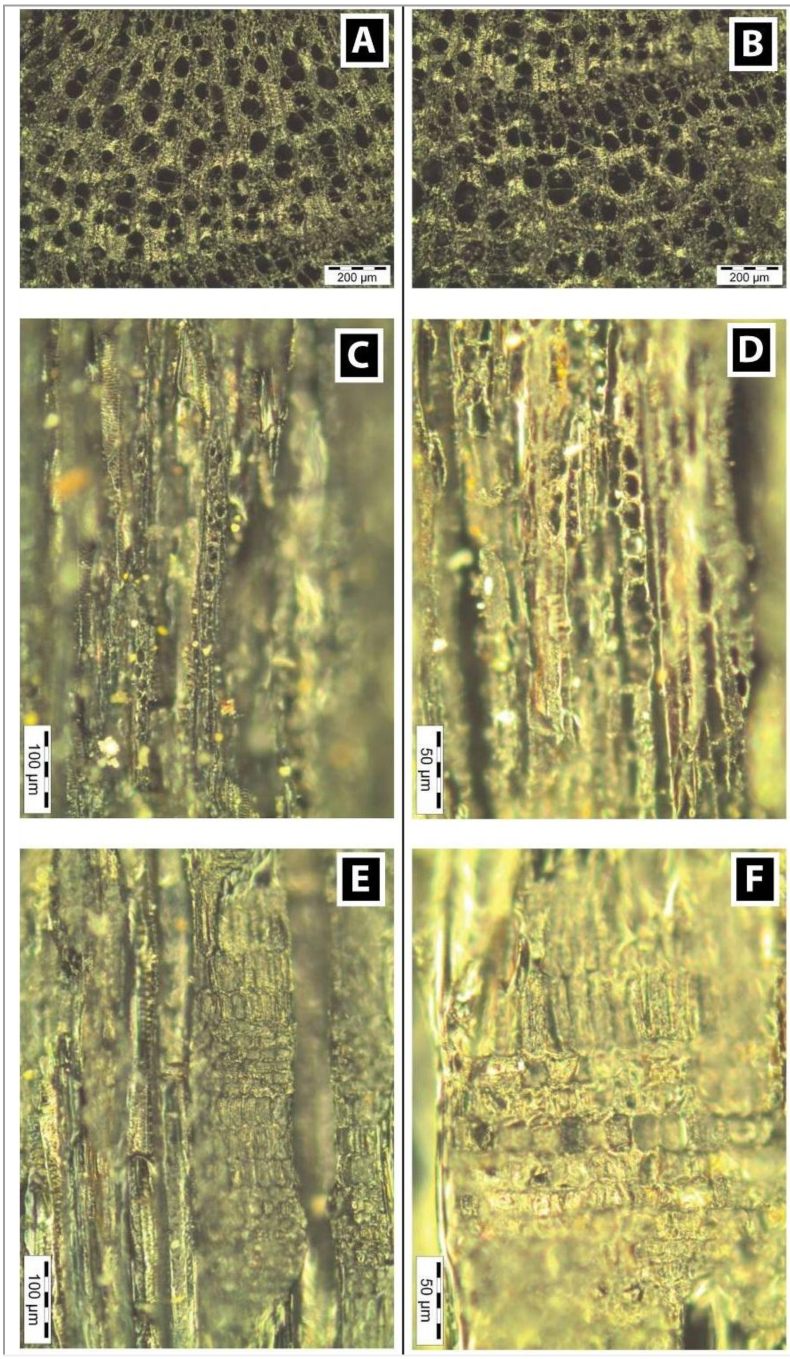


Figure 44: MYRTACEAE *Syzygium guineense* (Z71).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -vestured pits, -Vessel pits with much reduced border to apparently simple, pits rounded or angular, horizontal (scalariform like) to vertical (palisade), -tyloses common, -fibres with simple to minutely bordered pits, non septate fibres present, fibres thin- thick-walled, -axial parenchyma diffuse, diffuse in aggregates, aliform, winged aliform, confluent, 5-8 cells per parenchyma strand, -ray height> 1 mm, -body ray cells procumbent with over 4 rows of upright and / or square marginal cells, -ray cells procumbent, square and upright, 4-12 / mm

Family: ANNOACEAE	**Genus and species**:*Annona senegalensis*	**Collection No**: *Z77*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-4) predominant
•solitary
•1-4 seriate
•amorphous deposits
•Scanty to vasicentric parenchyma

Mean tangential vessel diameter = 76.55 µm
Vessels per millimetre square=45

Tangential longitudinal plane (TLS)
Rays:
•have a width of 1-5 cells
•are large
•some of the rays are short and slightly fat and biseriates
•have idioblasts
•are hetrocellular

Fibres have septa

Radial longitudinal plane (RLS):
•mixed procumbent and upright cells
•predominantly procumbent cells
•heterocellular

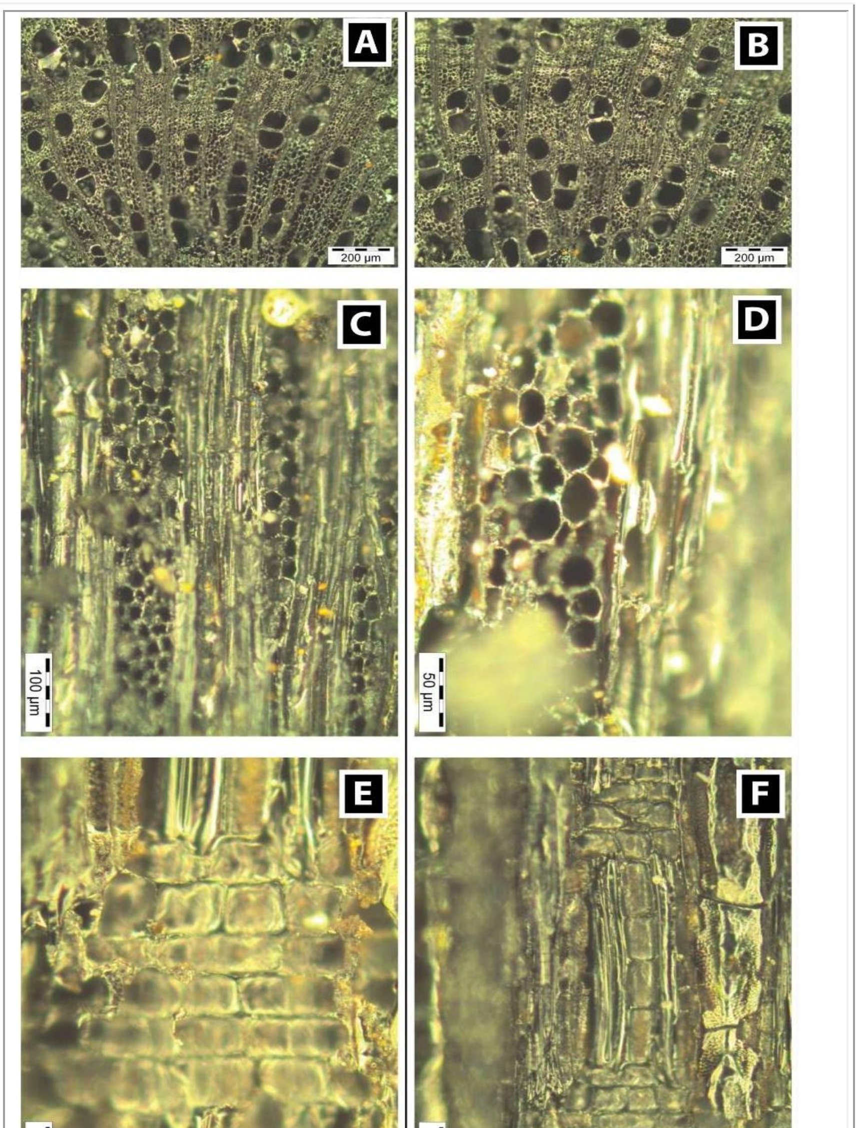


Figure 45: ANNONACEAE *Annona senegalensis* (Z77)

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -vessel-ray pits with distinct borders similar to intervessel pits in size and shape, -fibres with simple to minutely bordered pits, fibre pits common in both radial and tangential walls, non- septate fibres present, fibres thin to thick walled, fibres very thick thick walled, reticulate, scalariformparenchyma bands 2- to 4 cells wide, -ray height>1 mm, -4-12 /mm.

Family: OLEACEAE ***Genus and species***:*Olea africana* ***Collection No***: *Z 91*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary (predominant)
•radial multiples (2-6)
•amorphous deposits
Mean tangential vessel diameter= 57 µm
Vessels per millimetre square = 51

Tangential longitudinal plane (TLS)
Rays:
•are 1-3 cells wide
•triseriates have ray canals
•are heterocellular
•have idioblasts

Fibres have simple pits

Radial longitudinal plane (RLS):
•mixed upright, procumbent and square cells

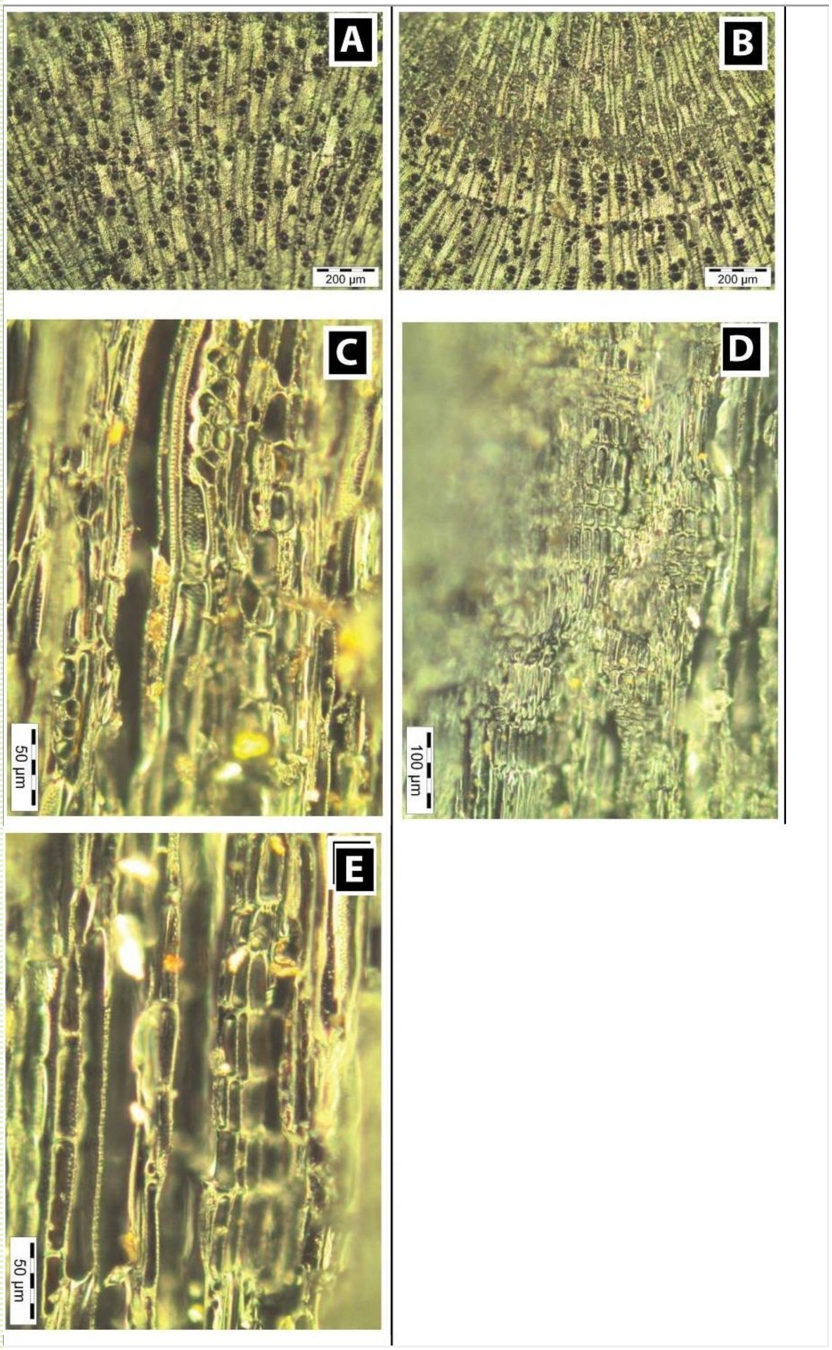


Figure 46: OLEACEAE *Olea africana* (Z91).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: vessel- ray pits with distinct borders, similar to intervessel pits in size and shape throughout the ray cell, fibres very thick-walled, axial parenchyma vasicentric, 3-8 cells per parenchyma strand, -disjunctive ray parenchyma cell walls, 4-12 / mm, -acicular, crystals, crystals of other shapes mostly small.

Family: BURSERACEAE ***Genus and species***: *Commiphora schimperi* ***Collection No***: *Z96*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary (predominant)
•radial multiples (2-6)
•amorphous deposits
Mean tangential vessel diameter= 57 µm
Vessels per millimetre square = 51

Tangential longitudinal plane (TLS)
Rays:
•are 1-3 cells wide
•triseriates have ray canals
•are heterocellular
•have idioblasts

Fibres have simple pits

Radial longitudinal plane (RLS):
•mixed upright, procumbent and square cells
•simple perforation plates

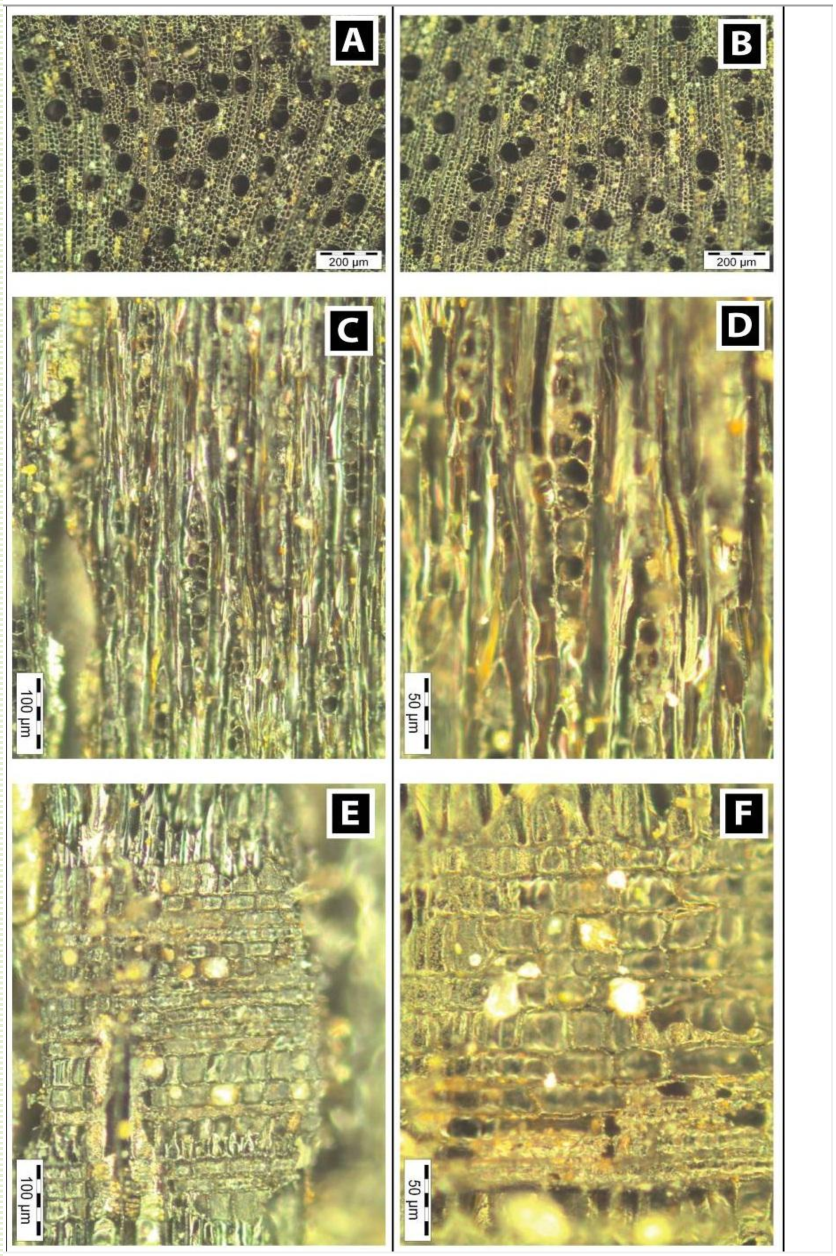


Figure 47: BURSERACEAE - *Commiphora schimperi* (Z96).

Extra features from the Inside Wood Online database that are not available in the charcoal reference collection: no data

***Family**: ANACARDIACEAE* ***Genus and species**: Ozoroa paniculosa* ***Collection No**: Z97*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary
•radial multiples (2-4)
•1-2 seriate
•scanty to vasicentric parenchyma
•amorphous deposits
Mean tangential vessel diameter= 22 µm
Vessels per millimetre square= 45

Tangential longitudinal plane (TLS)
Rays:
•are 1-3 cells wide
•some uniseriates are weakly heterocellular
•are heterocellular

There are horizontal and oblique perforation plates
Vessels have alternate pits

Fibres have simple pits

Radial longitudinal plane (RLS):
•mixed upright, square and procumbent cells
•heterocellular
•simple perforation plates

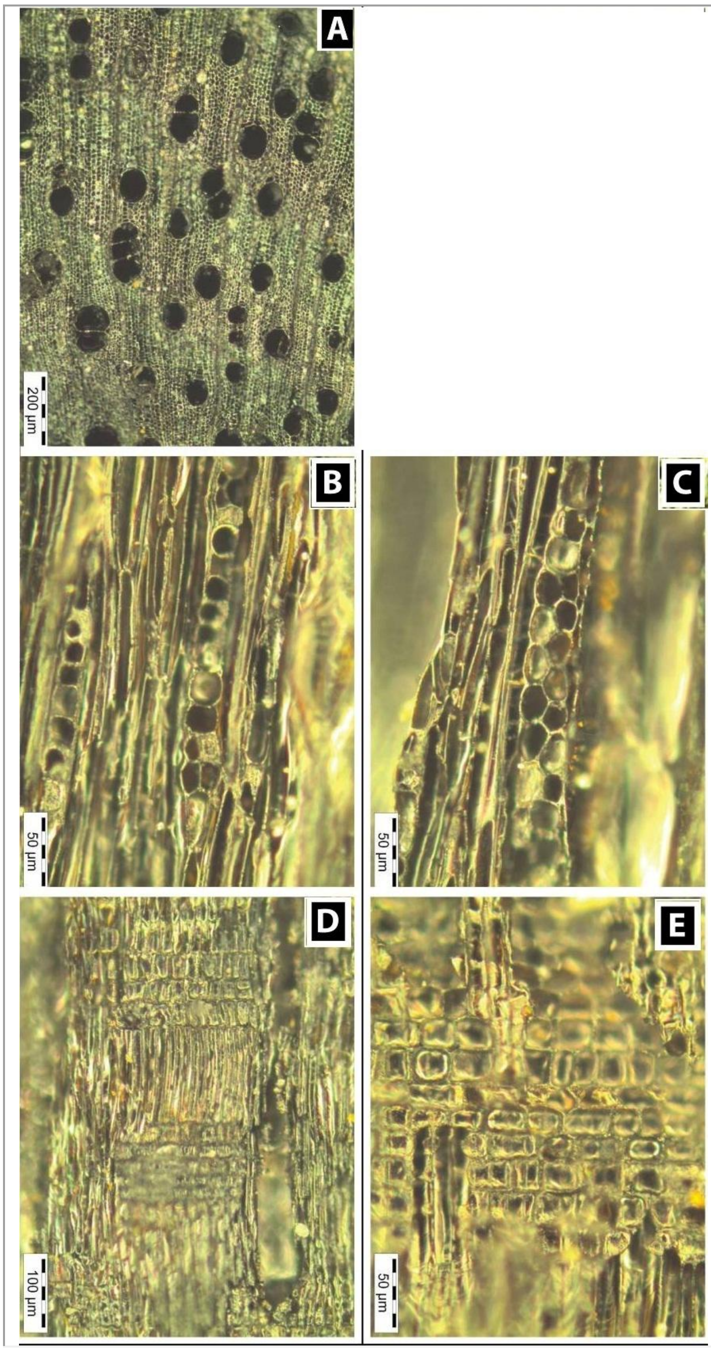


Figure 48: ANACARDIACEAE *Ozoroa paniculosa* (Z97).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: vessel pits with much reduced borders to apparently simple: rounded or angular, vessel ray pits with much reduced borders to apparentls simple: pits horizontal (scalariform like) to vertical (palisade), 20-40 vssels per square millimeter, septate fibres present, 4-12 / mm

Family: LOGANANIACEAE **Genus and species**: *Strychnos spinosa* **Collection No**: *Z101*

Transverse plane (TS)

- no diastinctive growth rings
- diffuse ring porous
- radial multiples (2-4)
- solitary
- clustering
- amorphous deposits
- 1-6 seriate
- scanty to vasicentric parenchyma

Mean tangential vessel diameter = 34.82µm
Vessels per millimetre=65

Tangential longitudinal plane (TLS)

Rays:

- have a width of 5-11 cells
- are fat and long
- are heterocellular

Vessels have parenchyma 2 layers

- alternate pits

Radial longitudinal plane (RLS):

- mixed procumbent, square and upright cells
- heterocellular

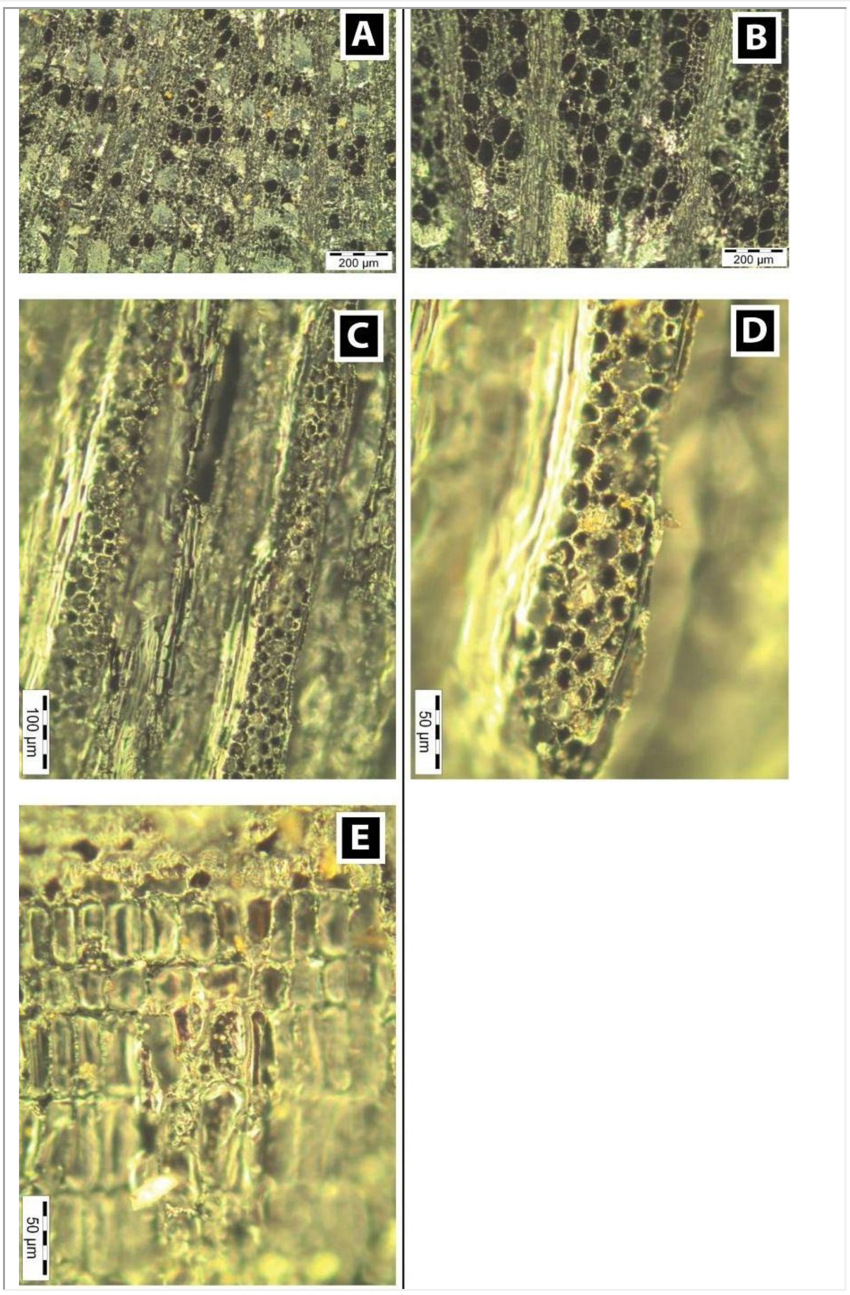


Figure 49: LOGANIACEAE *Strychnos spinosa* (Z101).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: vestured pits, vessel ray pits with distinct borders, similar to intervessel pits in size and shape throughout ray cell, fibres with simple to minutely bordered pits, fibres with distinctly bordered pits, fibre pits common in both radial and tangential walls, non-septate fibres present, fibres very thick –walled, - axial parenchyma, diffuse, aliform, confluent, parenchyma bands more than three cells wide, axial parenchyma in marginal or seemingly marginal bands, -3-8 cells per parenchyma strand, ray height> 1mm, rays of two distinct sizes, 4-12 / mm, prismatic crystal in radial alignment in procumbent cells

Family: MORACEAE ***Genus and species***: *Ficus sycomorus* ***Collection No***: *Z110*

Transverse plane (TS)

- no distinctive growth rings
- diffuse ring porous
- radial multiples (2-4)
- seriate
- amorphous deposits
- axial parenchyma- in bands of 4 cells or more
- scanty to vasicentric parenchyma

Mean tangential vessel diameter =69 µm

Vessels per millimetre square = 55

Tangential longitudinal plane (TLS)

Rays:

- are 2-6 cells wide
- are heterocellular

Fibres have simple pits

Radial longitudinal plane (RLS):

- mixed procumbent, square and upright cells
- heterocellular
- simple perforation plates

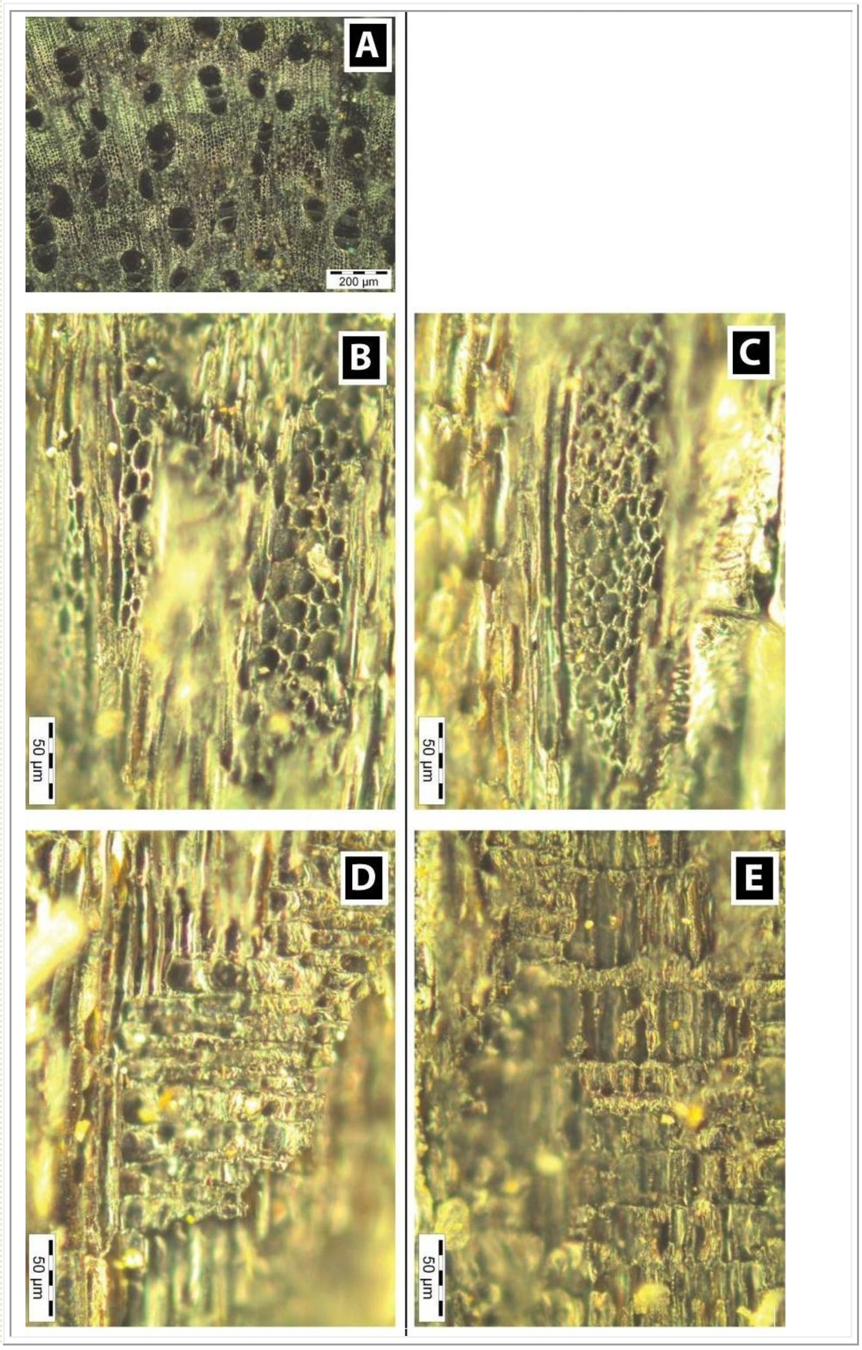


Figure 50: MORACEAE *Ficus sycomorus* (Z110).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth boundaries distinct, intervessel pits alternate, -shape of alternate pits polygonal, Vessel ray pits with much reduced borders to apparently simple, <5 vessels per square millimeter, fibres thin to thick- walled, ray height> 1 mm, 4- 12 / mm, prismatic crystals in upright and / or square ray cells

Family: LEGUMINOSAE CEASALPINIOIDEAE **Genus and species**: *Brachystegia boehmii* **Collection No**: *Z116*

Transverse plane (TS)
•no distinctive growth rings
•diffuse ring porous
•solitary
•radial multiples (2-4)
•1-2 seriate, but predominantly uniseriate
•amorphous deposits
•paratracheal axial parenchyma – confluent, confluent to banded, banded and vasicentric
•crystalliferous parenchyma cells
Mean tangential vessel diameter = 85 µm
Vessels per millimetre square = 13

Tangential longitudinal plane (TLS)
Rays:
•are 1-2 cells wide, but predominantly uniseriates
• are usually 2-16 cells long for uniseriates
•are weakly heterocellular
•are crystalliferous
•have idioblasts
•have parenchyma strands

Fibres have septa and simple pits

Radial longitudinal plane (RLS):
•mixed procumbent and square cells
•heterocellular

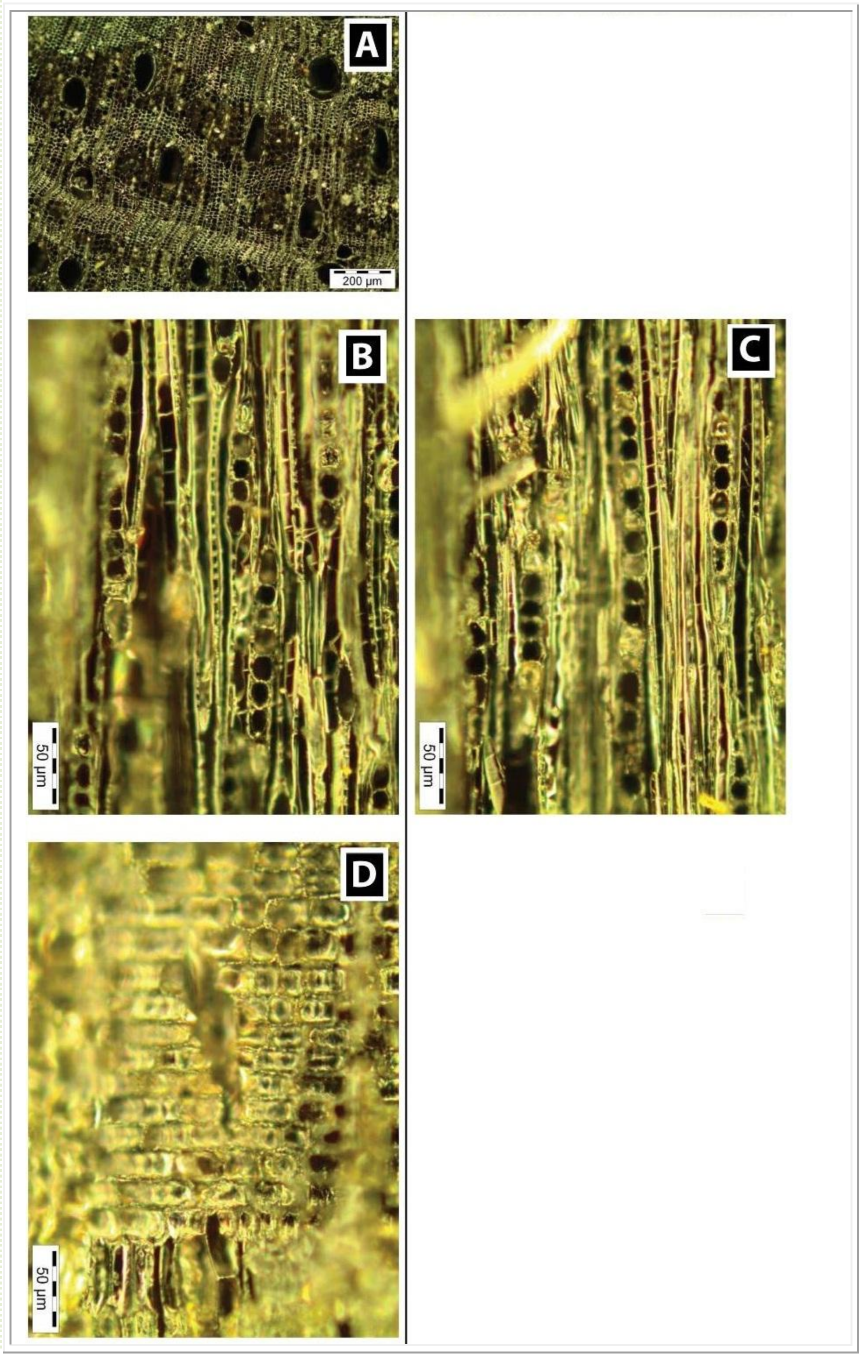


Figure 51: LEGUMINOSAE CAESALPINIOIDEAE *Brachystegia boehmii* (Z116).

Extra features from the Inside Wood Online database that are not in the charcoal reference collection: no data

Family: LOGANIACEAE *Genus and species*:*Strychnos madagascariensis* *Collection No*: *Z 132*

Transverse plane (PS)
•no distinctive growth rings
•diffuse ring porous
•dendritic
•1-3 seriate
•amorphous deposits
•parenchyma apotracheal
•foraminate intraxyleral phloem

Mean tangential vessel diameter = 31µm
Vessels per millimetre square=148

Tangential longitudinal plane (TLS)
Rays:
•are 2 cells wide
•are heterocellular
•have idioblasts
•are narrow and tiny

Vessels are narrow with alternate pits

Radial longitudinal plane (RLS):
• upright cells
•mixed square and procumbent cells

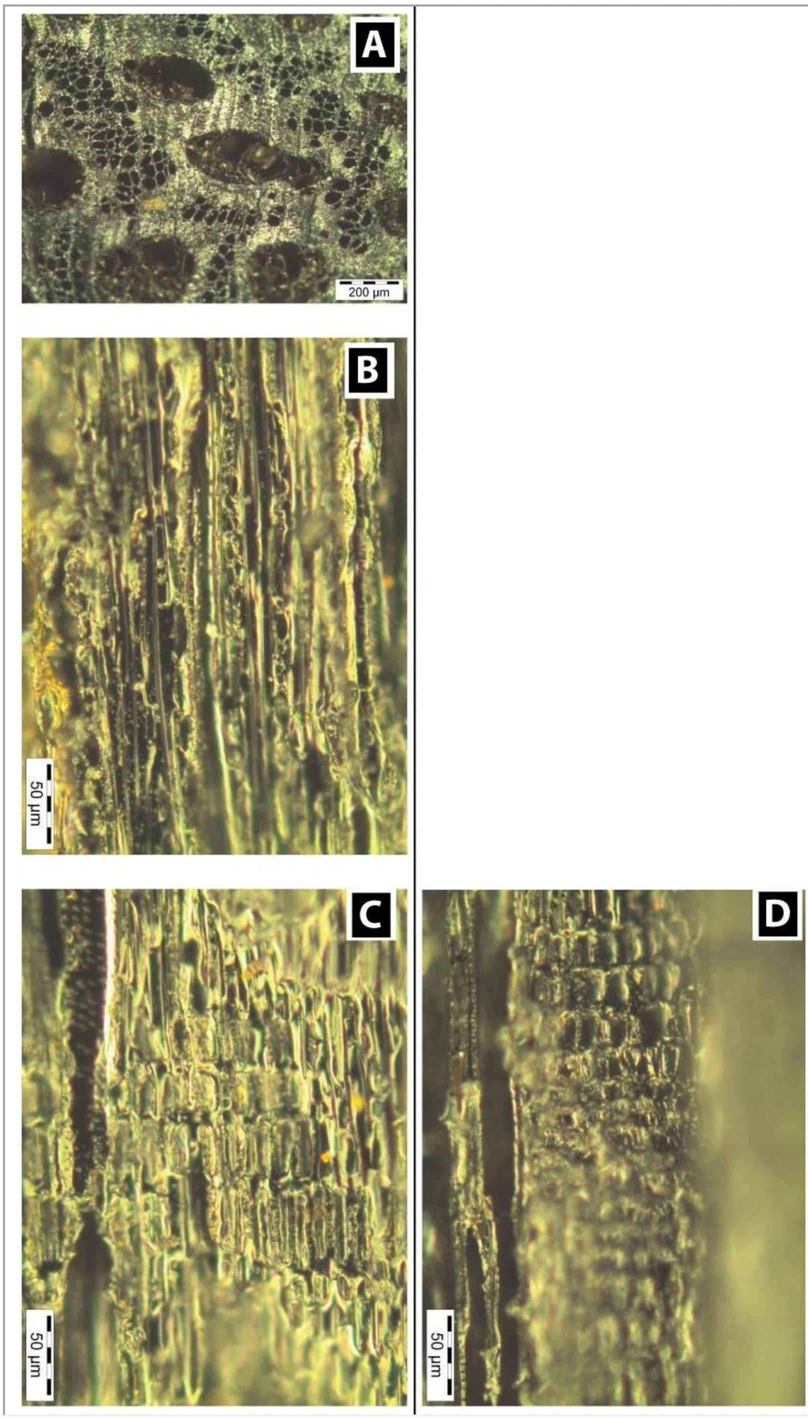


Figure 52: LOGANIACEAE *Strychnos madagascariensis* (Z132).

Extra features the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE CAESALPINIOIDEAE ***Genus and species***: *Schotia brachypetala* **Collection No**: *Z141*

Transverse plane (TS)

•no distinctive growth rings
•diffuse ring porous
•solitary
•Radial multiples (2-8)
•1-3 seriate
•amorphous deposits
•confluent, confluent to aliform, banded, axial paratracheal
Mean tangential diameter=49.85 µm

Tangential longitudinal plane (TLS)

Rays:
•are 1-4 cells wide
•uniseriates are weakly heterocellular
•are fat and thin rays
•fat rays are heterocellular and are up to 4 cells wide

Fibres have simple pits

Radial longitudinal plane (RLS):

•mixture of upright, square and procumbent cells
•heterocellular

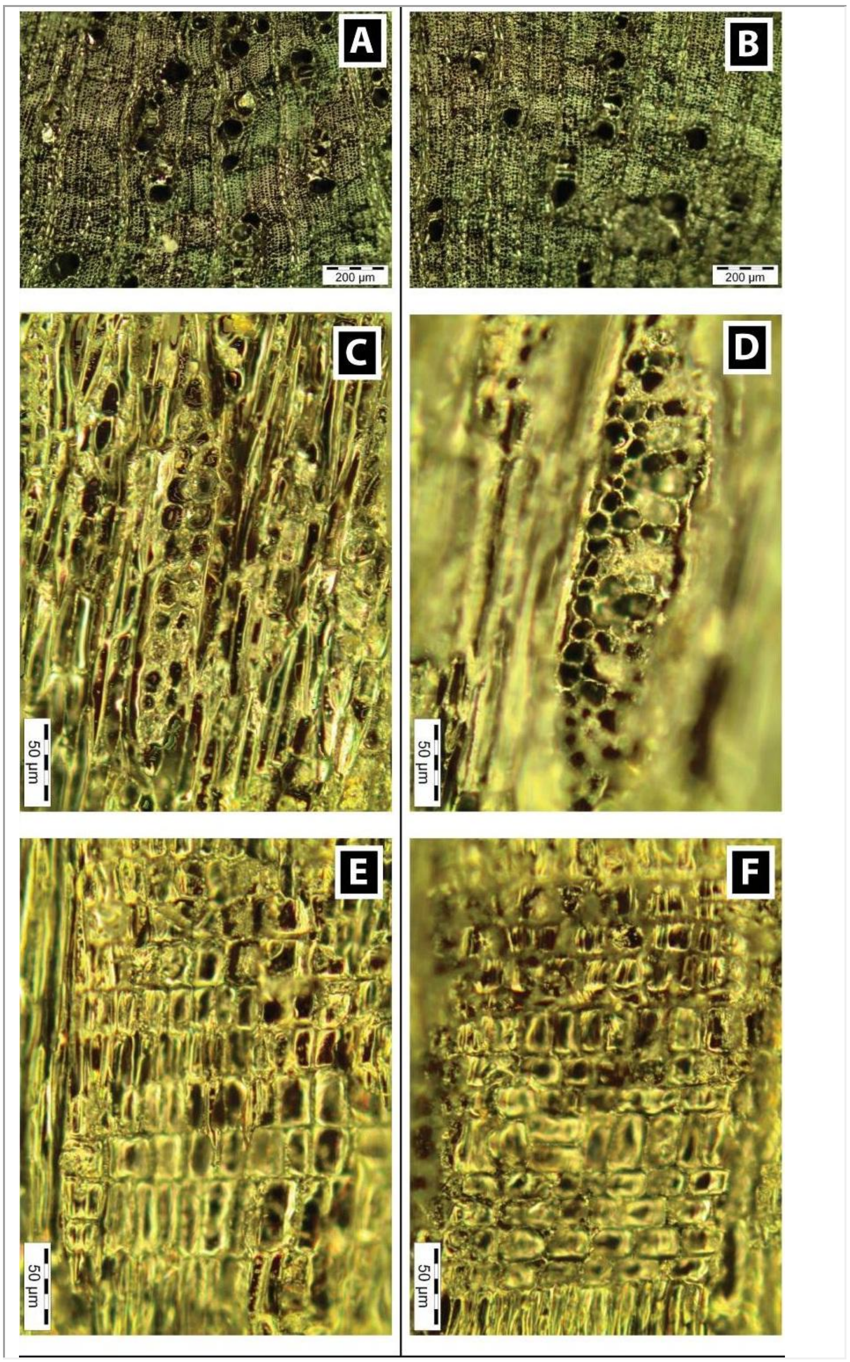


Figure 53: LEGUMINOSAE CAESALPINIOIDEAE *Schotia brachypetala* (Z141).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: no data

Family: LEGUMINOSAE CAESALPINIOIDEAE ***Genus and species***: *Brachystegia glaucescens* ***Collection No***: *Z149*

Transverse plane (TS)
- •no distinctive growth rings
- •semi-diffuse ring porous
- •solitary
- •radial multiples (2-6)
- •1-2 seriate (predominantly uniseriate)
- •amorphous deposits in vessels
- •Tyloses
- •Confluent, confluent to banded or aliform
- •Mean tangential vessel diameter = 71.69 µm

Vessels per millimetre square = 82

Tangential longitudinal plane (TLS)

Rays:
- •are 1-3 seriate
- •biseriates with short sections that are 2 cells wide and 1-2 cells long
- •weakly heterocellular
- •some biseriates are heterocellular
- •have crystals inside ray cells
- • there are horizontal and oblique perforation plate

Radial longitudinal plane (RLS):
- •mixed cells upright to square cells
- •mixed square and procumbent cells along the margins

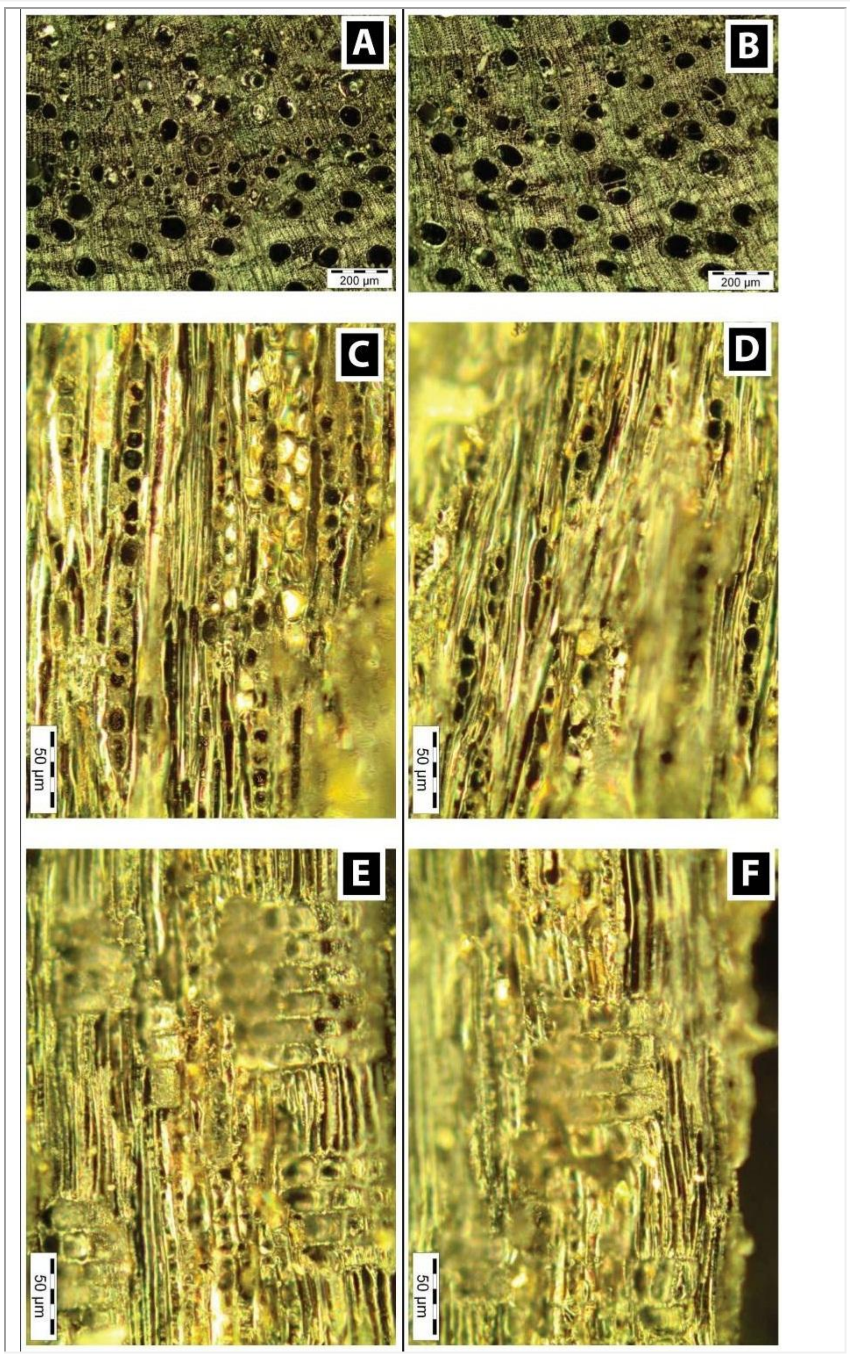


Figure 54: LEGUMINOSAE CAESALPINIOIDEAE - *Brachystegia glaucescens* (Z149).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: growth ring boundaries distinct, -wood diffuse- porous, -intervessel pits alternate, shape of alternate pits polygonal, -vestured pits, -vessel ray pits with distinct borders, intervessel pits in size and shape throughout ray cells, fibres with simple to minutely bordered pits, non-septate fibres present, and fibres very thick-walled, -axial parenchyma: in marginal or in seemingly marginal bands, -2-4 cells per strand, >=12 / mm, -rays and / or axial elements irregularly storied, -prismatic crystals in fibres, -prismatic crystals in chambereaxial parenchyma cells

Family: OLACACEAE **Genus and species**: *Ximenia caffra* **Collection No**: *Z56*

Transverse plane (TS)

•no distinctive growth rings
•diffuse ring porous
•radial multiples (2-3)
•solitary
•1-3 serites
•amorphous deposits in vessels
•Vessels per millimetre square = 102

Mean tangential vessel diameter=67.89 µm

Tangential longitudinal (TLS)

Rays:

•are 1-3 cells wide

•uniseriates are at least 4-10 cells long

•are heterocellular

•have idioblasts
•Fibres have simple pits

•simple perforation plates

Radial longitudinal

(RLS): mixed upright and square cells•mixed square and procumbent cells

•heterocellular

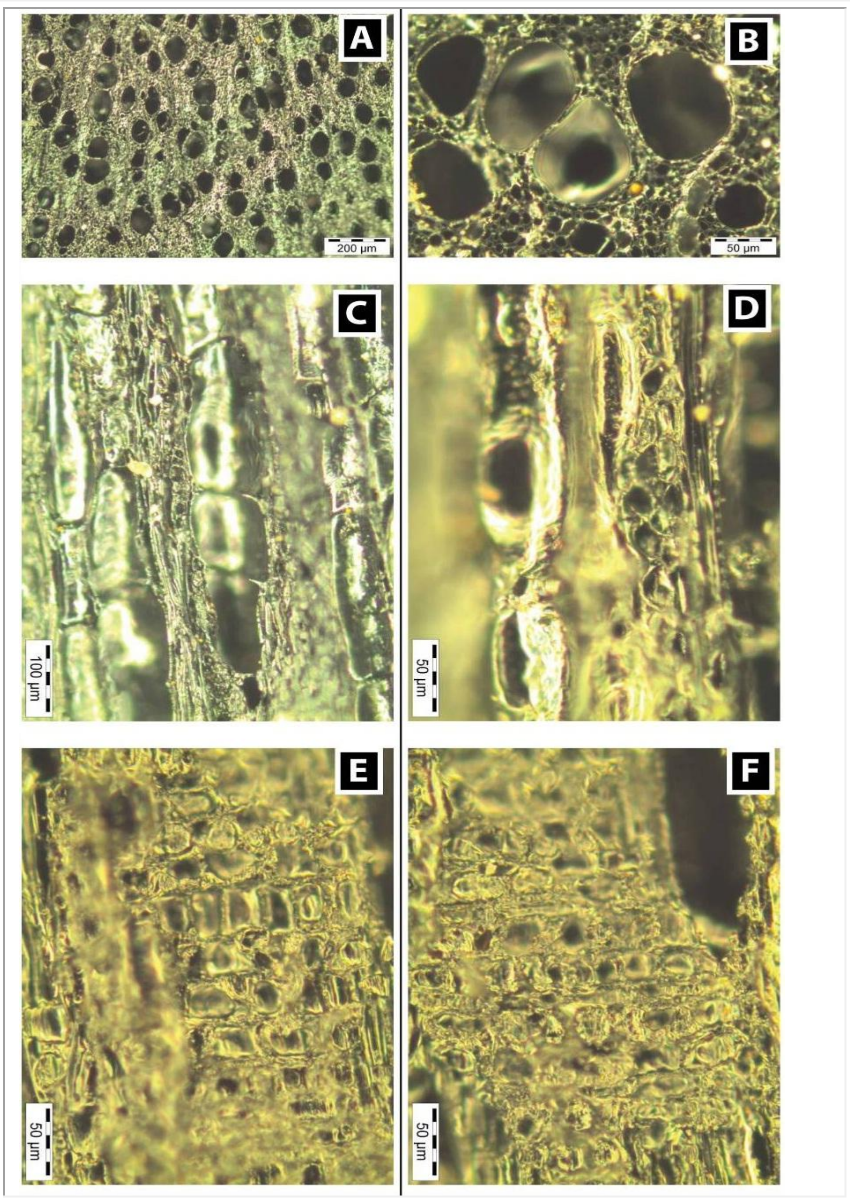


Figure 55: OLACACEAE *Ximenia caffra* (Z56).

Extra features from the Inside Wood Online database that are not visible in the charcoal reference collection: intervessel pits alternate, shape of alternate pits polygonal, -Vessel ray pits with distinct borders, similar to intervessel pits in size and shape throughout ray cel, vessel-ray pits with much reduced borders to apparently simple:rounded or angular, pits horizontal (scalariform like) to vertical (palisade), vessel ray pits of two distinct sizes or types in the same ray cells, -fibres with distinctly bordered pits, fibre pits common in both radial and tangential walls, non- septate fibres present, fibres thin to thick-walled, <=900 µm, 900-1600 µm, -axial parenchyma, diffuse, diffuse in aggregates, -3-4 cells per parenchyma strand,-perforated ray cells, 4-12 /mm, prismatic crystals present in: upright and / or square cells, procumbent ray cells, chambered axial parenchyma cells

5.1 Summary

It has been shown in this chapter that different vegetation taxa have different microscopic anatomical structures. The differences in microscopic anatomical structures form the basis for wood vegetation identification in archaeology and palaeontology. It is however, not easy to clearly distinguish between species and subspecies of the same genus as they closely resemble each other. This problem is however, dealt with by comparing them in three different planes that are TS, TLS and RLS. Identification to the species level is also possible with a very good reference collection that is complimented by literature. Species and subspecies may be similar for example in the TLS and not in all the the three different planes. Therefore identification of specimens should be done simultaneously in all the three planes. In the next chapter microscopic anatomical structures of archaeological specimens from Great Zimbabwe are presented.

CHAPTER SIX

Archaeological charcoal from Great Zimbabwe

6 Introduction

The chapter deals with microscopic anatomical analysis of charcoal fragments that were collected from different contexts at Great Zimbabwe: the Hill Complex, Terrace Ruin on the hill, Nemamwa Ruin, Great Enclosure, Ridge Ruin, Barrier Hut and 2030 BD 57 (Fig 56).

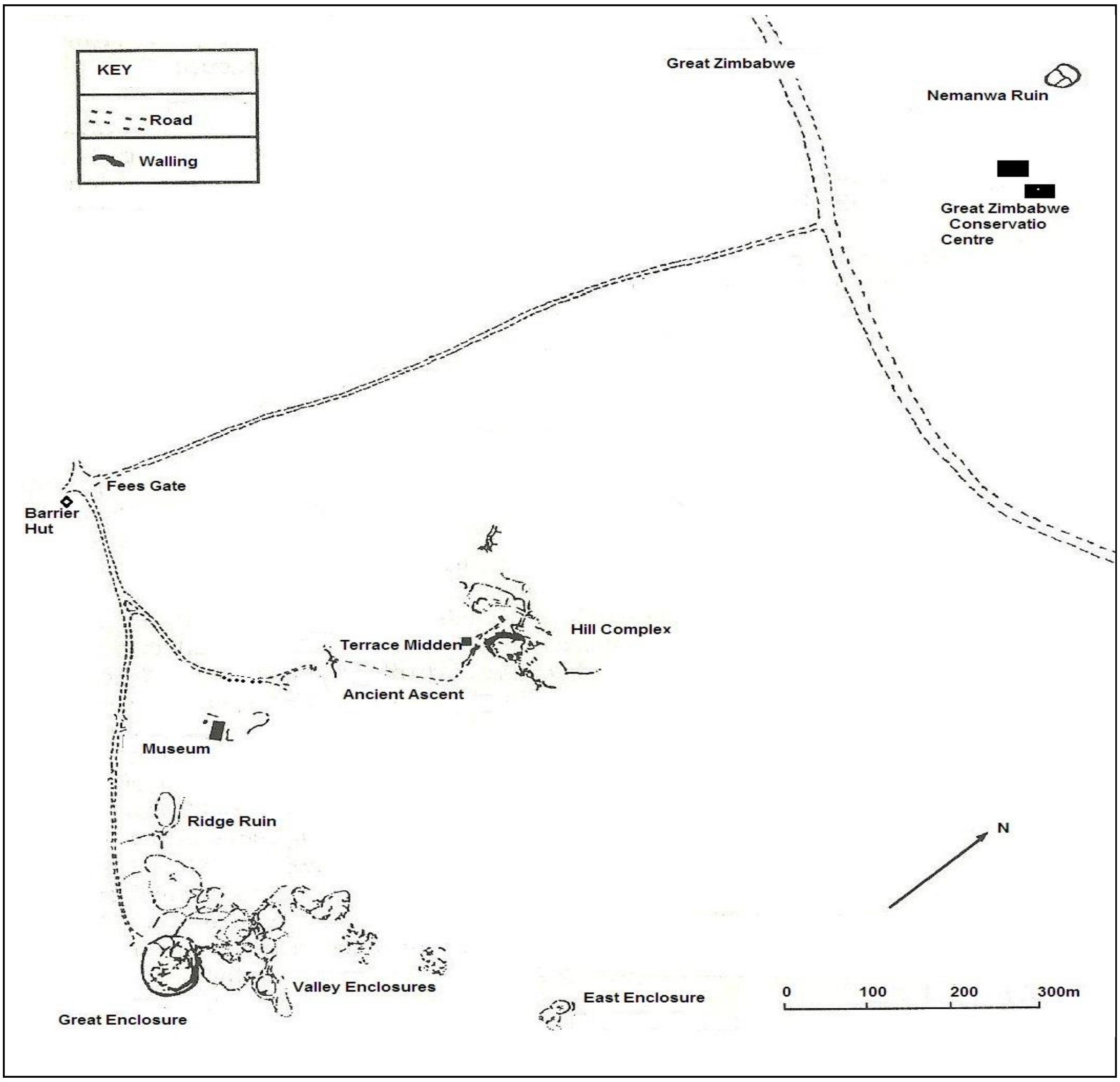


Figure 56: The contexts from where charcoal samples were collected (modified after Thorp 1995**).**

Table 3: Archaeological taxa from Great Zimbabwe and Chigaramboni.

	Great Zimbabwe									Chigaramboni										
	Barrier hut	**2030 BD**	**Enclosure**	**Complex**	**Ridge ruin**	**ruin**	**area**	**Total**	**Percentage**	**Site**	**Trench 1**	**Trench 2**	**Trench 4**	**Trench 5**	**Test pit 5**	**Test pit 7**	**oni ~**	**Road site**	**Total**	**Percentage**
A. sieberiana	2							2	**0.5**											
A. versicolor			57					57	**14.6**											
A. burkei				2				2	**0.5**											
A. johnsonii				24	24		1	49	**12.6**											
A. karoo						2		2	**0.5**											
A. mellifera			1			1		2	**0.5**		10								10	**0.6**
A. polyacantha?	50	1	4	10	4		9	78	**20**		416	11			5			253	685	**41.4**
A. robusta				2				2	**0.5**											
A. sp?											10								10	**0.6**
A. tortilis							7	7	**1.8**						10			10	20	**1.2**
A. xanthophloea							2	2	**0.5**											
Araliaceae																		2	2	**0.1**
B. boehmii				8			4	12	**3.1**	85	31		300			25			441	**26.7**

B. discolor	3							3	**0.8**										
B. spiciformis				2			5	7	**1.8**	25			131		7	111		274	**16.6**
C. mopane			74	3				77	**19.7**										
D. cinerea				7				7	**1.8**	48			31	43	3	5		130	**7.9**
F. capensis							1	1	**0.3**										
F. saligna				1				1	**0.3**					18	2	2	18	40	**2.4**
F. sycomorus							1	1	**0.3**										
F.macnaughtonii										20								20	**1.2**
J. globiflora			1	10	20		6	37	**9.5**										
K. africana															6			6	**0.4**
M. zeyheri				5				5	**1.3**										
N.I				10				10	**2.6**	2					3			5	**0.3**
P. angolensis		1				5		6	**1.5**										
P. curatellifolia			1	5			3	9	**2.3**										
P. longifolia				1				1	**0.3**										
P. rotundifolius							1	1	**0.3**	6								6	**0.4**
Rubiaceae							1	1	**0.3**										

S. africana					2			2	**0.5**											
S. brachyp/B africana																2			2	**0.1**
S. spinosa							2	2	**0.5**											
Sapotaceae				1				1	**0.3**											
Solanum											2								2	**0.1**
Type A				1				1	**0.3**											
U. kirkiana				2				2	**0.5**											
Context Total	**55**	**2**	**138**	**94**	**50**	**8**	**43**	**390**	**100**	**85**	**570**	**11**	**300**	**162**	**76**	**48**	**118**	**283**	**1653**	**100**

KEY : *A. mellifera=Acacia mellifera, A. versicolor=.Albizia versicolor, C. mopane=Colophospermum mopane, J. globiflora=Julbernardia globiflora, P. curatellifolia=Parinari curatellifolia, A. polyacantha= Acacia polyacantha, N.I= non identifiable, A. burkei = Acacia burkei, U. kirkiana =Uapaca kirkiana, F. saligna =Faurea saligna, A. robusta = Acacia robusta, P. longifolia = Protorhus longifolia, B. boehmii = Brachystegia boehmii, M. zeyheri = Mimusops zeyheri, D. cinerea = Dichrostachys cinerea, B. spiciformis = Brachystegia spiciformis, P. angolensis = Pterocarpus angolensis, P.rotundifolius=Pterocarpus rotundifolius, A. jonhsonii = Androstachys jonhsonii, S. spinosa= Strychnos spinosa, S. brachyp/B. africa=Schotia brachypetala/Burkea africana, S.africana= Spirostachys africana, A. sp= Acacia sp, A.tortilis=Acacia tortilis, F.sycomorus=Ficus sycomorus, F.macnaughtonii=Faurea macnaughtonii, K.africana=Kigelia africana*

7 The Great Enclosure

The Great Enclosure is located south of the Hill Complex and it is the largest such stone structure in southern Africa. Garlake (1982) believed that it was the ruler's residence during the later part of Great Zimbabwe's life, while Huffman (1996) argued that it was used for initiation ceremonies. Either way the Great Enclosure must be regarded as a restricted area occupied by the elites and which had a strong ritual function.

A total of 138 charcoal fragments were obtained from the Great Enclosure. Charcoal from the Great Enclosure contributed 37 percent of the total charcoal fragments from Great Zimbabwe. The identified species were *Acacia mellifera*, *Albizia versicolor*, *Colophospermum mopane*, *Julbernardia globiflora*, *Parinari curatellifolia* and *Acacia sp* resembling *Acacia polyacantha*. *Acacia mellifera*, *Parinari curatellifolia* and *Julbernardia globiflora* were identified by a single fragment of charcoal each. Only four fragments of *Acacia polyacantha?* were identified (Table 3). *Colophospermum mopane* was the most well represented taxon in the Great Enclosure. A total of 74 *Colophospermum mopane* charcoal fragments were identified. *Albizia versicolor* and was represented by 57 charcoal fragments. Figures 57 to 60 show micrographs of some taxa identified from the Great Enclosure.

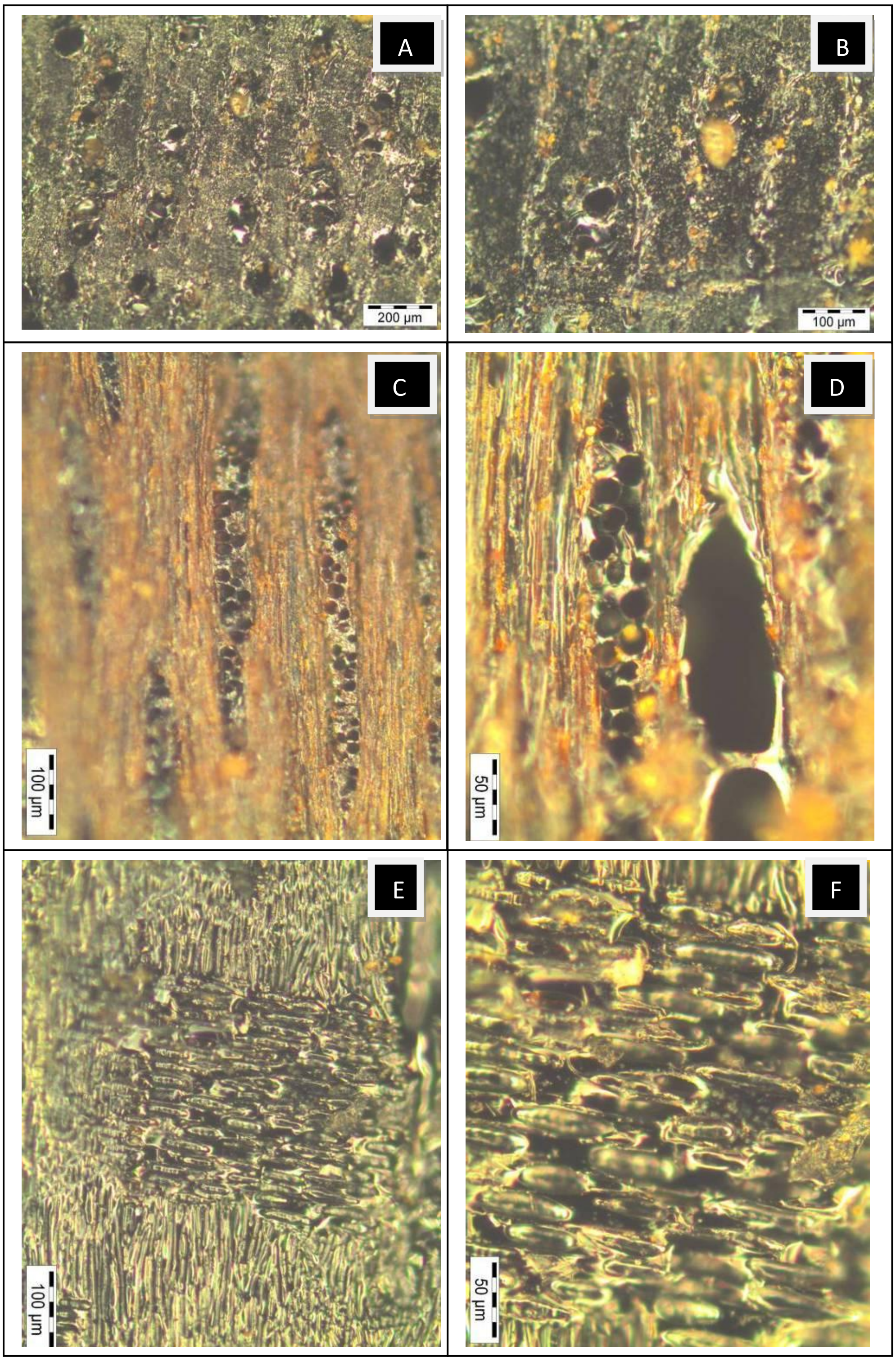


Figure 57: LEGUMINOSAE CAESALPINIOIDAE *Colophospermum mopane*, 2030 BD-WV1-14A, Great Enclosure, Great Zimbabwe. A, B- TS (1-2 seriate, radial multiples 2-3, parenchyma: radial, vasicentric, confluent); C, D – TLS (oblique perforation plates, crystals in ray cells, 1-3 seriate, uniseriates are homocellular); E, F –RLS (procumbent and square cells)**.**

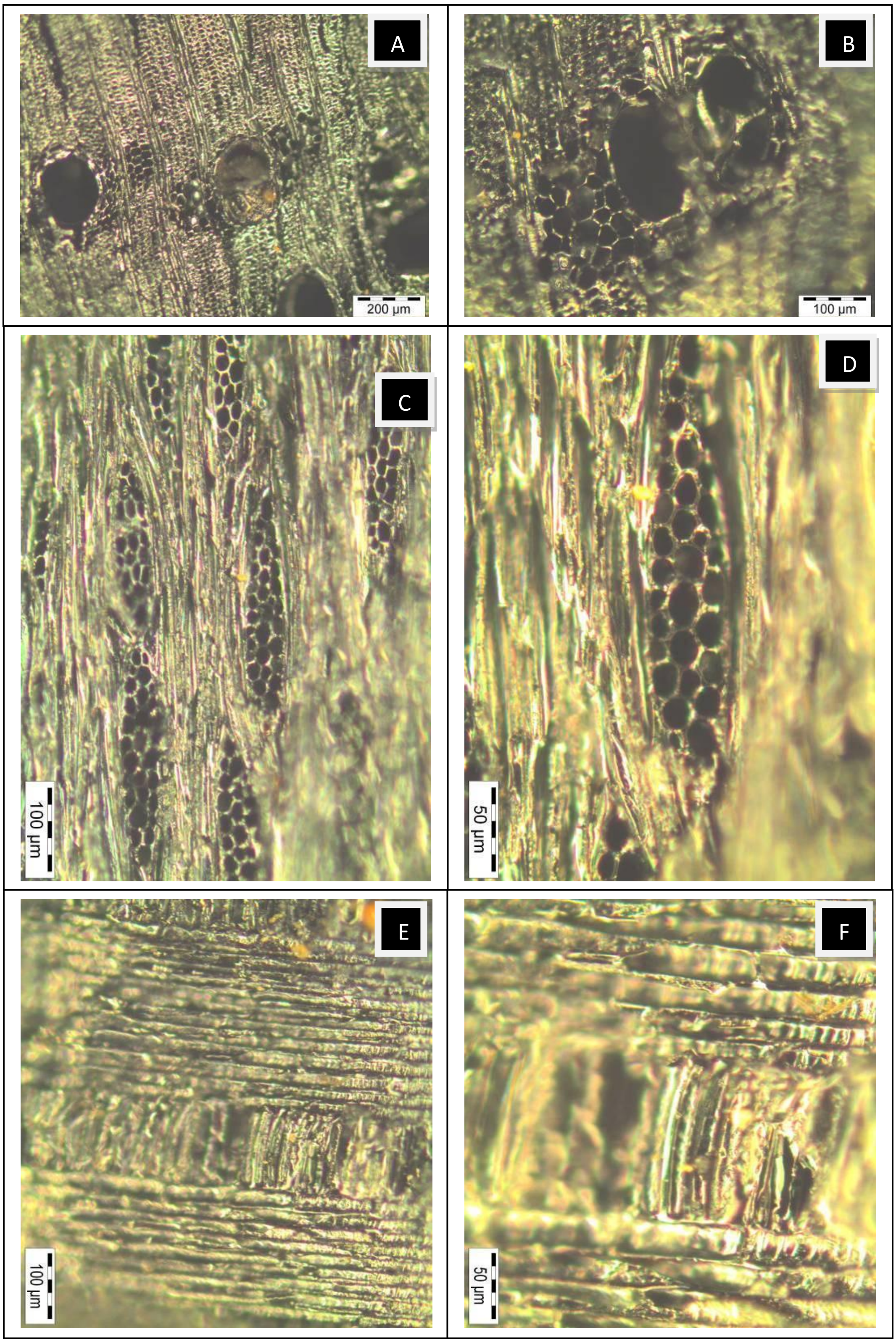


Figure 58: LEGUMINOSAE MIMOSOIDEAE *Acacia mellifera*, 2030 BD-WV-C, Great Enclosure, Great Zimbabwe. A, B- TS (axial parenchyma: diffuse, vasicentric, lozenge-aliform); C, D-TLS (uniseriates and triseriate are weakly heterocellular, prismatic crystals present); E, F-RLS (procumbent cells).

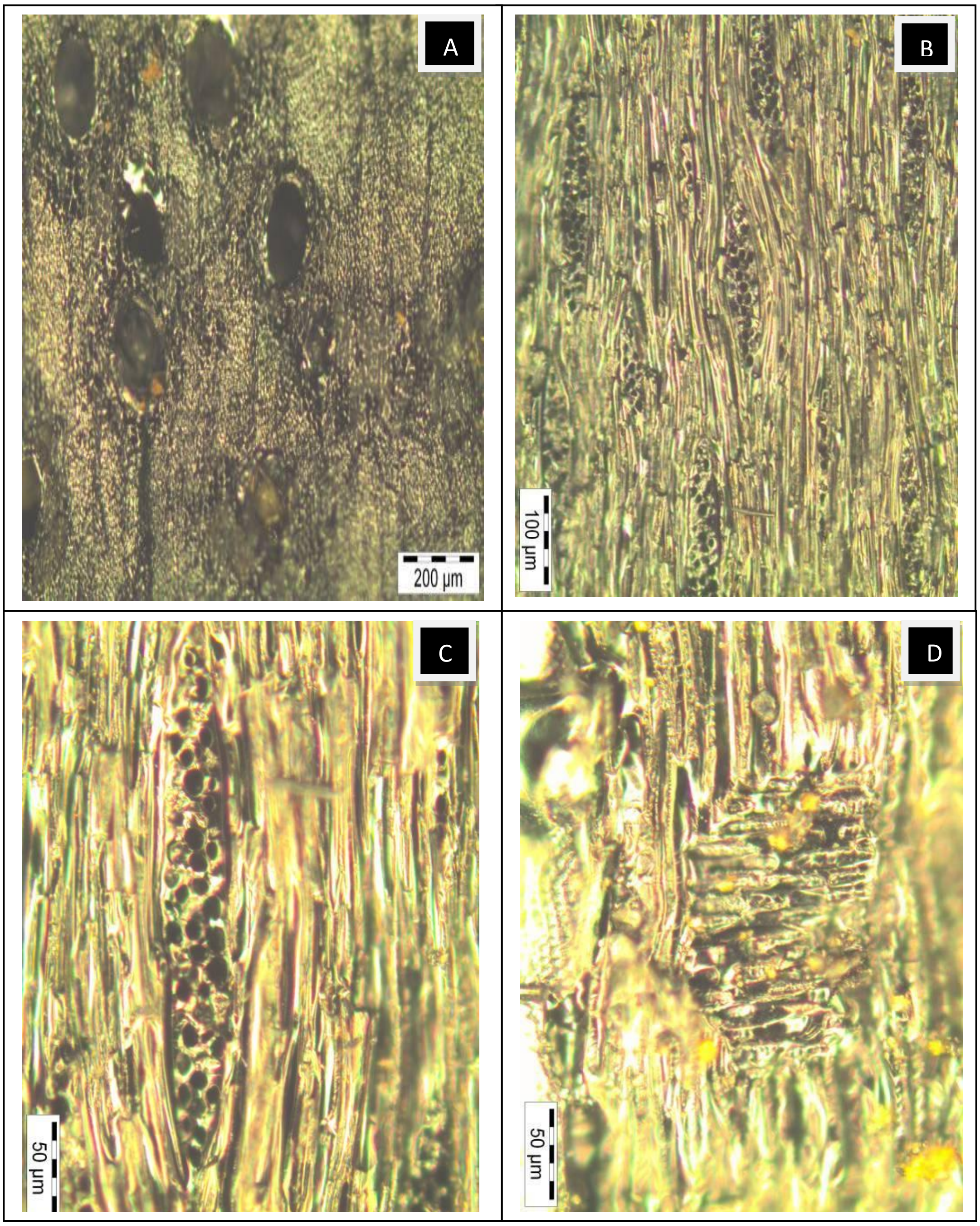


Figure 59: LEGUMINOSAE MIMOSOIDAE *Albizia versicolor*, 2030 BD-WV32-A, Great Enclosure, Great Zimbabwe. A- TS (parenchyma confluent to banded, tylose, vessels: solitary, radial multiples 2-3, 1-4 seriate); B, C-TLS (oblique perforation plates, intervessel pits alternate, 1-4 seriate, uniseriates heterocellular, prismatic crystals); D – RLS (ray cells are procumbent).

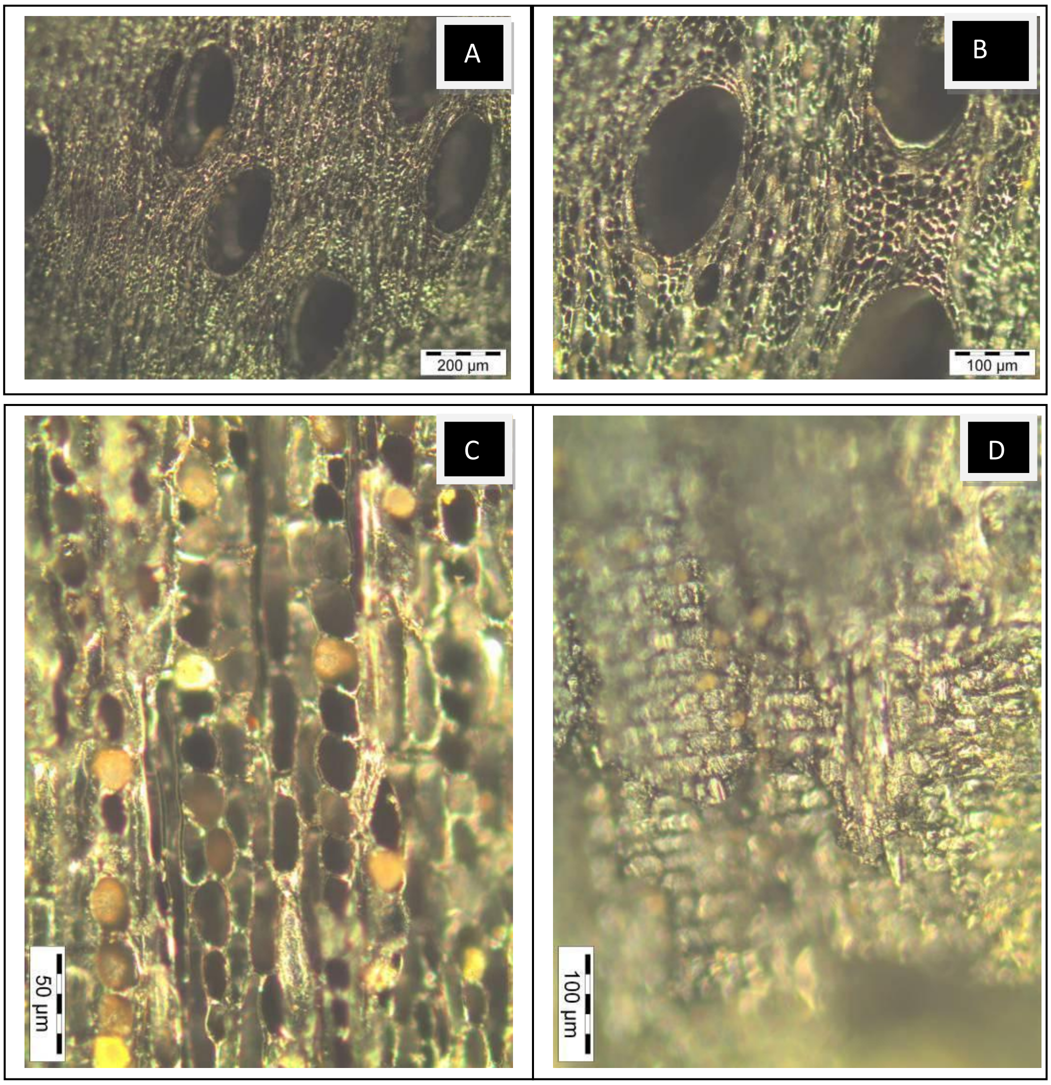
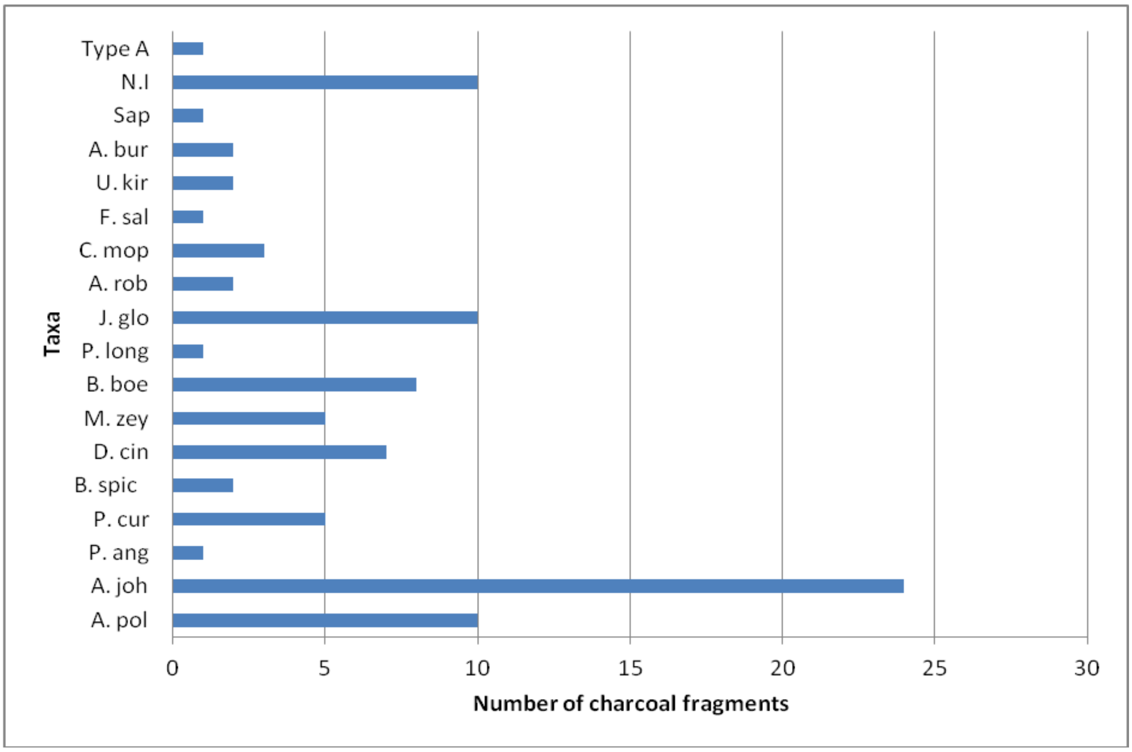


Figure 60: CHRYSOBALANACEAE *Parinari curatellifolia*, 2030 BD-WV1-14B, Great Enclosure, Great Zimbabwe. A, B-TS (exclusively solitary vessels, 1-2 seriate, banded parenchyma up to 3 cells wide); C-TLS (1-2 cells wide, heterocellular, non-septate fibres, silica bodies in ray cells); D-RLS (mixed cells that are square to procumbent).

7.1 The Hill Complex

The Hill Complex is located on the highest hill at Great Zimbabwe. It is the oldest stone complex at Great Zimbabwe and was probably the first royal residence. The Hill Complex also shows evidence of long occupation (Garlake 1982). Archaeologists found a complete sequence occupation whereby five occupation periods were found in the Western Enclosure on the Hill Complex. According to Huffman (1987), the lowest deposit is radiocarbon dated to AD 320 (Period1) and the next is dated to AD 1075 (Period 2), period 3 being dated to 12th century, period 4 dated between AD 1270-1450 and finally period 5 being dated to the 18th century.



KEY:

N.I= Non identifiable, *Sap= Sapotaceae*, *A. bur = Acacia burkei*, *U. kir =Uapaca kirkiana*, *F. sal =Faurea saligna*, *C. mop = Colophospermum mopane*, *A. rob = Acacia robusta*, *J. glo = Julbernardia globiflora*, *P. long = Protorhus longifolia*, *B. boe = Brachystegia boehmii*, *M.zey = Mimusops zeyheri*, *D. cin = Dichrostachys cinerea*, *B. spic = Brachystegia spiciformis*, *P. cur = Parinari curatellifolia*, *P. ang = Pterocarpus angolensis*, *A. joh = Androstachys jonhsonii* and *A. pol = Acacia polyacantha*

Figure 61: Graph of identified taxa from the Hill Complex

A total of 95 archaeologically charcoal fragments were retrieved studied from this area, which is 26 percent of the whole assemblage from Great Zimbabwe, came from the Hill Complex as shown in Fig 61 above. It is evident that a wide range of species were burnt on the Hill Complex These species are *Acacia burkei*, *Uapaca kirkiana*, *Faurea saligna*, *Colophospermum mopane*, *Acacia robusta*, *Julbernardia globiflora*, *Protorhus longifolia*, *Brachystegia boehmii*, *Mimusops zeyheri*, *Dichrostachys cinerea*, *Brachystegia spiciformis*, *Parinari curatellifolia, Pterocarpus angolensis, Androstachys jonhsonii* and *Acacia polyacantha?* One charcoal fragment was identified as belonging to the family *Sapotaceae*. Ten of the fragments were not identifiable (NI). One charcoal fragment was identified as Type A. Type here refers to a fragment with features that are either *Protorhus longifolia* or *Rhus chirindensis. Androstachys johnsonii* was the most commonly burnt wood with 24 charcoal fragments. Burnt worked or carved wood fragments that were hexagonally shaped (Fig 62) were found in this collection of charcoal. The carved charcoal was also identified as belonging to the same taxon of *Androstachys johnsonii.* The second most dominant taxa on the Hill Complex were *Acacia polyacantha?* and *Julbernardia globiflora*. They each had 10 charcoal fragments. *Brachystegia boehmii* was also burnt and this was identified by 8 charcoal fragments. *Dichrostachys cinerea* was exploited as well and was identified by 7 charcoal fragments. *Parinari curatellifolia* and *Mimusops zeyheri* were identified by five charcoal fragments each. The Hill Complex contained fewer charcoal fragments of *Colophospermum mopane* when compared to the Great Enclosure. Only 3 charcoal fragments of this taxon were identified. *Acacia robusta, Brachystegia spiciformis, Acacia burkei* and *Uapaca kirkiana* were each represented by two charcoal fragments. The least well represented were *Faurea saligna, Protorhus longifolia*, and *Pterocarpus angolensis* that were each represented by one charcoal fragment. The identified charcoal fragments are shown in Figures (63-71).

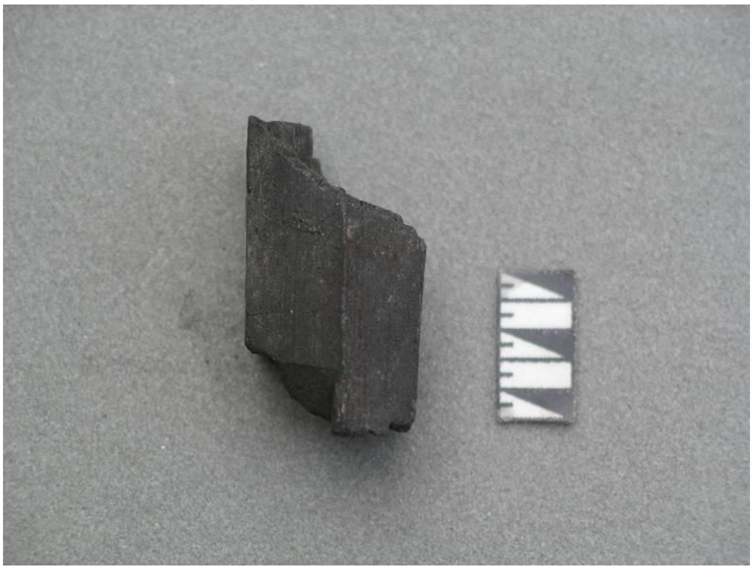


Figure 62: Hexagonal shaped charcoal

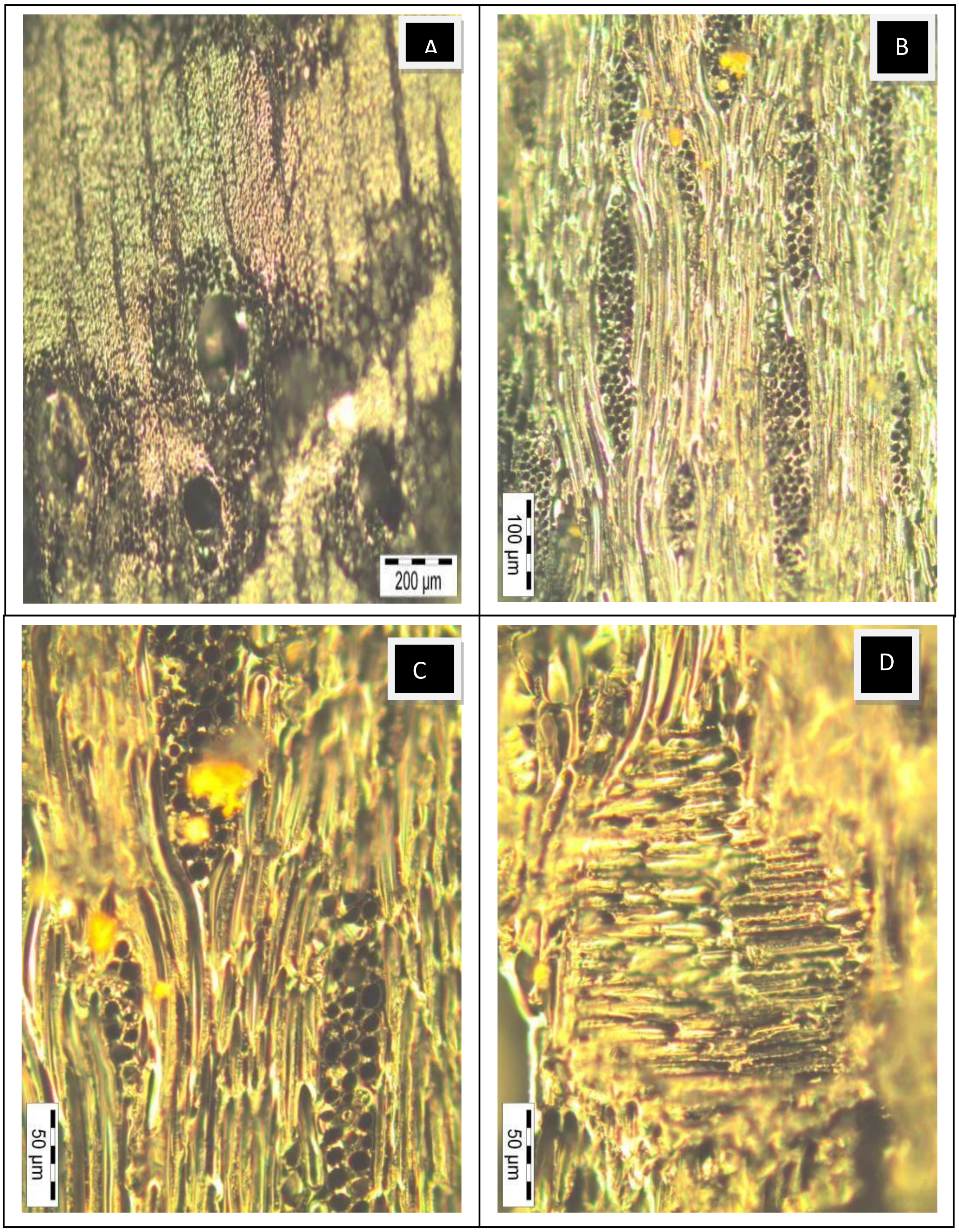


Figure 63: LEGUMINOSAE MIMOSOIDEAE *Acacia robusta,* 2030 BD-PL-T1-L1-A, Platform Terrace, Great Zimbabwe. A-TS; B (exclusively solitary vessel arrangement, rare amorphous deposits, parenchyma: banded, vasicentric); C-TLS (crystals in cells); D-RLS (mixed cells).

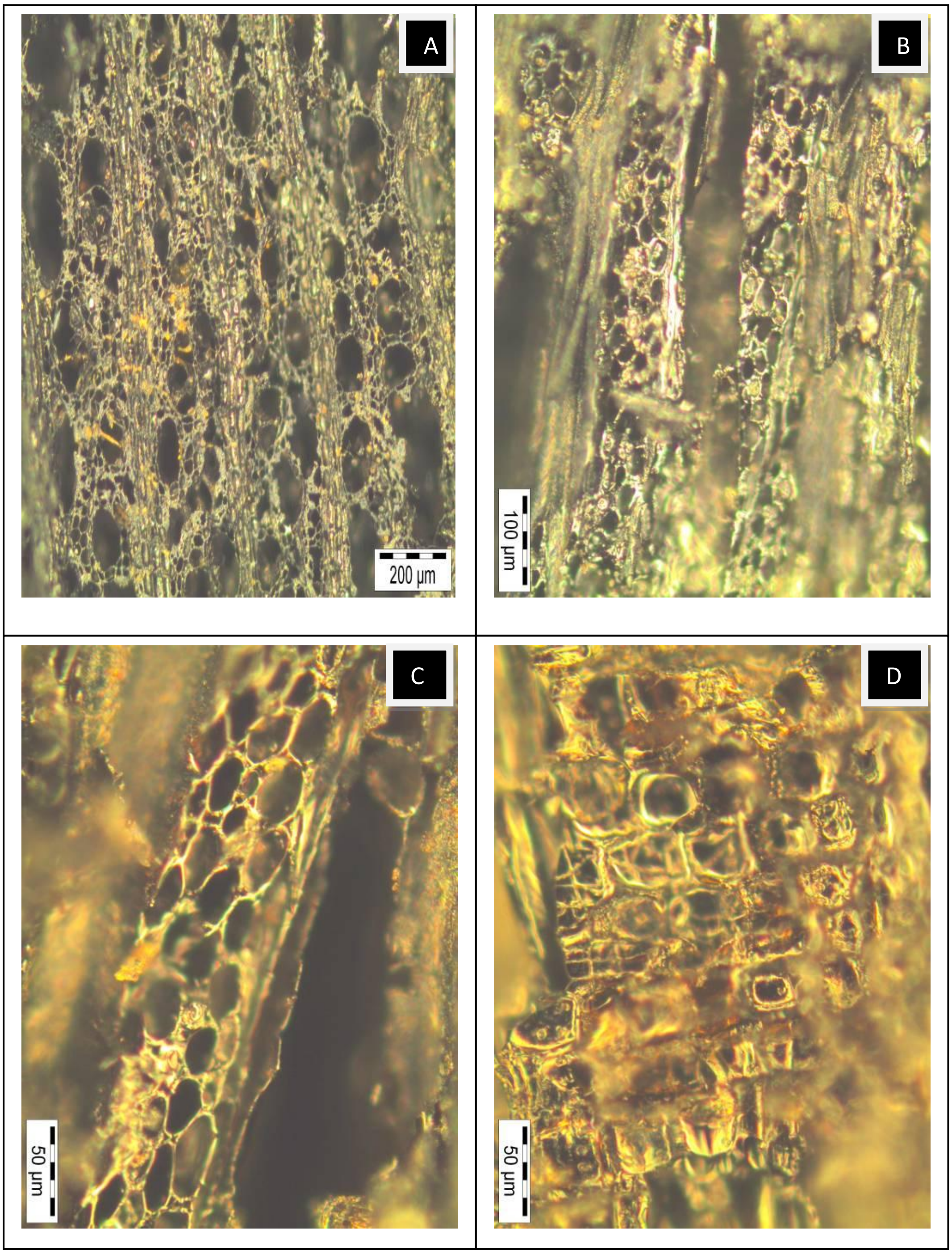


Figure 64: PHYLLANTHACEAE *Uapaca kirkiana* NRS-T1-L1- B, Northern Rock Shelter, Great Zimbabwe. A – TS (exclusively solitary vessels); B, C- TLS (fibres with simple minutely bordered pits); D – RLS (procumbent, upright and square cells mixed).

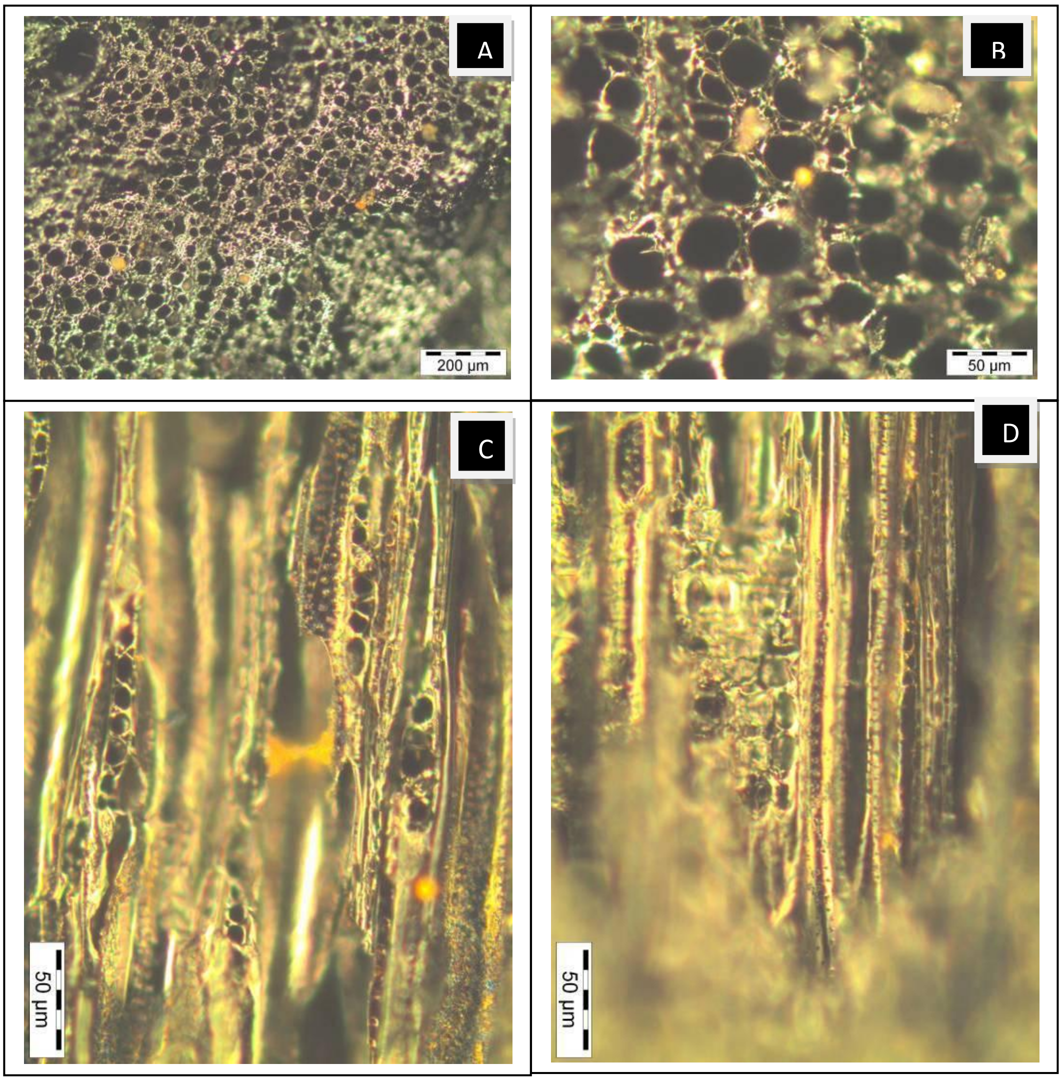


Figure 65: *Androstachys johnsonii*, QMIA 1691 - A, Hill Complex, Great Zimbabwe. A, B – TS (exclusively uniseriate, axial parenchyma extremely rare); C- TLS (rays exclusively uniseriate); D – RLS (mixed cells: upright, procumbent and square).

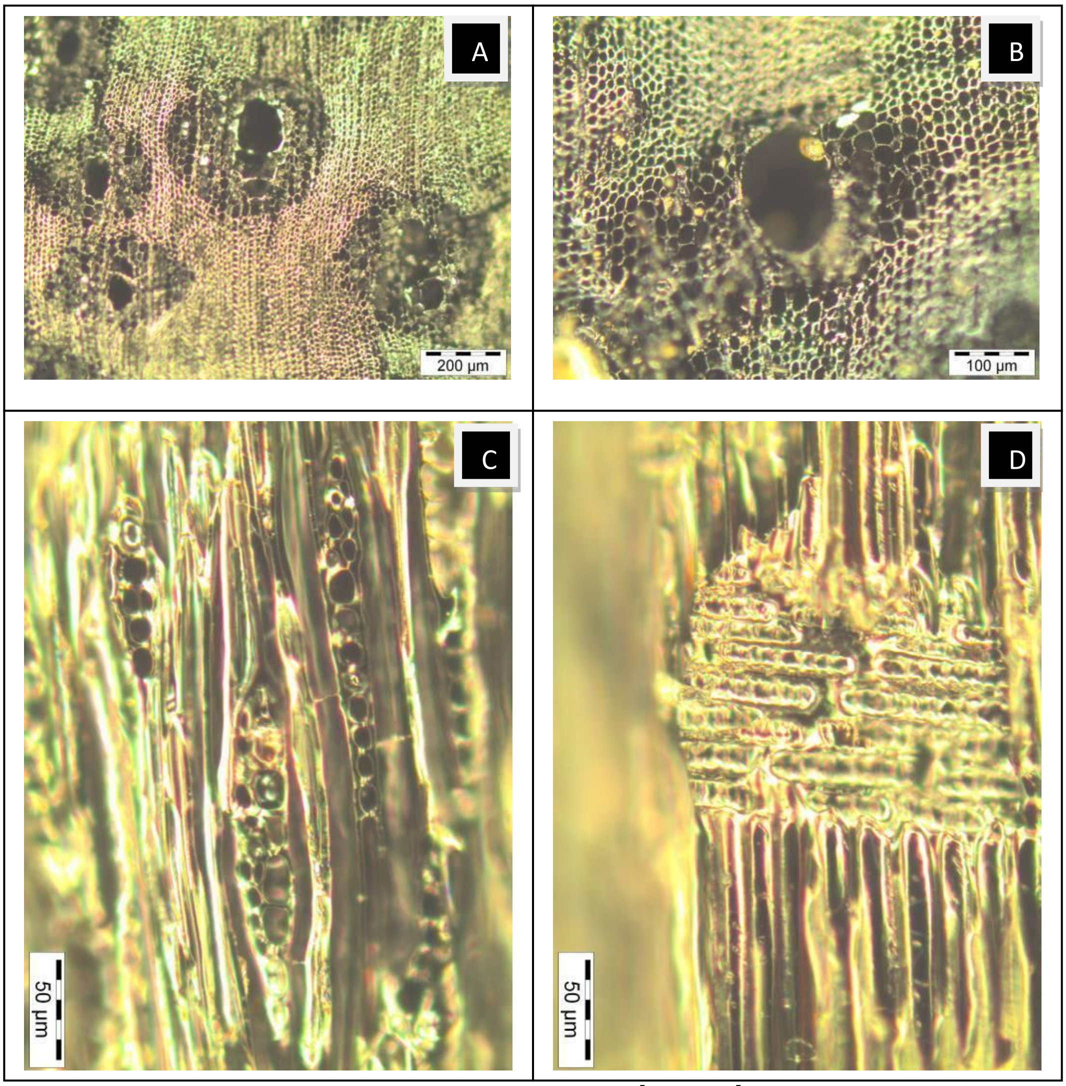


Figure 66: LEGUMINOSAE MIMOSOIDEAE *Dichrostachys cinerea* - 2030 BD-HC-W20-A, Hill Complex, Great Zimbabwe. A, B-TS (axial parenchyma: vasicentric); C- TLS (amorphous deposits, prismatic crystals); D- RLS (procumbent ray cells).

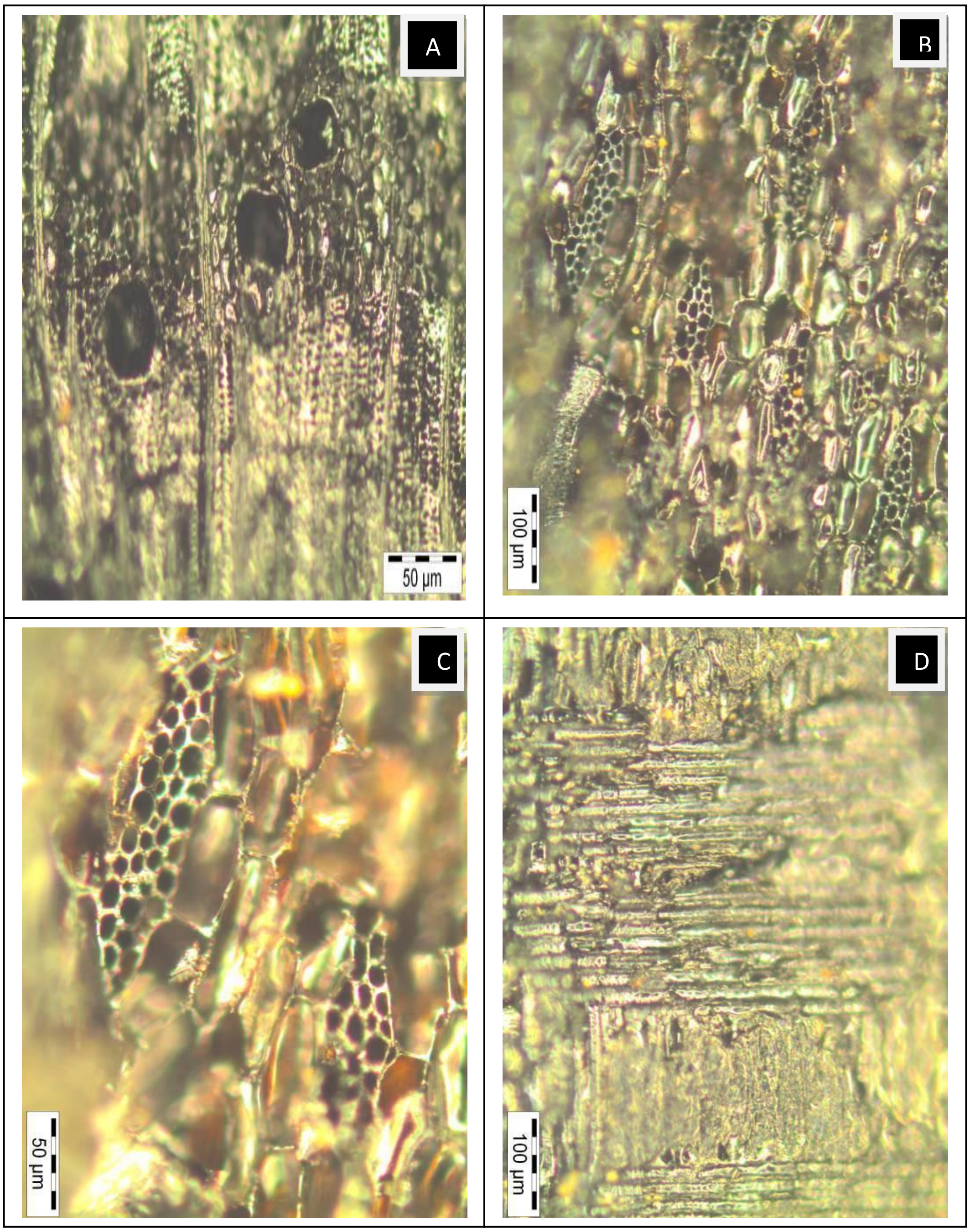


Figure 67: LEGUMINOSAE MIMOSOIDEAE *Acacia burkei,* W8-T1-L2-E, Hill Complex, Great Zimbabwe. A – TS (1-4 seriate, parenchyma: vasicentric, confluent to banded); B, C – TLS (idioblasts, ray parenchyma); D- RLS (procumbent ray cells).

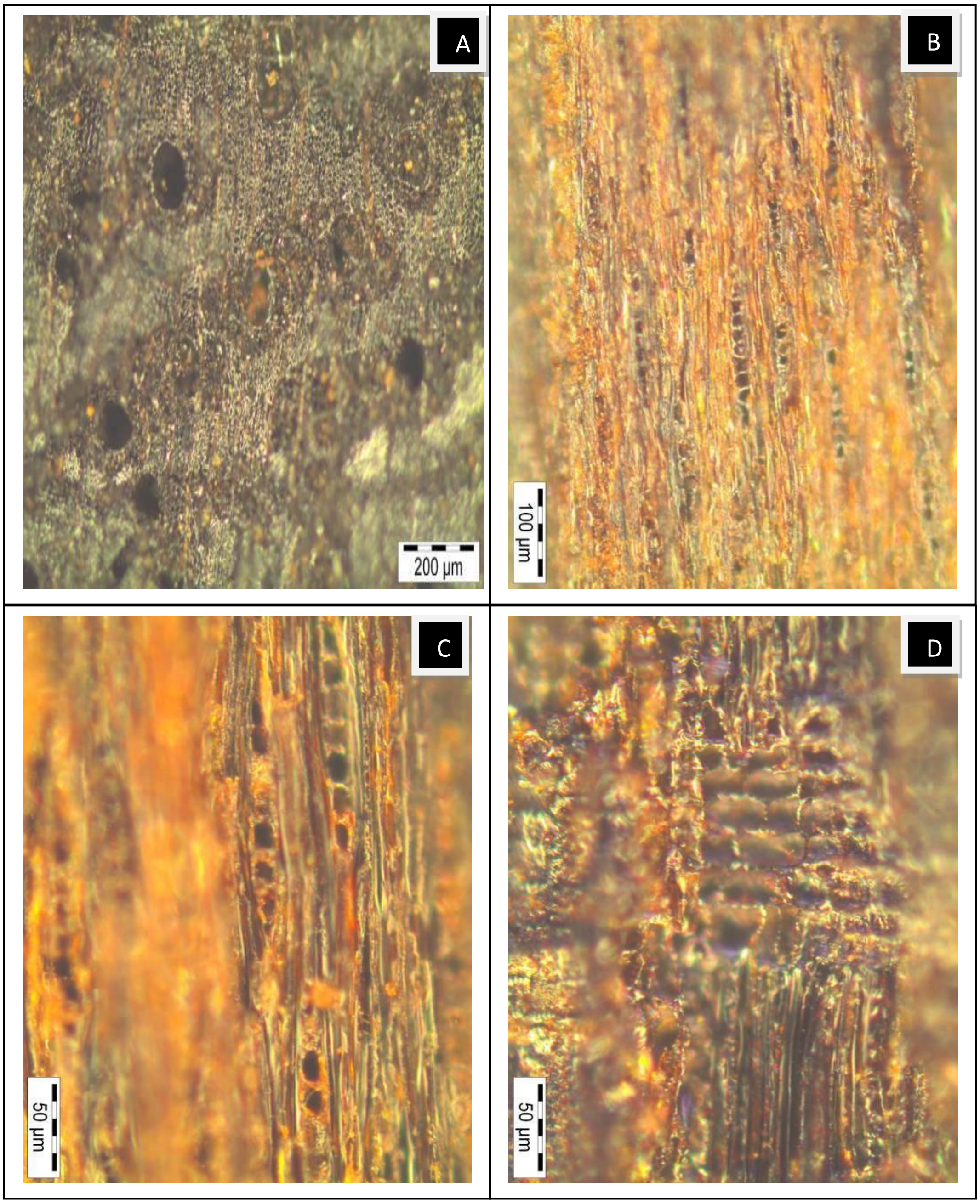


Figure 68: LEGUMINOSAE CAESALPINIOIDEAE *Brachystegia boehmii*, QMIA-1691-C, Hill Complex, Great Zimbabwe. A- TS (uniseriate, parenchyma: vasicentric, confluent to banded); B, C- TLS (oblique perforation plates, idioblasts, predominantly uniseriates, vessels with alternate pits); D – RLS (4- to 6 layers procumbent cells and then a layer of square cells).

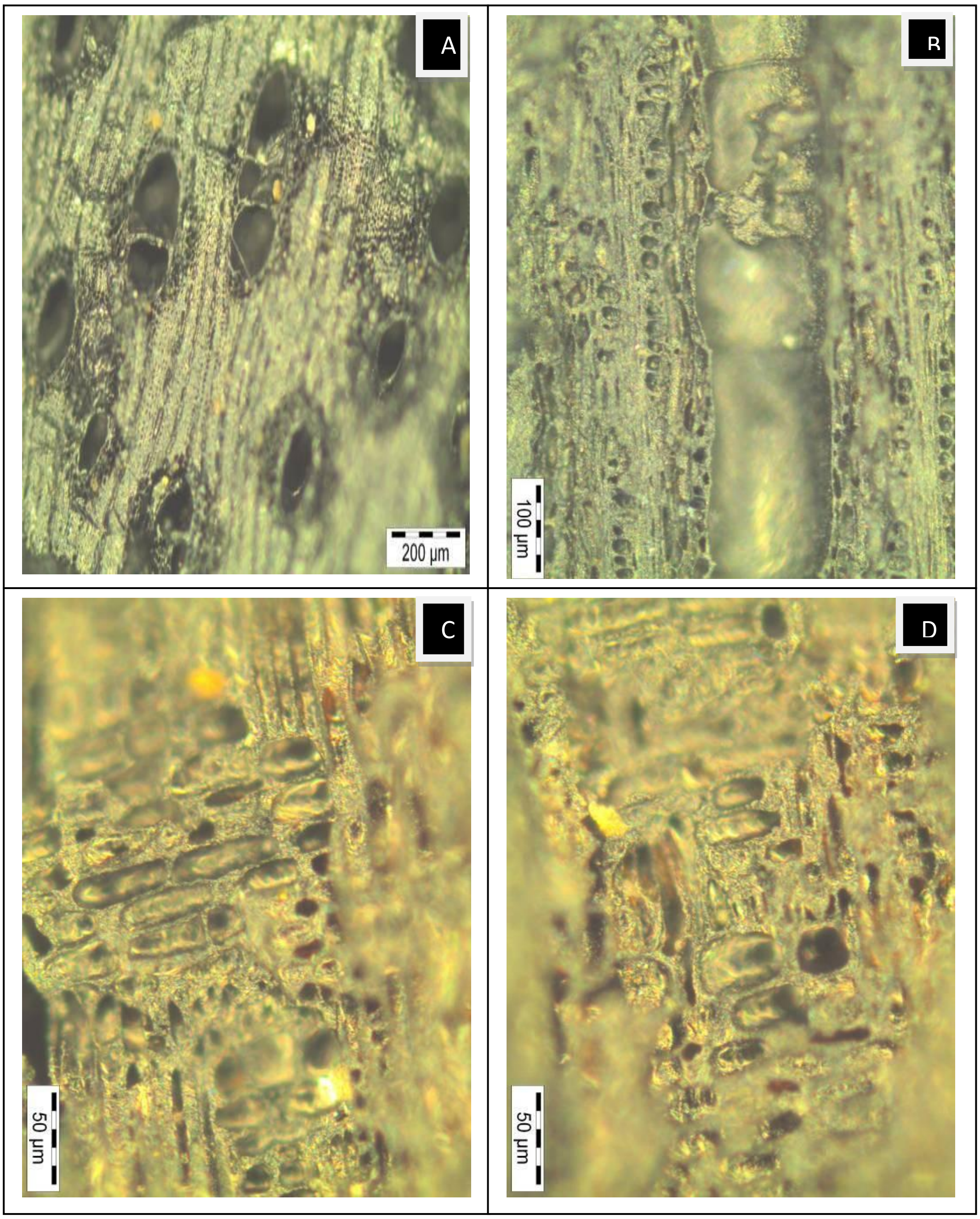


Figure 69: LEGUMINOSAE CAESALPINIOIDEAE *Brachystegia spiciformis*, NRS-T2L2-E, Hill Complex, Great Zimbabwe. A –TS (crystals in ground tissue and parenchyma cells, solitary and radial multiples 2-3, vasicentric parenchyma); B-TLS (uniseriates, rows of square crystals cells); C, D –RLS (mixed cells: square to upright and procumbent).

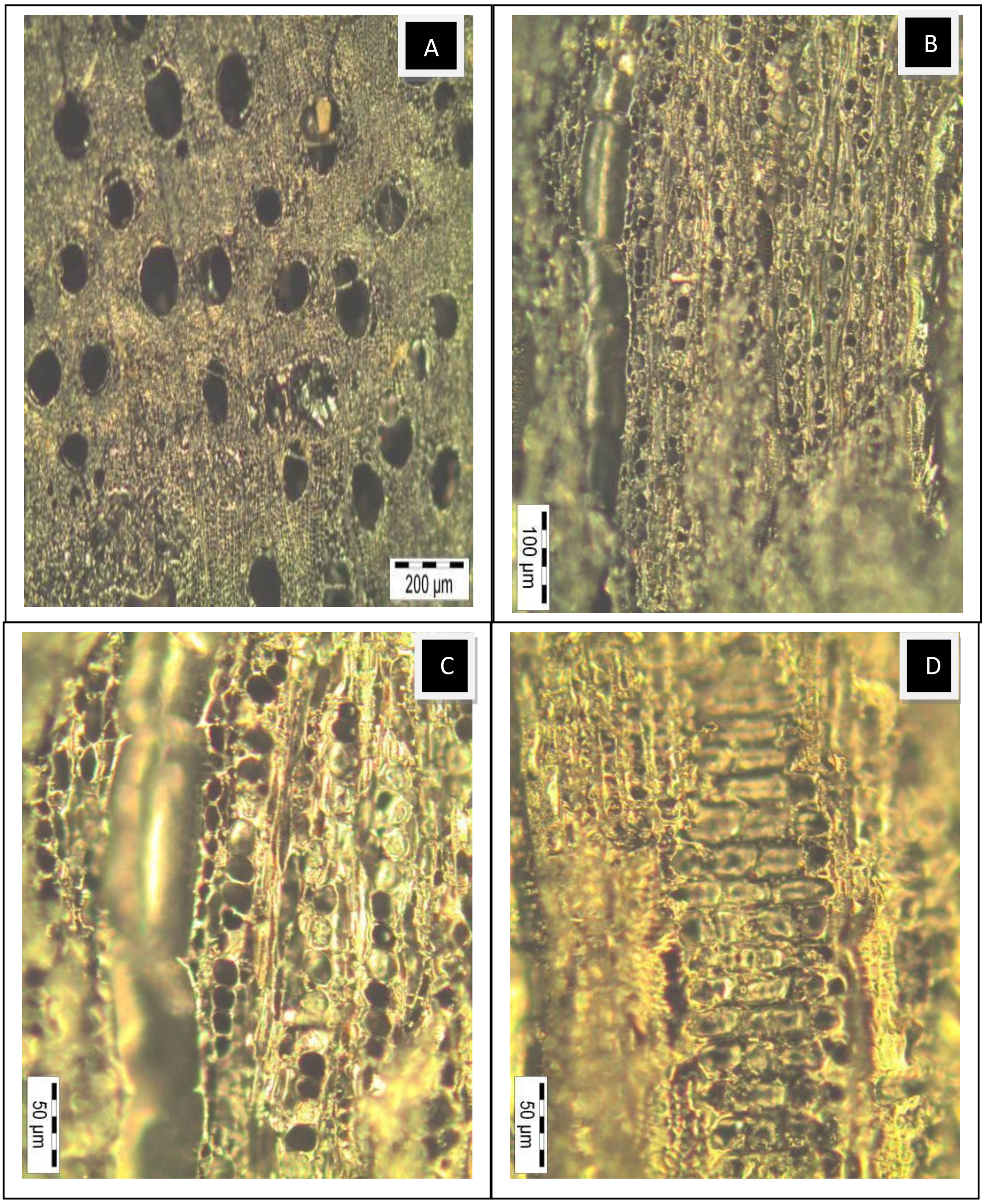


Figure 70: LEGUMINOSAE CAESALPINIOIDEAE *Julbernardia globiflora*, QMIA- 1691-E, Hill Complex, Great Zimbabwe. A – TS (uniseriate, solitary, radial multiples 2-3, tyloses, confluent to banded parenchyma); B, C –TLS (horizontal perforation plates, crystalliferous cells, weakly heterocellular uniseriates); D – RLS (mixed procumbent and square cells, marginal square and procumbent cells, septate fibres).

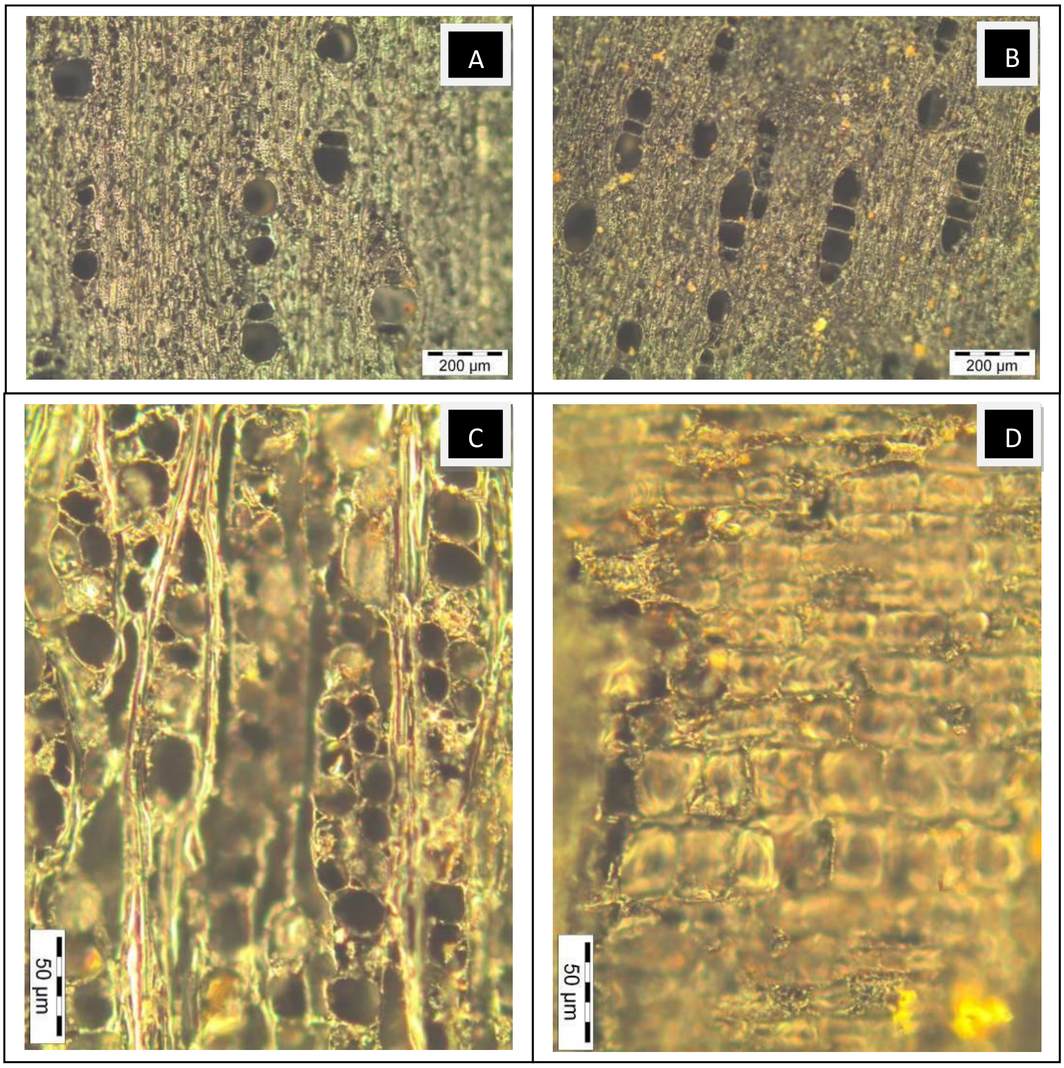
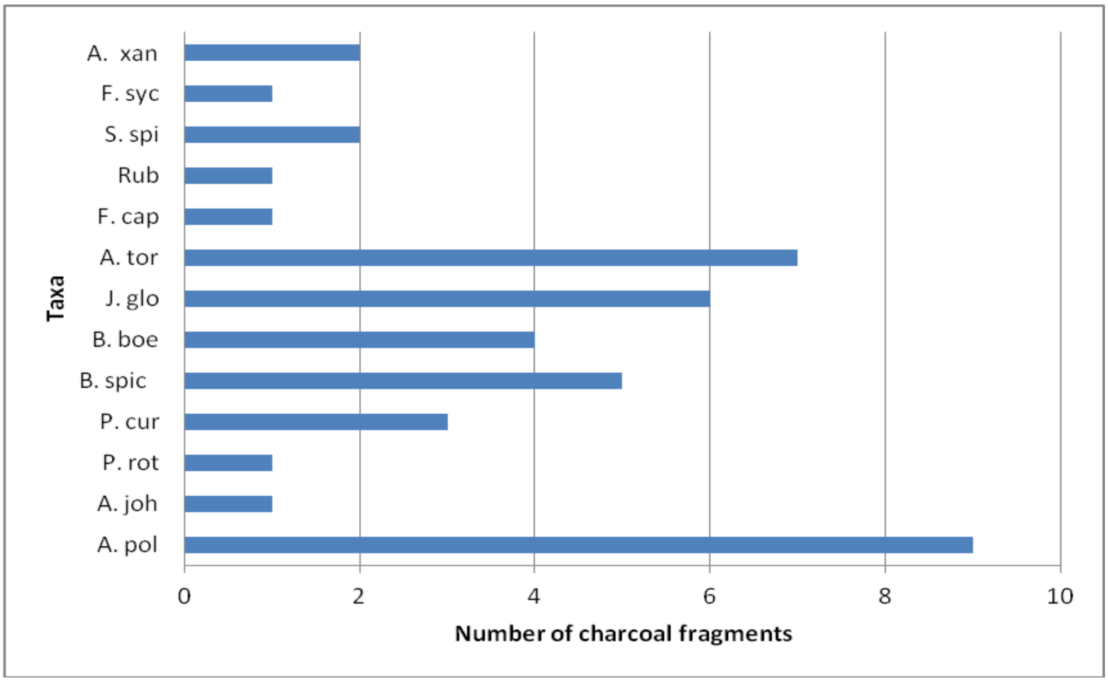


Figure 71: SAPOTACEAE *Mimusops zeyheri*, W8-T1-L2, Hill Complex, Great Zimbabwe. A, B- TS (diffuse ring porous, solitary and radial multiples 2-3, predominantly uniseriate); C- TLS (1-2 cells wide, heterocellular, crystalliferous, idioblasts); D- RLS (square ray cells, mixed procumbent and square).

7.2 The Terrace area

This area is located on the foot of the Hill Complex and near the museum.



KEY:

Rub=Rubiaceae, J. glo=Julbernardia globiflora, B.spic= Brachystegia spiciformis, B. boe=Brachystegia boehmii, P.cur= Parinari curatellifolia, A.xan= Acacia xanthophloea, S.spi=Strychnos spinosa, P. rot= Pterocarpus rotundifolius, A.joh=Androstachys johnsonii, F.cap=Ficus capensis, F. syc=Ficus sycomorus, A. pol=Acacia polyacantha, A. tor= Acacia tortilis.

Figure 72: A graphical represantation of charcoal from the Terrace Ruins

Twelve species were identified from a total of 42 charcoal fragments that were analyzed (Figure 72). One fragment was identified to the family *Rubiaceae*. The *Acacia polyacantha?* was the most well represented and was represented by 9 charcoal fragments. The second well represented was *Acacia tortilis* with 7 charcoal fragments. There were 6 *Julbernardia globiflora* 6 charcoal fragments, 5 fragments of *Brachystegia spiciformis*, 4 of *Brachystegia boehmii*, 3 *Parinari curatellifolia*, 3 *Acacia xanthophloea* and 2 *Strychnos spinosa*.

Pterocarpus rotundifolius, *Androstachys johnsonii*, *Ficus capensis*, and *Ficus sycomorus* were represented by one charcoal fragment each as is shown in the figure 72 above. The figures (73 – 76) show micrographs of the identified taxa.

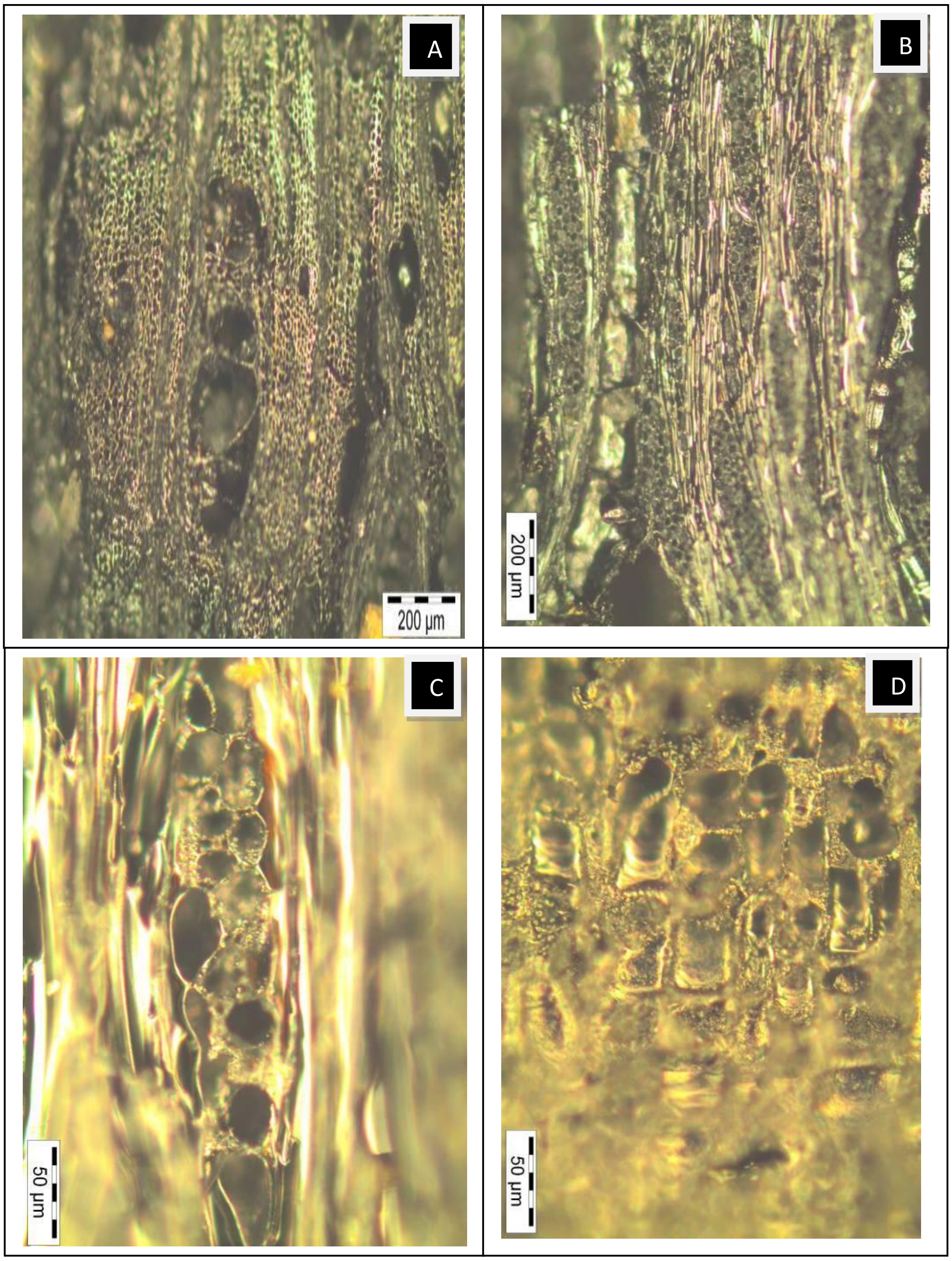


Figure 73: MORACEAE *Ficus sycomorus*, 2030 BD – TPW - 1A, Terrace path wall, Great Zimbabwe. A – TS (I-3 seriate, amorphous deposits, diffuse ring porous, radial multiples 2-3); B, C – TLS (1-5 cells wide, heterocellular, non-septate fibres); D – RLS (mixed body ray cells-procumbent, square and upright).

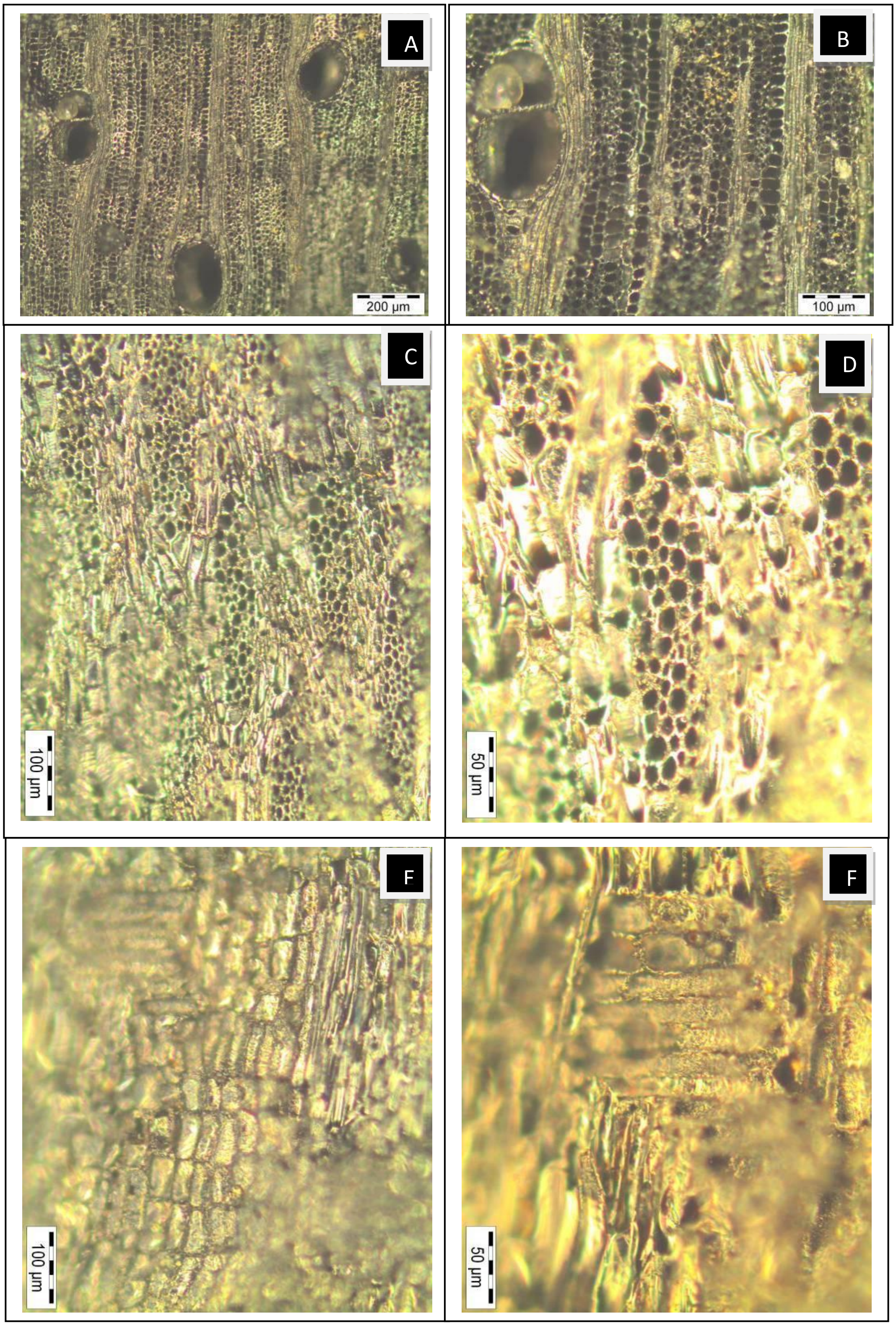


Figure 74: MORACEAE *Ficus capensis*, 2030 BD-TM-1C, Terrace Midden, and Great Zimbabwe. A, B- TS (1-8 seriate, tyloses, diffuse ring porous, solitary, radial multiples 2-3 vessel arrangement); C, D- TLS (4-8 cells wide, heterocellular ray cells); E, F –RLS (mixed procumbent and square, upright, simple fibres).

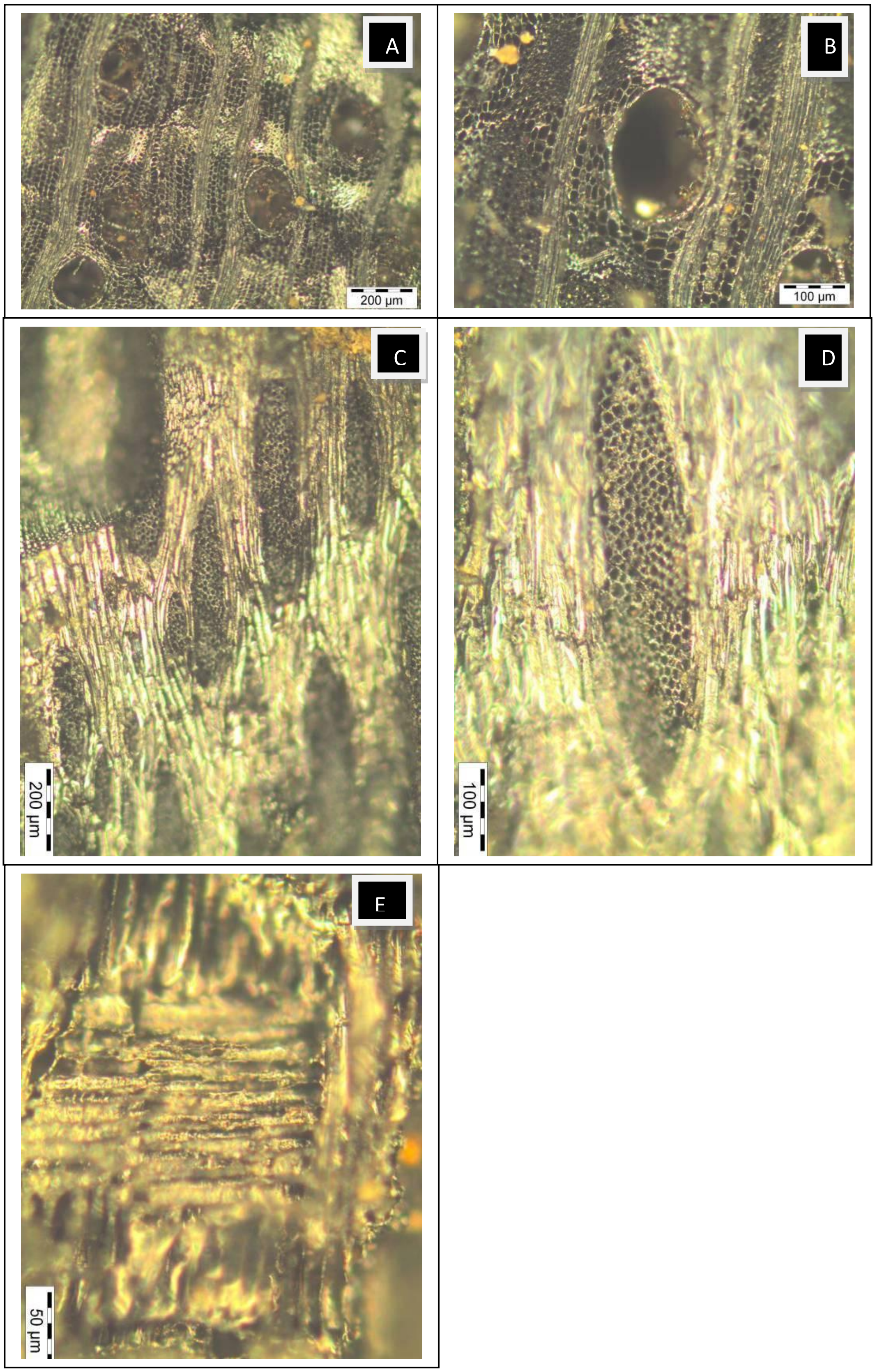


Figure 75: LEGUMINOSAE MIMOSOIDEAE *Acacia xanthophloea*, 2030 BD-TPW-1B, Terrace Path Wall, Great Zimbabwe. A, B- TS (exclusively solitary vessel arrangement, 2-10 seriate, confluent to banded parenchyma); C, D – TLS (2-12 seriate and weakly heterocellular); E – RLS (procumbent ray cells, fibres between the rays).

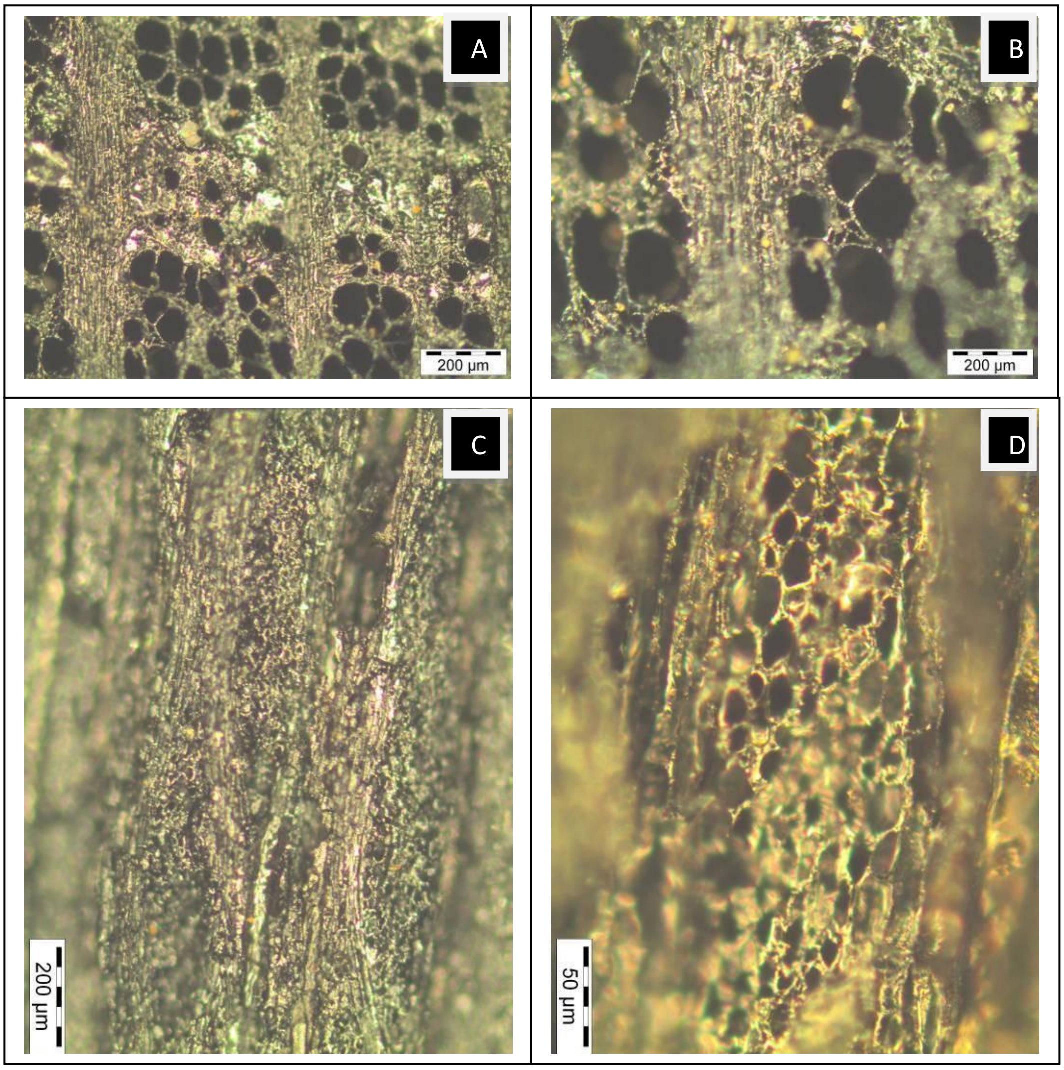


Figure 76: LOGANIACEAE *Strychnos spinosa*, 2030 BD-TM-C, Terrace Midden, Great Zimbabwe. A, B – TS (vessels forming in clusters of 3-12, 3-9 seriate, amorphous deposits); C, D- TLS (multiseriate, crystalliferous cells, minute alternate pits on vessels).

7.3 Barrier Hut

The Barrier hut is located to the west of the Hill Complex and forms part of the commoners' part of the settlement at Great Zimbabwe. It is found outside the perimeter wall. A total of 55 (15% of the total charcoal from Great Zimbabwe) charcoal fragments was analyzed from the Barrier hut. All the fragments were identified to the species level. *Acacia polyacantha?* was the widely dominant taxon in the Barrier hut with 50 charcoal fragments. Only 3 and 2 fragments were identified as *Acacia sieberiana* and *Brachylaena discolor* respectively. The figures (77 - 79) below show micrographs of the identified specimens from the Barrier Hut.

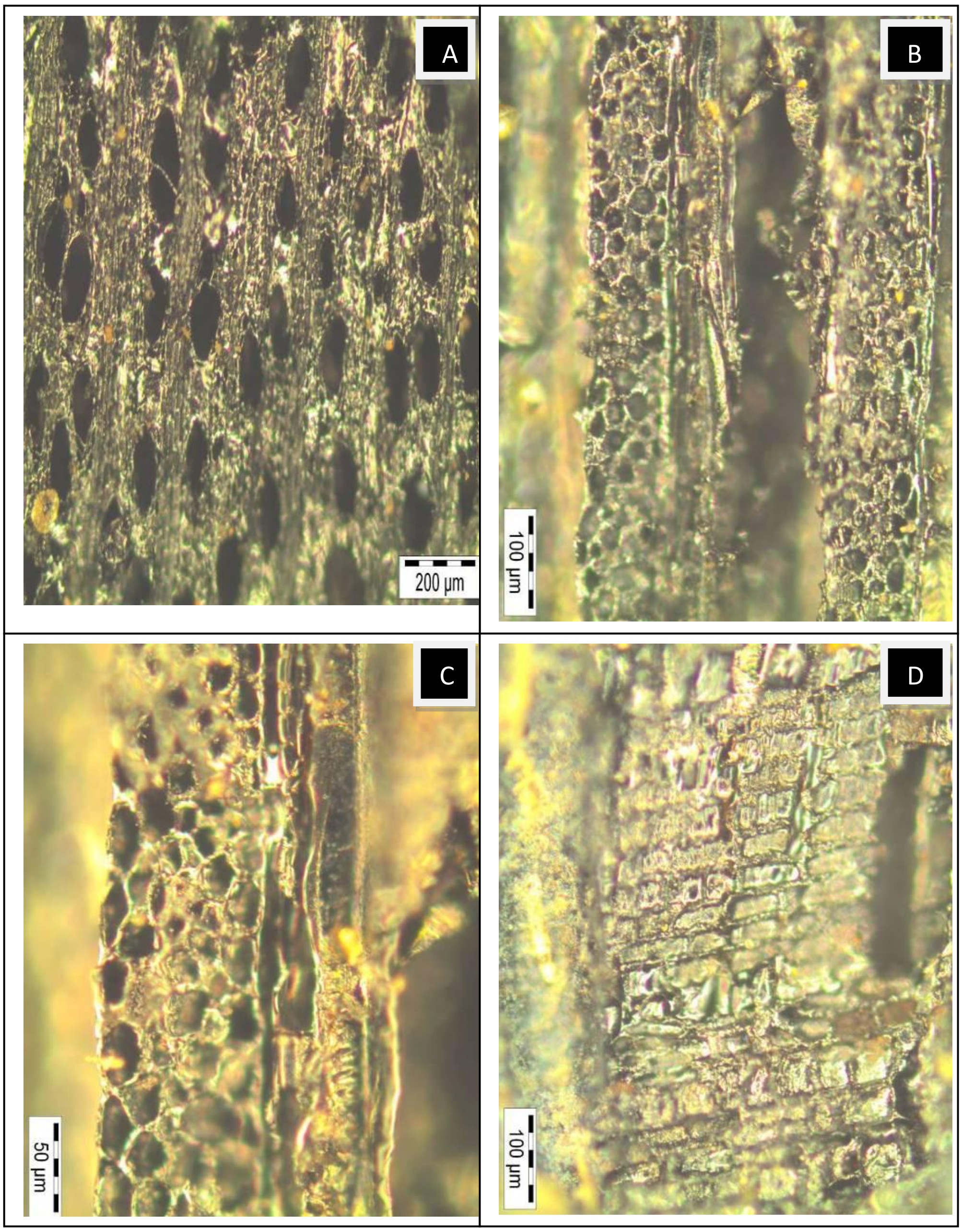


Figure 77: LEGUMINOSAE MIMOSOIDEAE *Acacia polyacantha?,* 2030-BD-BH-A, Barrier Hut. A – TS (radial multiples 2-3, 1-6 seriate); B, C-TLS (procumbent cells along vessels, 1-7 seriate, heterorocellular, oblique perforation plates, fibres thin -to thick walled); D- RLS (mixed cells: procumbent, square and upright).

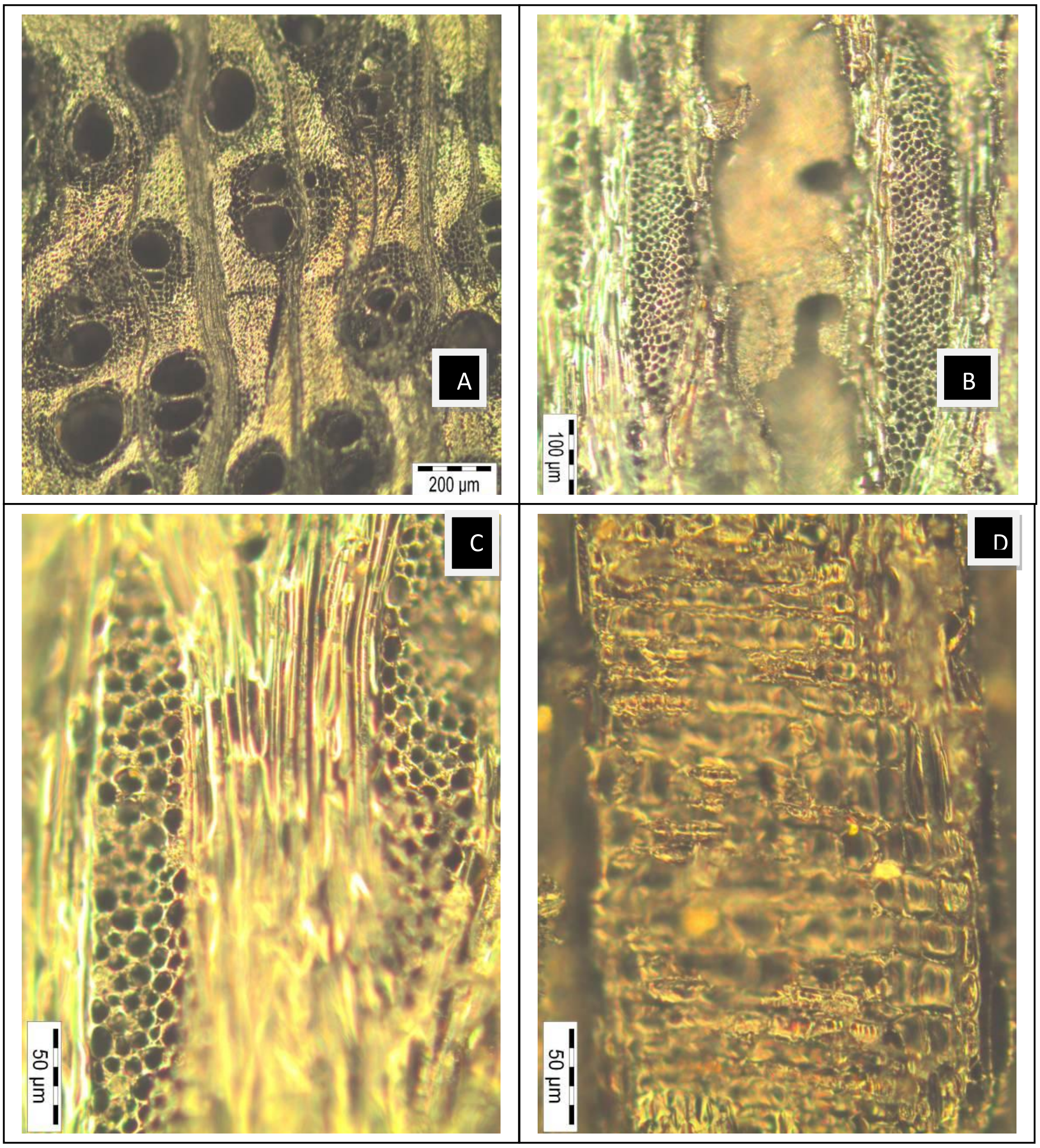


Figure 78: LEGUMINOSAE MIMOSOIDEAE *Acacia sieberiana*, 2030 BD - BH86 - A, Barrier Hut. A – TS (solitary, radial multiples vessel arrangement, 1-4 seriate, scanty , vasicentric, confluent parenchyma); B, C – TLS (horizontal perforation plates, prismatic crystals, 2-6 seriate, homocellular rays); D – RLS (mixed procumbent and square cells).

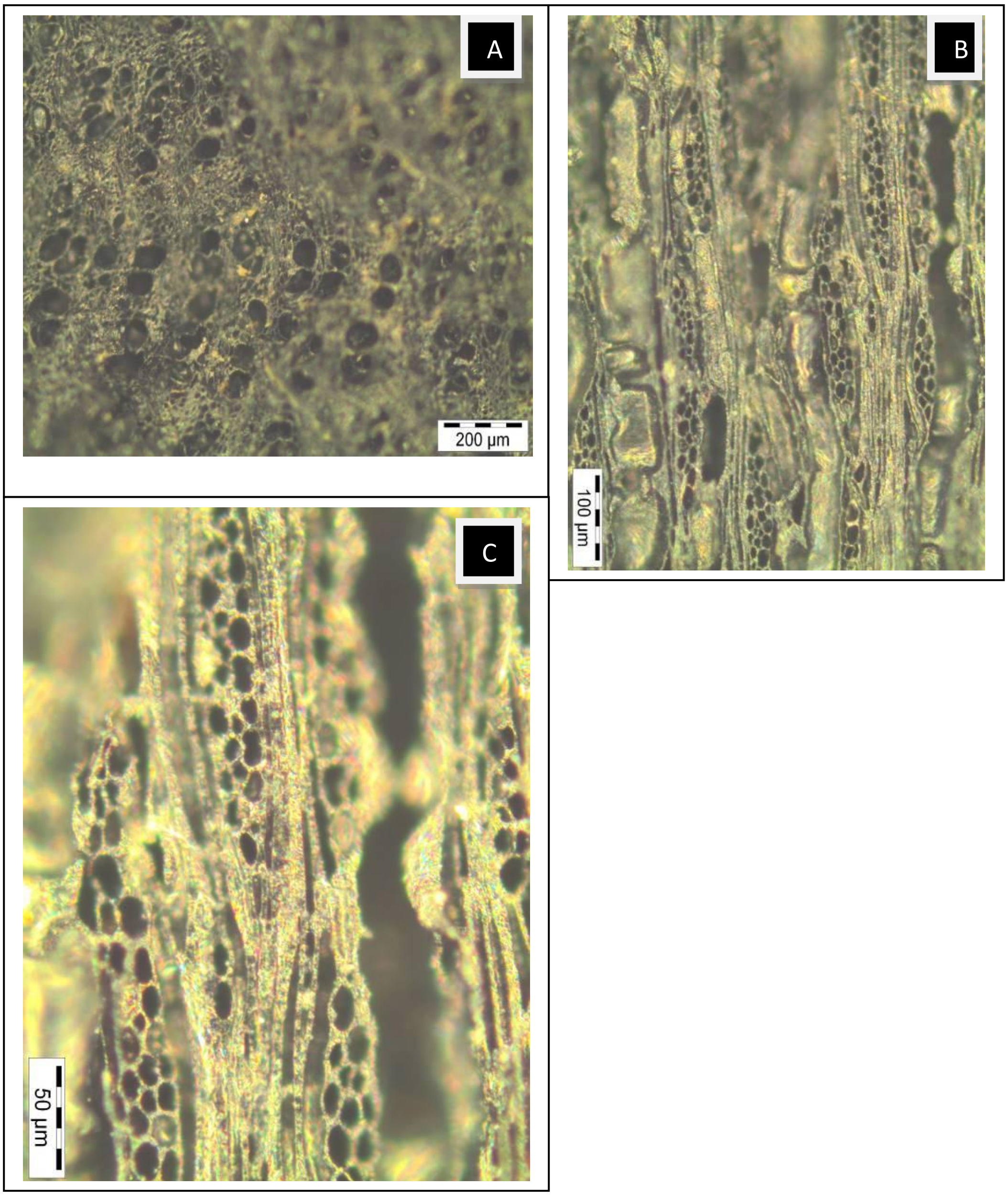


Figure79: ASTERACEAE *Brachylaena discolor*, 2030 BD-BH86-C, Barrier Hut. A – TS (no distinct growth rings, solitary, radial multiples 2-4, 1-4 seriate); B, C- TLS (2-4 seriate, horizontal perforation plates).

7.4 The Ridge Ruin

The ruin is located between the museum and the Great Enclosure. It comes later in the history of the occupation of Great Zimbabwe after the State had declined (Garlake 1982). Three taxa were identified to the species level. These are *Julbernardia globiflora, Spirostachys africana* and *Acacia polyacantha?* The three identified taxa altogether contributed 26 charcoal fragments, which are 7 percent of the total charcoal assemblage from Great Zimbabwe. The most dominant taxon was *Julbernardia globiflora*. A total of 20 charcoal fragments were identified as *Julbernardia globiflora,* and 4 *Acacia sp* that resemble *Acacia polyacantha*. The *Spirostachys africana* (Figure 80) was identified from two charcoal fragments.

7.5 Nemanwa Ruin

The ruin is located to the north of the Hill Complex near the Conservation Center. It forms part of the outer stone walling enclosures. Only two taxa were identified at Nemanwa ruin. Five out of six of these charcoal fragments were identified as *Pterocarpus angolensis* whilst the remainder was *Acacia mellifera*.

7.6 2030BD 57

2030 BD 57 is found within the Great Zimbabwe archaeological site but the exact context is not known. Two firewood pieces were found in the late 19th century. According to the archival information available the firewood pieces were collected from a furnace context. They have been identified to resemble *Acacia polyacantha?* and *Pterocarpus angolensis* (Figure 81).

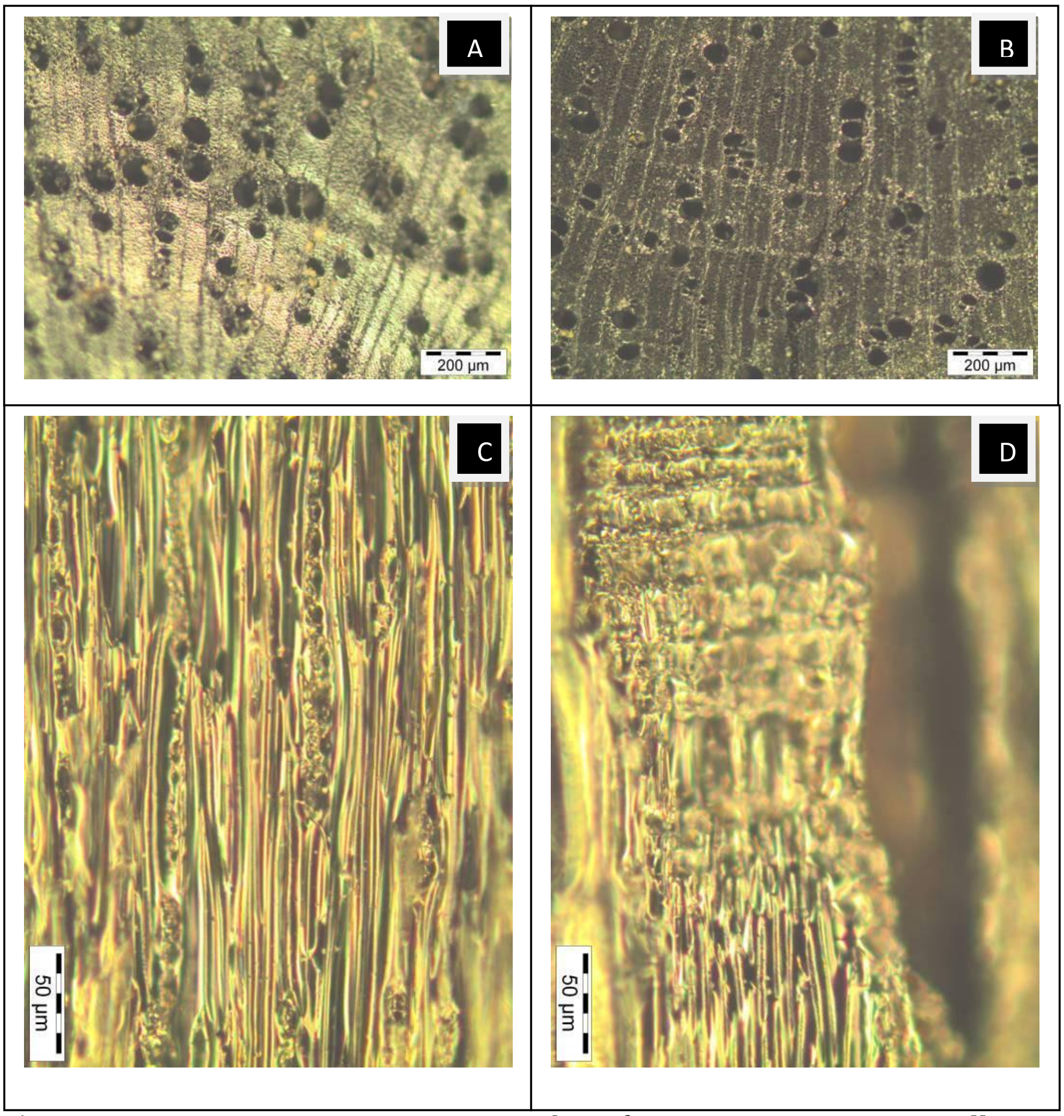


Figure 80: EUPHORNIACEAE *Spirostachys africana*, QMIA-1721-A, Hill Complex, Great Zimbabwe. A, B- TS (radial multiples 2-5 or more, uniseriate, amorphous deposits, growth ring boundaries indistinct or absent); C – TLS (vasicular/ vascular tracheids present, fibres thin to thick –walled, fibres with simple minutely bordered pits, axial parenchyma diffuse in aggregates, prismatic crystals); D – RLS (mixed procumbent and upright cells).

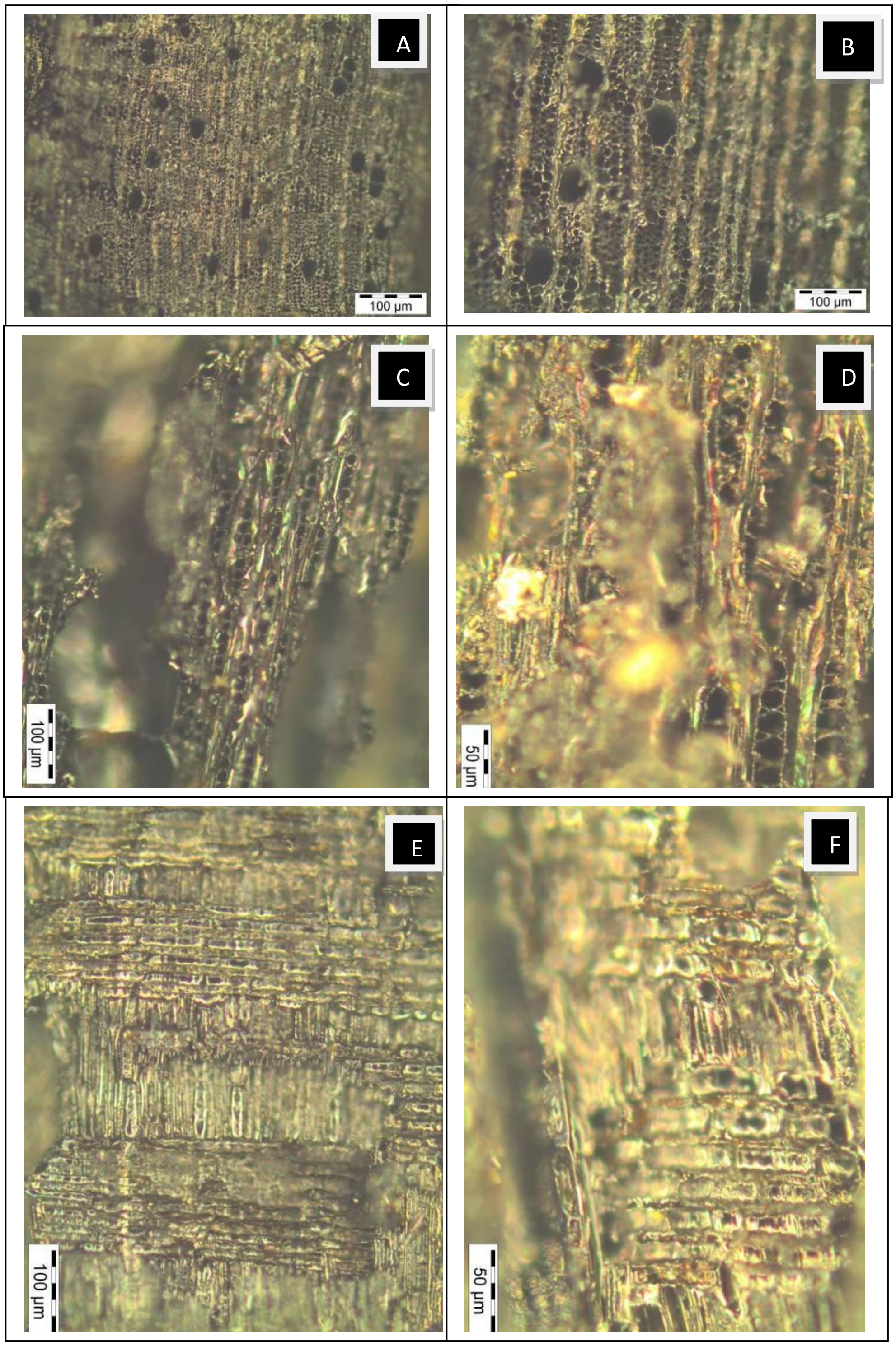


Figure 81: LEGUMINOSAE PAPILIONOIDEAE *Pterocarpus angolensis*, 2030 BD - 57-A, Great Zimbabwe, furnace context. A, B – TS (diffuse ring porous, solitary, diagonal to tangential vessel arrangement, 1-2 seriate, scanty , vasicentric parenchyma); C, D – TLS (predominantly biseriates, idioblasts); E, F- RLS (mixed upright and square, procumbent and square cells).

8 Summary

Most of the species were identified to the genus and species levels except for a few that were either identified to the family level or were non identifiable. In the latter case identification was made difficult because of the limitations of the comparative collection or the fragments were too small to show diagnostic features or details. The analysis of charcoal fragments from Great Zimbabwe resulted in the identification of twenty nine different taxa. The most commonly distributed taxon was *Acacia polyacantha?* It was found in six out of seven contexts that were investigated. The second most widely distributed were *Julbernardia globiflora* and *Parinari curatellifolia*. The two taxa were found in more than 50 % of the investigated contexts. The next chapter presents the results of anthracological analysis from Chigaramboni.

CHAPTER SEVEN

Archaeological charcoal from Chigaramboni site

9 Introduction

This chapter presents results of the charcoal excavated from Chigaramboni. The archaeological assemblages came from nine different contexts at Chigaramboni (Figure 82). Chigaramboni is an archaeo-metallurgical site where the identified wood charcoal was associated with metallurgical activities.

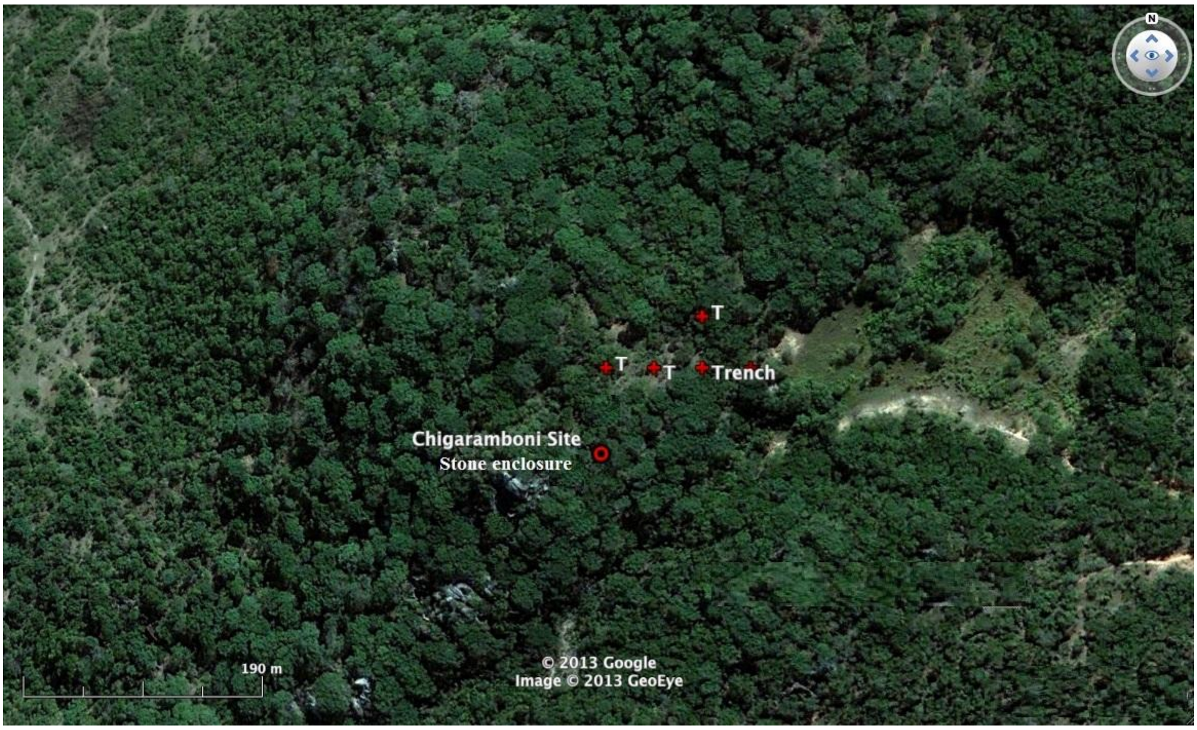


Figure 82: Position of the stone wall enclosure and the sampled contexts (Adapted from Google Earth 2013).

9.1 Bondolfi Site

The charcoal fragments that were excavated at Bondolfi site were all identified as *Brachystegia boehmii* (Figure 83). The charcoal sample totalled 85 charcoal fragments and all of the fragments were identified to the species level.

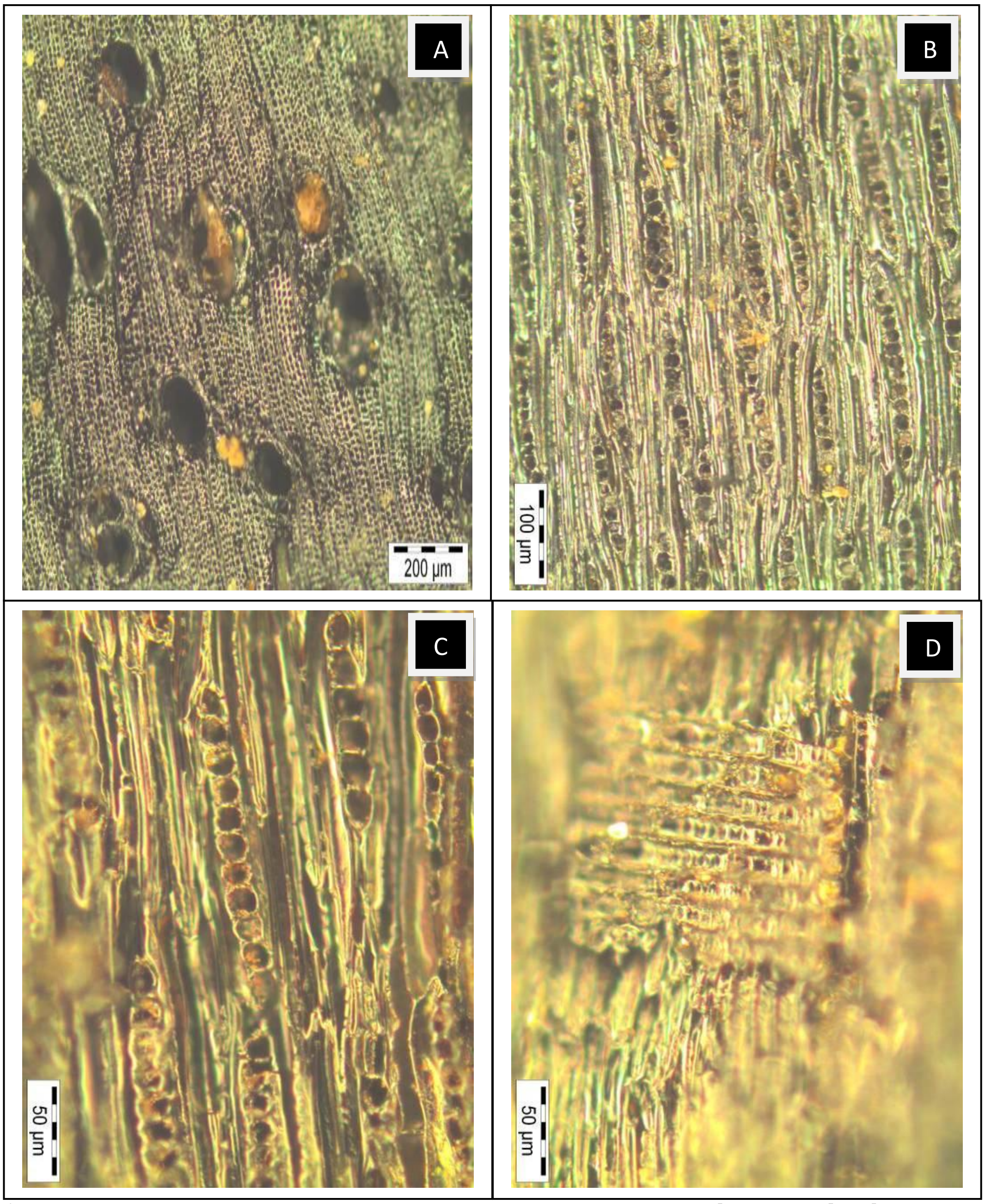
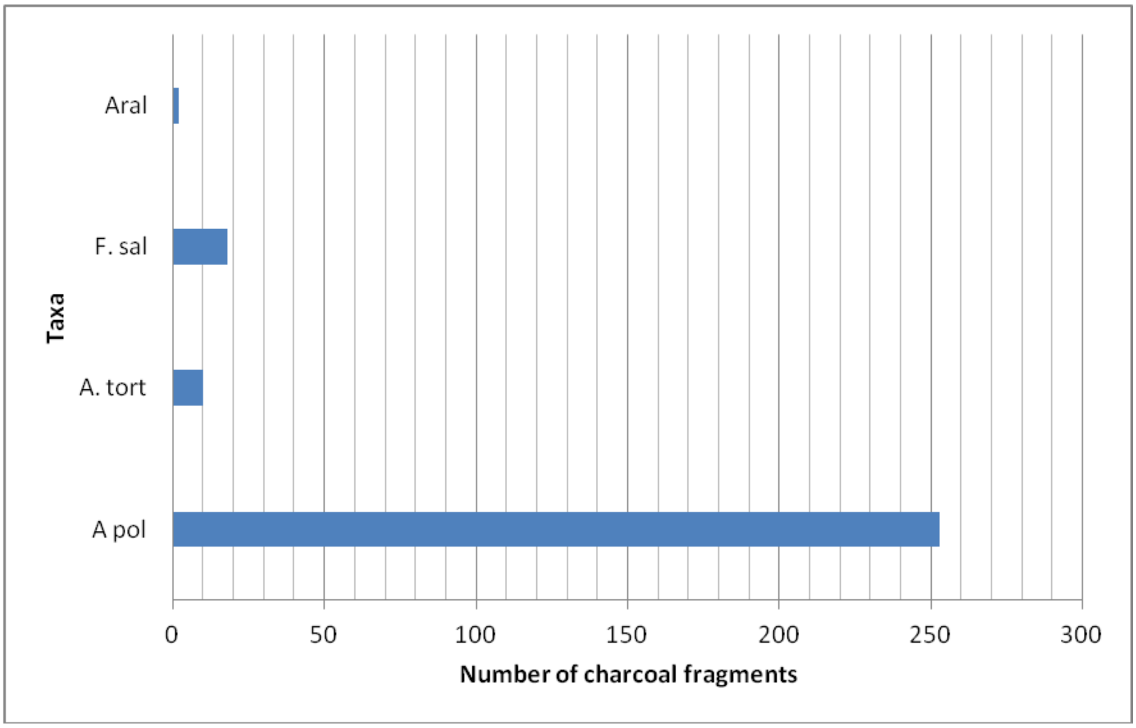


Figure 83: LEGUMINOSAE CAESALPINIOIDEAE *Brachystegia boehmii*, BS-T4-L1-A, Bondolfi site, Chigaramboni. A –TS (vasicentric, confluent to banded parenchyma, predominantly uniseriate, growth ring boundaries present); B, C- TLS (homocellular uniseriates, crystalliferous, rays are storeyed); D – RLS (all cells look procumbent).

9.2 Road site



KEY:

A. pol=Acacia polyacantha, F. sal=Faurea saligna, A. tort=Acacia tortilis, Aral=Araliaceae.

Figure 84: Taxa identified from Road site.

The graph above (Figure 84) shows the taxa excavated from the Road site at Chigaramboni. A total of 283 pieces charcoal fragments were excavated. The most abundant taxon was *Acacia polyacantha* (Figure 85). The taxon was identified from 253 charcoal fragments. The taxon *Faurea saligna* (Figure 86) was identified from 18 charcoal fragments. The rare taxon was *Acacia tortilis* (Figure 87) that comprised 10 charcoal fragments. Two charcoal fragments were identified to the Family *Araliaceae*.

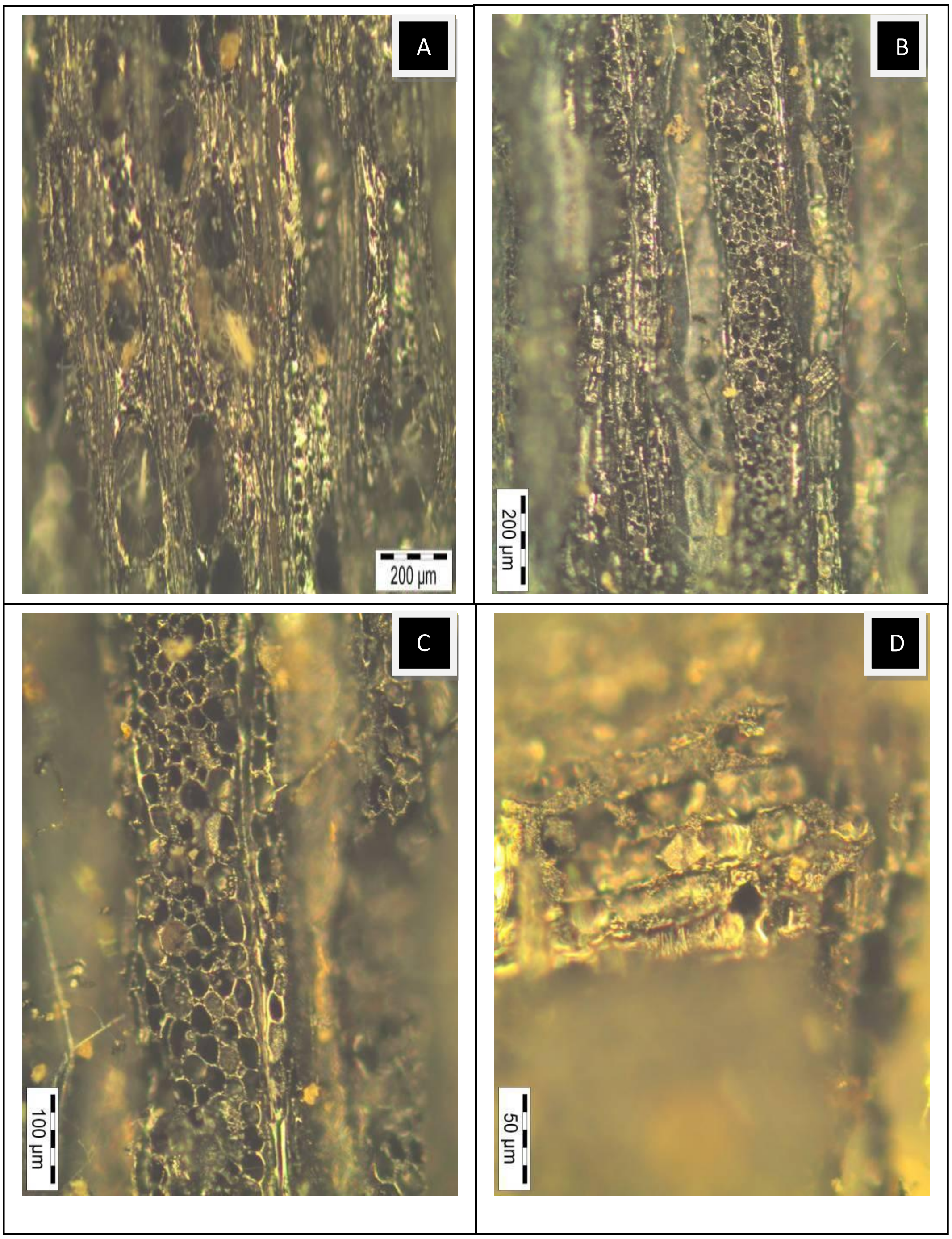


Figure 85: LEGUMINOSAE MIMOSOIDEAE *cf Acacia polyacantha*- CRS-a, Road Site, Chigaramboni. A – TS (solitary, radial multiples vessel distribution, scanty to vasicentric parenchyma, 1-5 or more seriate); B, C – TLS (1-7 seriate or more, crystalliferous, horizontal perforation plates); D –RLS (mixed procumbent, square and upright).

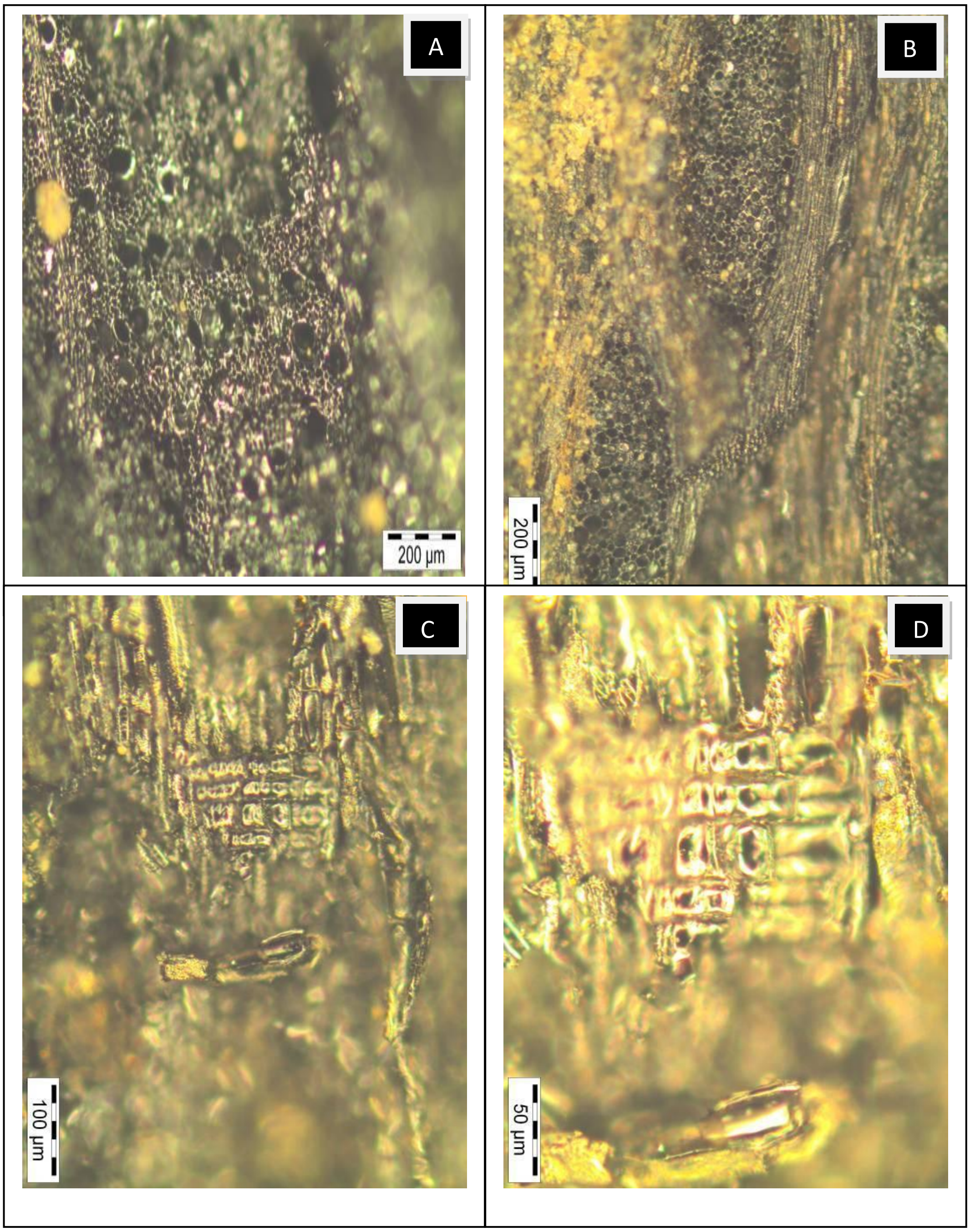


Figure 86: PROTEACEAE *Faurea saligna*, CP-TP7-a, A – TS (1-8 seriate, tyloses, predominantly solitary vessel distribution, and diffuse ring porous); B – TLS (1-8 seriate or more); C, D – RLS (mixed square, upright and procumbent cells).

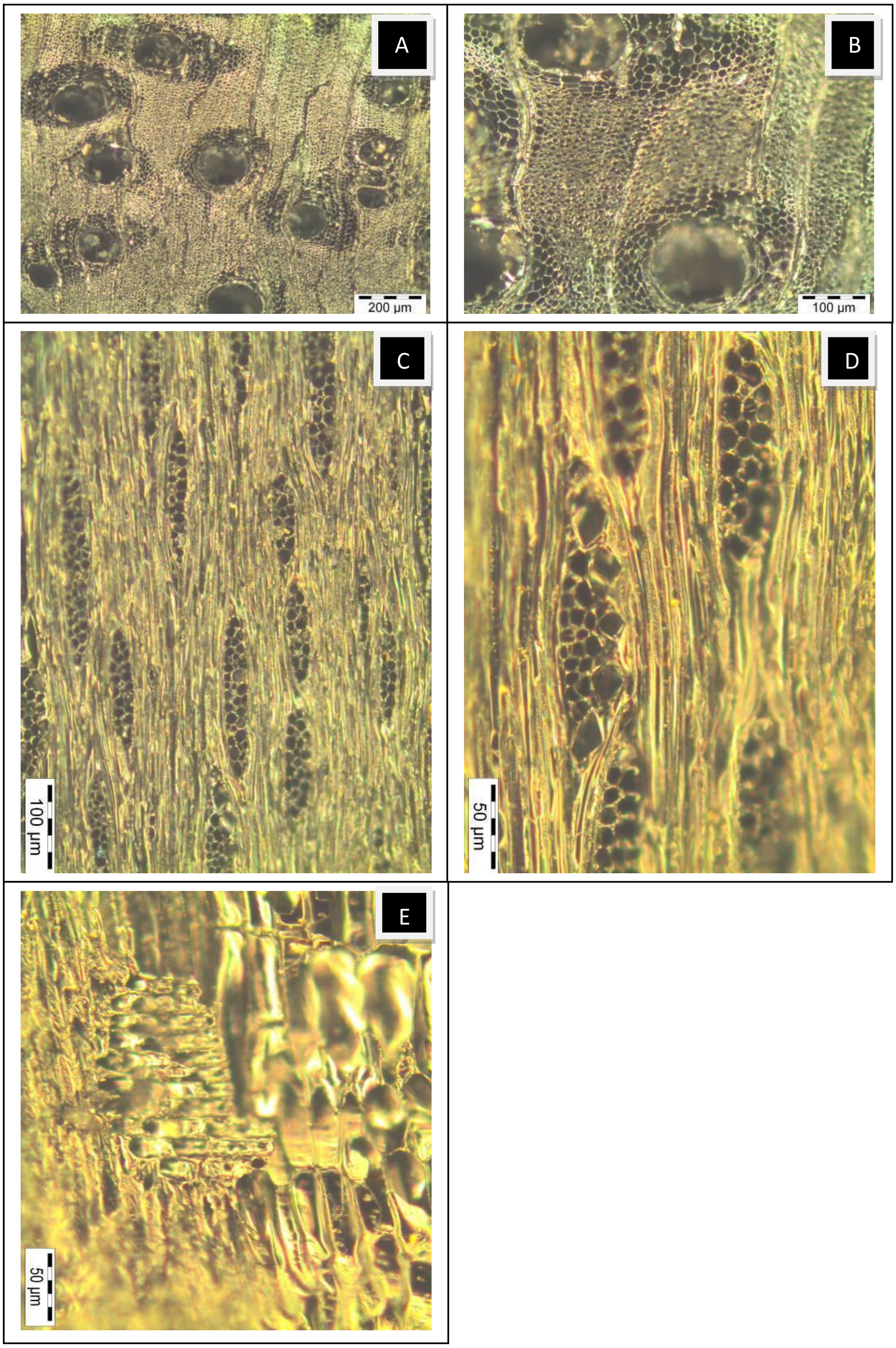
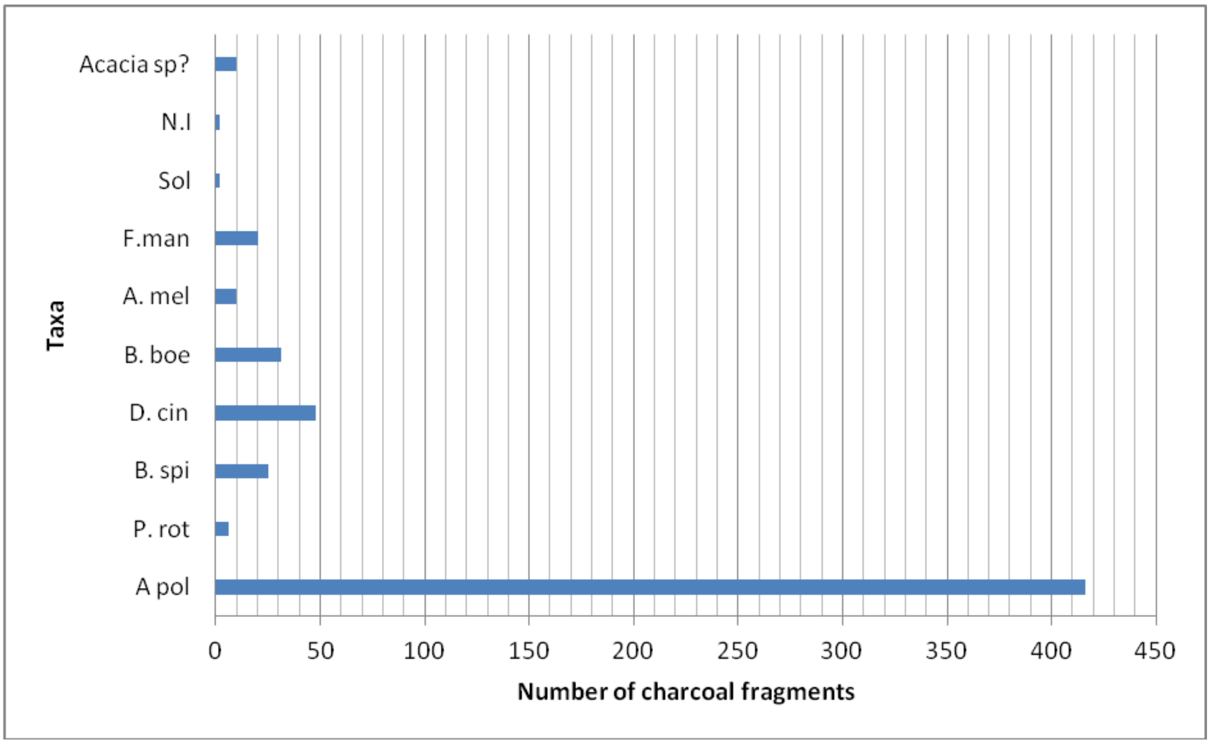


Figure 87: LEGUMINOSEAE MIMOSOIDEAE *Acacia tortilis,* C-PA-TP5-L1-d, A; B – TS (tyloses, amorphous deposits, solitary, radial multiples 2-3, 1-3 seriate); C, D – TLS (1-5 seriate, horizontal perforation plates, prismatic crystals); E- RLS (procumbent and square cells, simple perforation plates).

9.3 Trench 1



KEY:

Sol=Solanaceae, Acacia sp, A. pol=Acacia polyacantha, D. cin=Dichrostachys cinerea, B. spi=Brachystgea boehmii, A. mel=Acacia mellifera, P.rot=Pterocarpus rotundifolius, F. man=Faurea macnaughtonii

Figure 88: The identified taxa from Trench 1.

Figure 88 above shows different taxa identified from Trench 1 from Chigaramboni. A total of 570 charcoal fragments from Trench 1 were identified. Five hundred and sixty - six charcoal fragments were identified to the species level. Two fragments were identified to the family *Solanaceae* and the other two fragments were not identifiable. It is shown in the figure above that the most abundant taxon was *Acacia sp* that resembles *Acacia polyacantha* (416 charcoal fragments), *Dichrostachys cinerea* (48 charcoal fragments) and *Brachystgea boehmii* (31 charcoal fragments). Rare taxa were *Acacia mellifera* and *Pterocarpus* *rotundifolius*. The taxa described as rare are those that occur in low quantities. The Figures (89-92) below are micrographs of the taxa identified.

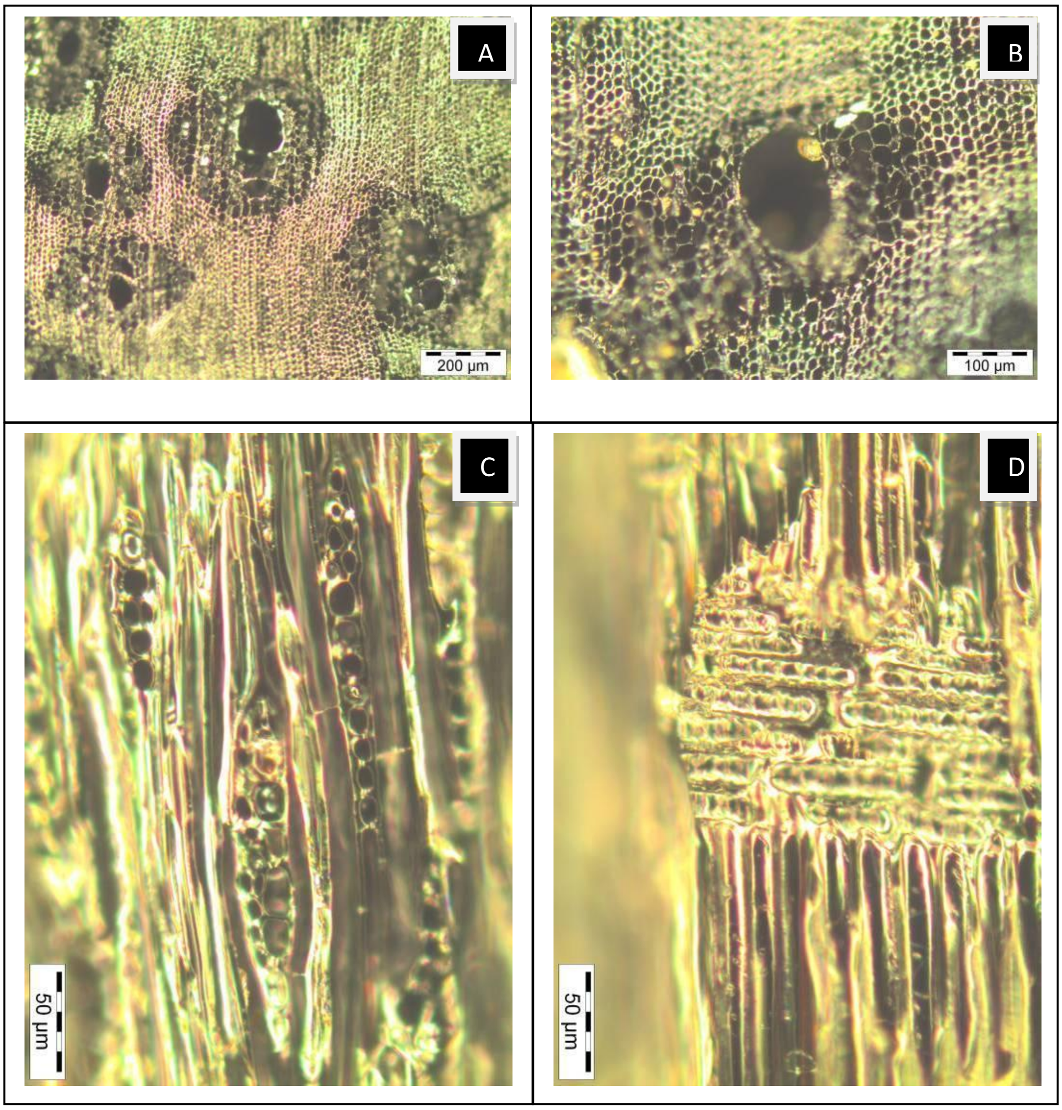


Figure 89: LEGUMINOSEAE MIMOSOIDEAE *Dichrostachys cinerea*, *C*-T1-L3-a, Chigaramboni, Trench 1. A, B – TS (solitary, radial multiples 2-3, vasicentric to confluent parenchyma, high proportion of unilateral parenchyma, crystallised parenchyma cells, 1-3 seriate, tyloses); C – TLS (2-3 seriate); D – RLS (ray cells are procumbent, horizontal perforation plates)**.**

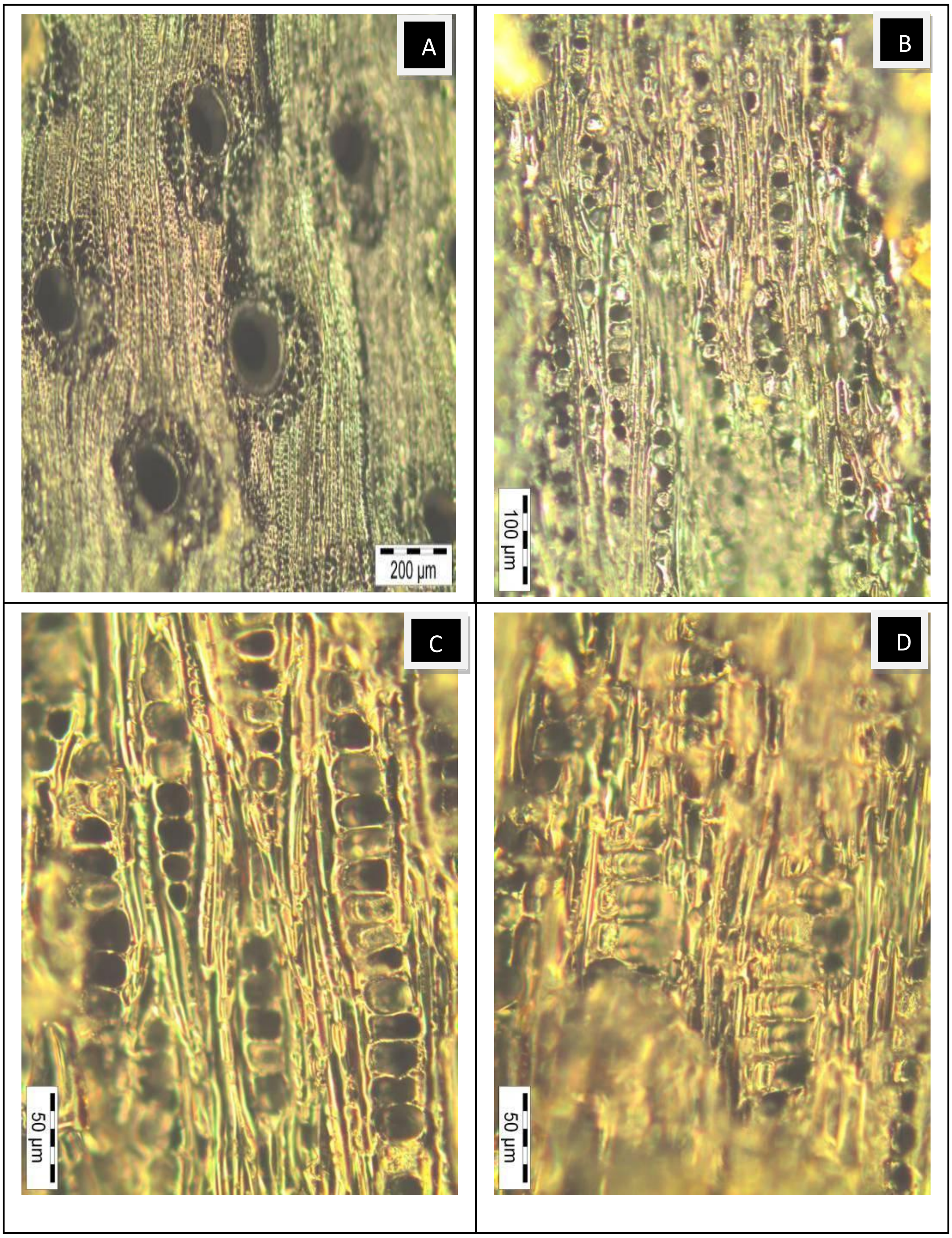


Figure 90: LEGUMINOSAE CAESALPINIOIDEAE *Brachystegia spiciformis*, C-T1-L2-b, Chigaramboni, Trench 1, A- TS (diffuse ring porous, predominantly solitary, vasicentric to confluent parenchyma); B, C- TLS (crystalliferous cells, square prismatic crystals); D – RLS (mixed procumbent and square cells).

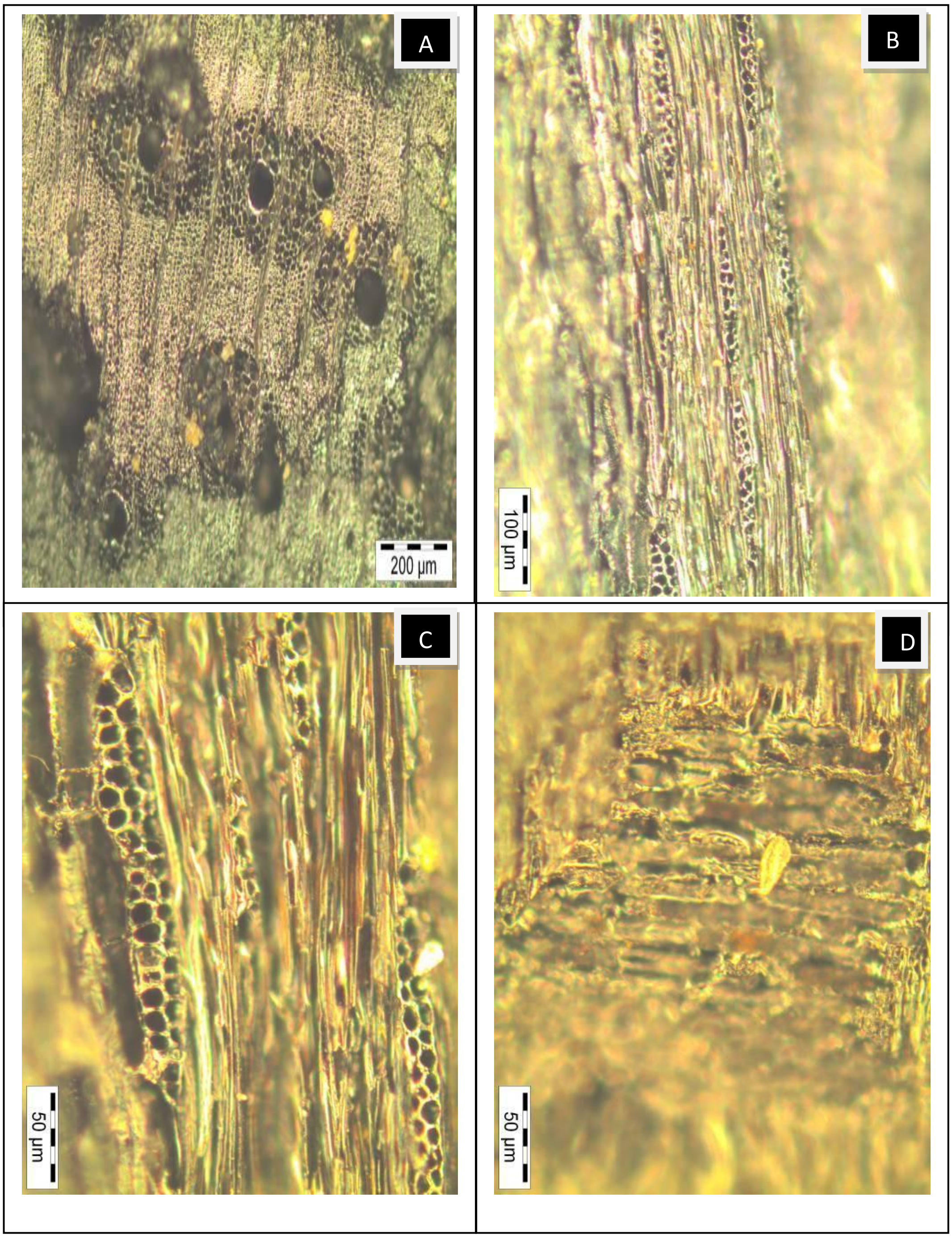


Figure 91: LEGUMINOSEAE MIMOSOIDEAE *Acacia mellifera*, C-T1-L3-d, Chigaramboni, Trench 1. A – TS (exclusively solitary, vasicentric, confluent –to banded parenchyma, 1-3 seriate diffuse ring porous); B, C – TLS (1-3 seriate, horizontal perforation plates, thin –to thick walled fibres); D- RLS (ray cells are procumbent).

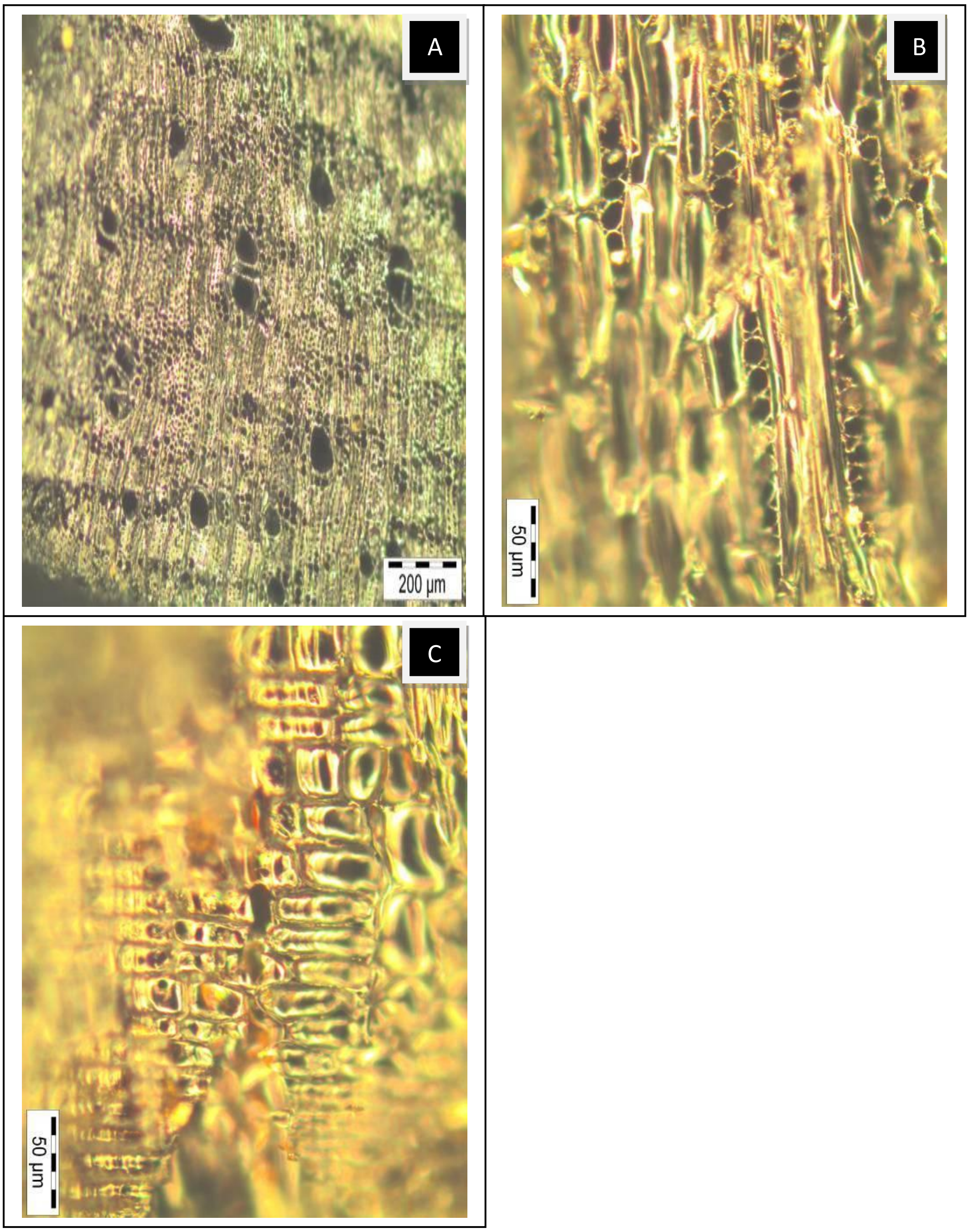


Figure 92: LEGUMINOSAE PAPILIONOIDEAE *Pterocarpus angolensis*, C-T1-L5-b, Cigaramboni, Trench 1. A – TS (diffuse ring porous, solitary, radial multiples 2-3, vasicentric, confluent-to banded, exclusively uniseriate); B-TLS (1-2 seriate, prismatic crystals present, oblique to horizontal perforation plates); C-RLS (mixed procumbent and square cells, marginal cells appear to be upright).

9.4 Trench 2

A total of 11 charcoal fragments were recovered from Trench 2. All the charcoal fragments were identified as *Acacia sp* that resembles *Acacia polyacantha.*

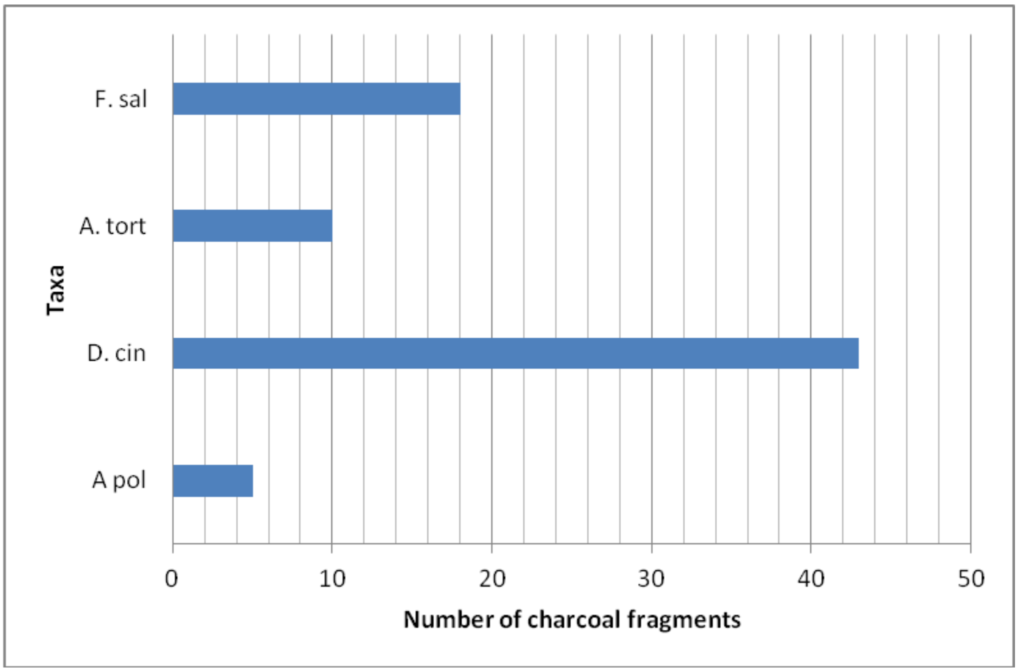
9.5 Trench 4

All the 300 charcoal fragments from trench 4 were identified to *Brachystegia boehmii*.

9.6 Trench 5

The taxa *Brachystegia spiciformis* and *Dichrostachys cinerea* were the only species identified in Trench 5. The taxon *Brachystegia spiciformis* was identified from 131 charcoal fragments, on the other hand *Dichrostachys cinerea* was identified from 31 charcoal fragments, thus *Brachystegia spiciformis* constituted more than 80 percent of the total charcoal fragments that were identified from Trench 5 whilst *Dichrostachys cinerea* contributed less than 20 percent of the total assemblage.

9.7 Test pit 5



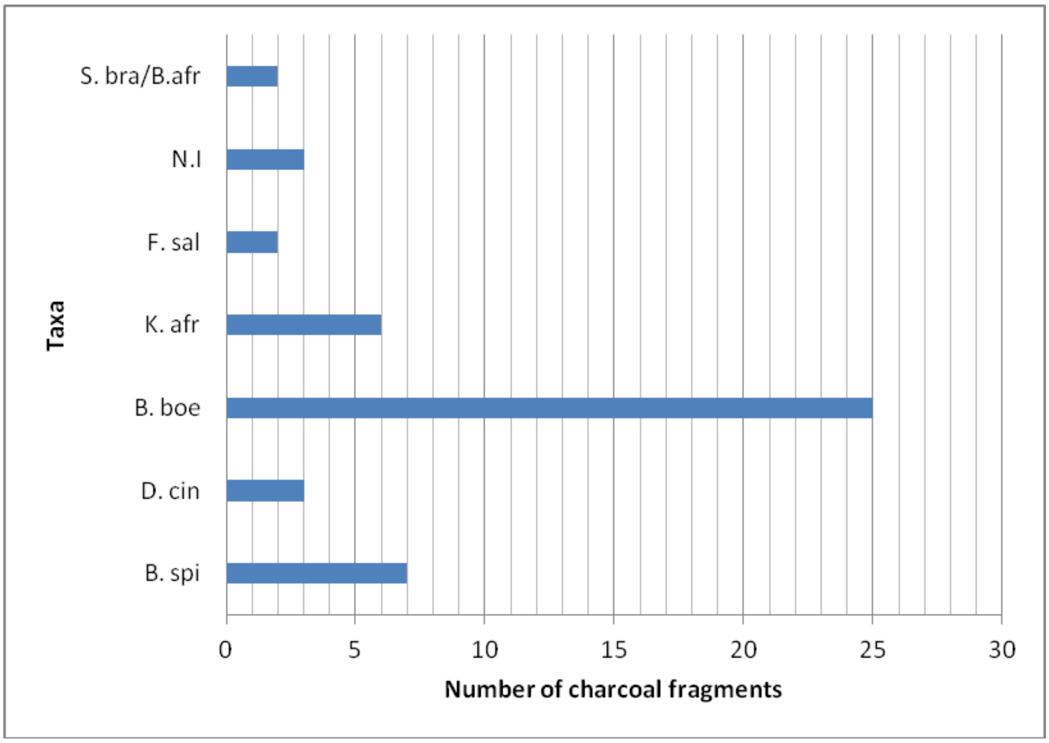
KEY:

F. sal= Faurea saligna, *A.tort=Acacia tortilis*, *D. cin=Dichrostachys cinerea* and *A. pol= Acacia polyacantha*

Figure 93: Identified taxa from Test pit 5.

Four taxa comprising *Faurea saligna*, *Acacia tortilis*, *Dichrostachys cinera* and *Acacia sp* resembling *Acacia polyacantha* were identified from Test pit 5 as shown in the Figure 93. *Dichrostachys cinerea* was the most abundant taxon identified from 43 charcoal fragments which comprised more than 50% of the total charcoal assemblage. *Faurea saligna* was the second best represented taxon that was identified from 18 (less than 25% of the total charcoal assemblage) charcoal fragments. The taxon *Acacia tortilis* comprised 10 charcoal fragments and it was the third most well represented taxon. A rare taxon was the *Acacia sp* that resembles *Acacia polyacantha* that was identified from 5 charcoal fragments.

9.8 Test Pit 7



KEY:

B. boe= Brachystegia boehmii, B.spi=Brachystegia spiciformis, K. afr=Kigelia africana, D. cin=Dichrostachys cinerea, F. sal=Faurea saligna, S.bra/B.afr=Schotia brachypetala and *Burkea africana, N.I=non identifiable*

Figure 94: Identified taxa from Test pit 7.

It is shown in the graph (Figure 94) that a total of five taxa were identifed from an assemblage of 48 charcoal fragments. Only 3 fragments were not identifiable. The most abundant taxon was *Brachystegia boehmii* whereby 25 (more than 50% of the charcoal assemblage) charcoal fragments were attributed to it. The second most well represented taxon was *Brachystegia spiciformis* identified from charcoal fragments. Six fragments were identified as *Kigelia africana*. The figure above also reflects that *Dichrostachys cinerea* was identified by 3 charcoal fragments. *Faurea saligna* and was identified from 2 charcoal fragments. There were two charcoal fragments that exhibited anatomical characteristics that were similar to *Schotia brachypetala* and *Burkea africana*. The small size and preservation condition of these charcoal fragments made it difficult to ascribe them to a specific taxon.

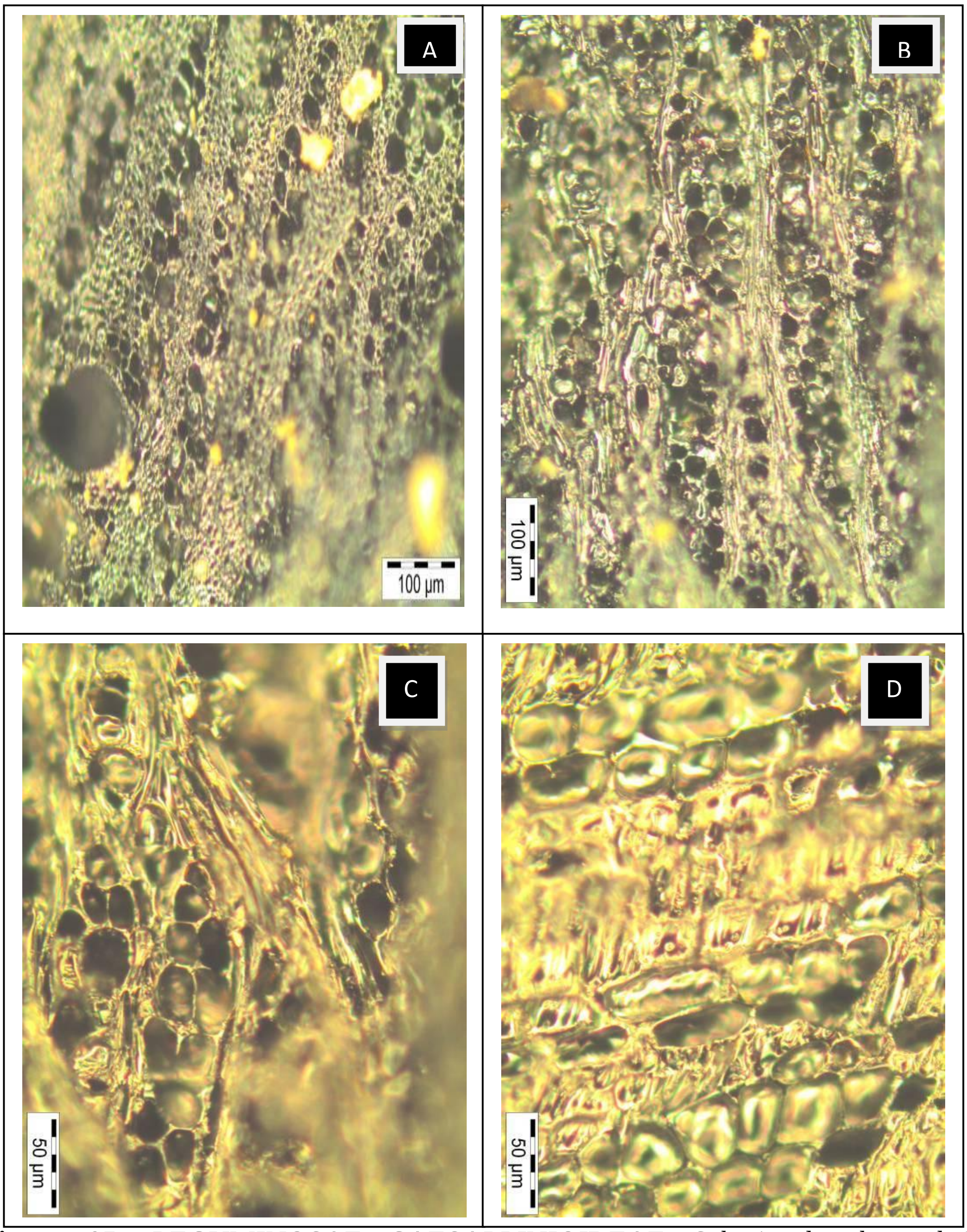
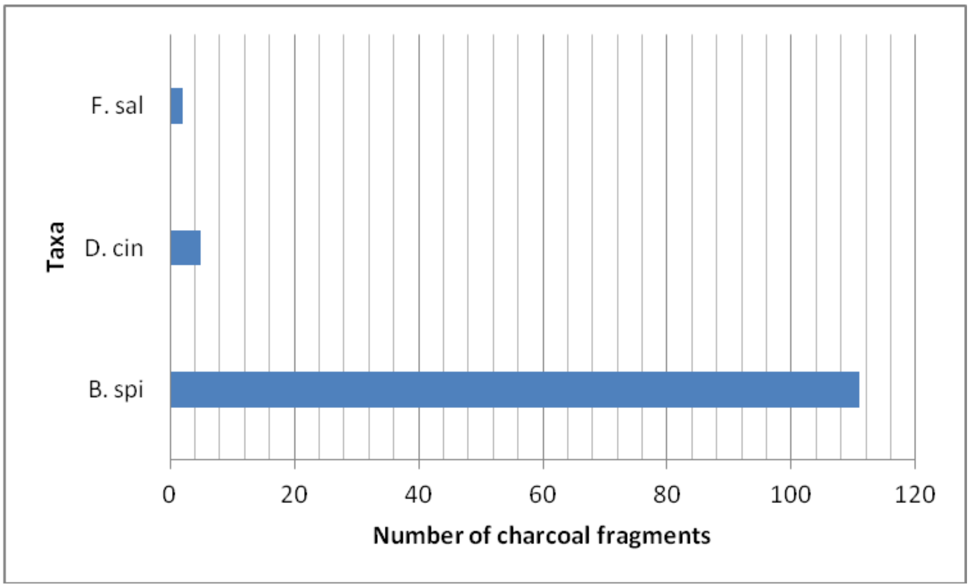


Figure 95: LEGUMINOSAE CAESALPINIOIDEAE *Schotia brachypetala/ Burkea africana*, C-TP&-BS-F, Chigaramboni Test Pit 7. A-TS (solitary vessel arrangement); B, C- TLS (crystalliferous cells, heterocellular, idioblasts present); D- RLS (mixed square and procumbent cells, two layers of square to procumbent cells).

9.9 Chigaramboni



KEY:

B. spi=Brachystegia spiciformis, D. cin=Dichrostachys cinerea, F. sal=Faurea saligna

Figure 96: Identified taxa from Chigaramboni Trench.

The three taxa that are *Brachystegia spiciformis*, *Dichrostachys cinerea*, and *Faurea saligna* were identified from an assemblage of 118 charcoal fragments. Figure 96 above shows that *Brachystegia spiciformis* was the most abundant taxon that was identified by a total of 111 charcoal fragments. Thus *Brachystegia spiciformis* was approximately 90% of the total charcoal assemblage obtained from this Chigaramboni trench. It is reflected in the figure above that *Dichrostachys cinerea* and *Faurea saligna* formed the rare taxa.

10 Summary

In summary the total diversity of species from Chigaramboni were 14 taxa with *Dichrostachys cinerea* being the most common taxon as it was found in five out of nine contexts. *Acacia polyacantha, Brachystegia spiciformis, Brachystegia boehmii* and *Faurea saligna* were the second most common taxa because they were found in four out of nine contexts. The chapter that follows provides some uses and qualities of the taxa that were identified at the Great Zimbabwe and Chigaramboni archaeological records.

CHAPTER EIGHT

Discussion

11 Introduction

In this chapter the modern flora and its significances, the archaeological flora and palaeoecological implications of the results of anthracology from Great Zimbabwe and Chigaramboni will be discussed. The relationships between the wood taxa used, human behaviour and the palaeoecological conditions of the woodland exploited are explored. The distribution of wood taxa in the charcoal samples and the spatial patterns of past distribution in the field, as deduced in the anthracological results, generally can be explained quite well by natural differences in the ecological conditions in the vicinity of the sites studied (Ludemann and Michiels 2004).

12 The modern flora

There is a floristic uniformity of the vegetation dominated by the family *Fabaceae,* subfamily *Caesalpinoideae* particularly *Brachystegia, Julbernardia globiflora* and *Isoberlina*. These characterize the *miombo* woodlands. The species richness of the flora is high (Frost 1996). It is clear that the environment at Great Zimbabwe was modified by the long history of occupation. Pioneering species such as *Celtis africana, Trema orientalis* and *Bridelia micrantha* are good indicators of disturbed environments (Bannerman 1982) and are present in the modern flora.

There were differences noted in the species composition documented by Ndoro (2001), the current study, Mauch (1876) and Bannerman (1982). The vegetation studies by Ndoro (2001) resulted in the recording of 45 different tree species, Bannerman (41), Mauch and Bent (10) and this study (149). The differences can be attributed to the fact that Mauch and Bent's focus was not on vegetation studies and therefore the short list of taxa was out of sheer curiosity. They also lacked expertise in the field of botany.

Early photographic records (Gayre 1972; Mauch 1876) show that Great Zimbabwe was less densely vegetated than it is today. The only place that was densely vegetated then was the Great Enclosure (Mauch 1876). The past degradation of vegetation resources at Great Zimbabwe may have been due to changes in the regional environment and/ or biotic influences. These changes might have been caused by cultivation and harvesting of trees for firewood and medicines that firewood could have put pressure on the tree resources at Great Zimbabwe. In addition the continued occupation by the Mugabe and Nemanwa clans could have had led to further pressure on wood resources.

Today the area is much more wooded than it was previously and has greater species diversity than before. The reasons could be that the management of the site promoted speedy regrowth of woody vegetation. Programs were put in place to encourage indigenous trees to grow; examples are the Aztec and ZIRRCON tree planting programs of 1996 that saw a number of indigenous tree species being planted in the area that had been earlier cleared to make way for a golf course. Nehowa (1997) was involved in *Lantana camara* eradication and *Eucalyptus sp* stumping programs. The various management regimes at Great Zimbabwe encouraged the growth of different vegetation species, for instance *Aloe excelsa* was planted for the visitors to the site. In the process the vegetation composition was altered and reshaped by different heritage management regimes.

The other reason is that people have been prevented from entering the monument as and when they desired by the management authorities. The protective legislation made it a crime for anyone to fetch wood resources from the monument. The management of vegetation has been one of the contentious issues at Great Zimbabwe as it was important to the local people for grazing, fuel wood, poles for construction and carving of crafts. Because of the touristic attraction of the site the management for the monument targets tourists: allowing communities to harvest vegetation leads to fears that the aesthetics of the monument may be affected (Ndoro 2001). This insulation of the monument for more than 100 years from the outside communities largely contributes to the diversity of and uniqueness of the flora found at Great Zimbabwe (Ndoro 2001). Therein lays evidence of anthropogenic impact on the ecosystem. It was noted, however, that there were conflicts with the communities as they illegally harvested tree resources from Great Zimbabwe. Moreover, *Kirkia acuminata* has since been depleted from the monument due to carving of sculptures targeted for tourists. This study did not record *Kirkia acuminata* at Great Zimbabwe although it used to grow there in the mid 1990s but it is found at Chigaramboni. The current management of the monument is making it possible for secondary succession of vegetation to take place with very limited anthropogenic disturbances.

The differences may also be explained in terms of miss-identification and also that new species were emerging through the process of succession. As succession continues diversity of species in a community increases. According to Clement (1916) succession begins when an area is made partially or completely devoid of vegetation due to natural and anthropogenic disturbances. Clement further states that the disturbances involve modification of the abiotic environment and biotic heterogeneity. Disturbances therefore shape the nature and structure of biotic interactions and processes. Various scholars have discussed succession in detail, for example, Davis *et al*. (2005), Glenn-Lewin (1992), Gleason (1926), and Clements (1916). Secondary succession is what is witnessed at Great Zimbabwe which may be allogenic or autogenic. According to Pidwirny (2006) biennial plants, herbs and shrubs will be replaced by perennial herbs and shrubs and then the forest canopies reduce the amount of light reaching the forest floor resulting in the exclusion of many light loving perennial herb and shrub species. Perennial herbs and shrub species adapted to low light conditions then take over the ground cover (Pidwirny 2006).

The present flora of Great Zimbabwe is completely indigenous (*miombo*) contrary to previous claims that there were non-indigenous trees close to Great Zimbabwe. The claims were that *Ficus sp* found at Great Zimbabwe were of Indian origins (Gayre 1972). *Lantana camara*, *Citrus limon*, *Jacaranda mimosifolia* and *Eucalyptus sp* (introduced from Australia) are some of the exotic trees known to have been introduced in the late 19th century at Great Zimbabwe. These have since been removed and it appears that there has been a deliberate policy in the 1960s to replace the indigenous aloes with fast growing ones such as *Aloe excelsa* (Ndoro 2001).

The modern vegetation growing at Great Zimbabwe which is *miombo* woodlands in character provides a wide variety of benefits for communities especially during the dry season, for example poles, thatching, fibres, grasses, fodder and traditional medicines (Tyynela and Niskanen 2000). For more on the use of specific species the reader is referred to Table 2.

Trees are important for the spiritual and cultural life of local residents throughout the *miombo* zone (Wilson 1989; Shackleton and Clarke 2011; Campbell 1996; Mukamuri 1997). The various spiritual well-being and cultural benefits are revered at household or clan level and others are revered at community level. Territorial rainmaking ceremonies known as *mitoro* or *mukwerera, chipwa* and *mushashe* in Shona are conducted under big trees such as *Parinari curatellifolia* and *Ficus sycomorus* in Chivi and Runde areas in Zimbabwe (Mukamuri 1997; Wilson 1989) whilst in Wedza also in Zimbabwe (*personal observation*) they take place under the tree *Parinari curatellifolia*. During drought a pot of beer is placed at the foot of these trees, prayers are said and the beer is drunk. In Muzarabani area also in Zimbabwe the species *Adansonia digitata* known as the baobab or *dziva*, is used for rain prayers (Chikumbirike 2008). Trees are considered as boards for spirits (Ndoro 2001; Mukamuri 1997; Wilson 1989). They state that the spirits that possess people during rainmaking ceremonies are said to be descending from these *Parinari curatellifolia* trees. Species such as *Boscia albitrunca, Burkea africana* and *Gardenia spatulifolia* are said to never be struck by lightning and therefore communities in Zaka in Zimbabwe favour them for shelter during storms (Wilson 1989). Tree species that are revered occur as individuals or in groves. According to Morris (1995) sacred groves are found throughout the *miombo* region. Such groves are considered sacred as well and no one is allowed to cut them (Mukamuri 1997). Normally groves are saved as burial grounds for important people of the clan or as a grove of wild fruits such as *Uapaca kirkiana*. Examples are Dambakurimwa in Domboshava (Pwiti and Mvenge 1996) and Rambakutemwa in Chivi (Mukamuri 1997) in Zimbabwe. Two large pots (Fig 97) that are quite recent were found in the *miombo* grove while a transect was being done in the south eastern direction from the Hill Complex at Great Zimbabwe. This transect was dominated by *Uapaca kirkiana*, *Brachystegia spiciformis* and *Julbernardia globiflora* species. The pots were probably associated with rainmaking ceremonies. Thus *miombo* continues to provide spiritual and cultural functions to the communities around Great Zimbabwe.

Figure 97: Ritual pot found in the *miombo* woodlands at Great Zimbabwe.

Miombo ecosystem has been occupied and utilized by both human beings and animals. The taxa identified in this study show that some of them have medicinal and therapeutic properties and it may be possible that they were used for medicinal purposes. However, given the nature of the data analyzed in this study it is recommended that a more controlled study be conducted to ascertain this. The vegetation contributes to household food security such as fruits and mushrooms. Some tree leaves are cooked and consumed as relish. They influence mammal diversity and that has implications on higher levels in the food chain (Fleming *et al.* 2003). In addition a wide diversity of caterpillars is found in the woodlands that are harvested and supplement nutrition. Honey is also an important food supplement to communities. Honey is reported to be abundant under the tree species such as *Isoberlina angolensis, Julbernardia paniculata* and *Brachystegia spiciformis* (Kalaba *et al.* 2010). *Miombo* have local and regional if not global significance. For example some of the major rivers in southern, central and eastern Africa have their sources in areas covered by *miombo* woodland most notable is the Zambezi River. The *miombo* woodlands play a role in influencing climate.

Miombo also have a hydrological impact. For example *dambos* (swampy or marshy areas) are distinctive features of *miombo* region that are found in seasonally waterlogged shallow valley depressions. According to White (1983) *dambos* form headwaters of many rivers and streams. The clearance of *miombo* woodlands for farming has two global implications that are the release of carbon from the soil and biomass into the atmosphere. According to Xue and Shukla (1993), the second implication is that it results in changes in increased reflectance of solar radiation and decreased surface roughness which if extensive enough could result in increased atmospheric instability and a decrease in the formation of rain.

Miombo woodlands generate a significant fraction of trace gases that influence the radiation budget (Andreae 1993). For example fires are a characteristic feature of *miombo* woodlands which could influence atmospheric chemistry and ultimately climate by generating methane, carbon monoxide, nitric oxide and hydrocarbons that react to form the ozone layer. Fires are considered net carbon dioxide producers since this gas is taken in again during regrowth.

Methane comes from anaerobic *dambo* wetlands, from ruminants and to a lesser extent from termites. Nitric oxide is generated by microbial processes in the soil (especially following the first rains) and combine with hydrocarbons produced by woody vegetation to form ozone. Munishi *et al.* (2010) add that *miombo* have a great potential to either add to the growing content of carbon dioxide in the atmosphere, or help reduce it. Clearing of large areas for agriculture could lead to 6-10 Pg of carbon being released in the atmosphere and a similar amount could be taken back if the *miombo* is conserved.

13 Limitations of the study

The charcoal from Great Zimbabwe comes from a series of excavations. But it is not known from which period during the occupation it comes. The archaeological charcoal from Great Zimbabwe lacks precise spatial context. The charcoal has broad contexts, for instance Great Enclosure. It is not known where exactly from The Great Enclosure the charcoal is coming from and that presents challenges in their interpretation. It is possible that the charcoal under study might have resulted from daily uses such as firewood or construction. The charcoal from Great Zimbabwe lacks stratigraphic sequence. This is vital to establish cultural sequences and vegetation change for Great Zimbabwe. Stratigraphic sequence of charcoal permits the determination of changes in taxa over time and if there was climate change or not. Without good stratigraphic control of the charcoal we cannot establish whether or not Great Zimbabwe was abandoned as a result of ecological degradation. Therefore systematic excavations from sites that are properly documented are needed. There is already a bias in the manner in which the charcoal was collected. Firstly the charcoal was not collected with the idea of an anthracological studies but rather dating, as a result only large pieces of charcoal fragments were handpicked. It is necessary to conduct more than one excavation with long sequences that are not disturbed. Good dating is also required. Great Zimbabwe is a World Heritage site and with the current management plans a series of excavations are unlikely to be done in the near future. Nonetheless it has been possible to get an indication of the vegetation and wood usage in the past.

14 Archaeological flora

Analyzing charred macro remains from Great Zimbabwe archaeological site opened up possibilities for answering questions on the nature of the wood exploited by its inhabitants and the range of some tree species collected. It also helped in answering questions on why some tree species were found in abundance whilst others were not. In addition it provided valuable information about the culture and wood selection habits of the people and also opened a window on the environment exploited.

A greater variety of wood taxa would certainly be expected at Great Zimbabwe. All the charcoal fragments from Chigaramboni were collected by means of properly planned excavations by Webber Ndoro in the early 1990s whilst that from Great Zimbabwe was collected during conservation work of the stone structures. Some charcoal fragments from Great Zimbabwe were collected through excavations, but they were not many. Both charcoal assemblages from Great Zimbabwe and Chigaramboni lacked proper documentation.

Within the broad framework that the Great Zimbabwe samples are the oldest in this study (between 11th and 16th centuries have some spatial context, the Chigaramboni samples are younger (possibly earlier than AD 1800) and the modern vegetation is the youngest and most inclusive sample, a few trends are discussed below.

The results show that approximately 30 wood species were exploited when the site was occupied at Great Zimbabwe, whilst only 11 species were exploited at Chigaramboni and most of these were also used at Great Zimbabwe. Sampling biases are acknowledged but cannot be quantified or qualified. The differences in taxa most likely due to the different activities carried out at sites (multipurpose versus iron smelting) but wood availability may be a factor.

14.1 Common Flora

The number of pieces of charcoal cannot be taken at face value because of fragmentation of charcoal, fire conditions and burning quality of the wood (ash versus charcoal forming) and colleting biases (size, surface find, durability). Nonetheless common versus rare taxa are mentioned below and finally a more realistic interpretation is offered. The results indicated that certain tree species were present in different parts of the Great Zimbabwe site. For example the use of the taxon *Colophospermum mopane* was confined to two localities. These are the Great Enclosure and the Hill Complex. The results (Table 3) show that more than 95% of the *Colophospermum mopane* was burnt in the Great Enclosure whilst less than 4% was burnt on the Hill Complex. However, the exact context where the charcoal came from was not recorded therefore it could have been remains of a burnt structure or wood from a fire.

Colophospermum mopane is considered a good fire wood, and is readily used as constructional material for houses and stonewall enclosures. *Colophospermum mopane* was used as lintels at Great Zimbabwe (Matenga 1996; Sinamai 1997; Summers 1963).

In a study conducted by Vermeulen *et al*. (1996) in Gokwe communal area in Zimbabwe, vvillagers made it clear that for construction poles they went out of their way to cut preferred species, making special trips for the purpose. It is therefore possible that cconstruction poles were often carried over large distances and paid as tribute to the paramount chiefs at Great Zimbabwe.

The *Colophospermum mopane* fragments studied in this thesis indicate that mature wood was harvested, which suggests that construction poles rather than small pieces of firewood were brought to Great Zimbabwe. This is an indicator that *Colophospermum mopane* was traded and highly prized for structural properties. Although, more extensive excavations may suggest otherwise, based on the current sample it would seem that *Colophospermum mopane* only occurs in elite areas and its presence at the site may speak of its association with the elites and the ability of the leader at Great Zimbabwe to exact tribute effectively over long distances. It is likely that it would have been collected by locals or brought in as a form of tribute to the leaders at Great Zimbabwe. More excavations are required to establish whether *Colophospermum mopane* was burnt as firewood on a regular basis.

We must not lose sight of the fact that Great Zimbabwe was an economic hub where goods and services were brought to trade. Certainly the caterpillar moth *Gonimbrasia belina* feed on the *Colophospermum mopane* leaves and forms an important diet in many communities as they are rich in protein (Coates Palgrave 2002). It is possible that mopane worms would also have been brought to trade in the city of Great Zimbabwe. If *Colophospermum mopane* was a commodity that was traded more widely then examples of it may be discovered in future excavations of sites around Great Zimbabwe.

Albizia versicolor contributed 16 % of the total charcoal assemblage from Great Zimbabwe. *Albizia versicolor* was not present in the studied samples from Chigaramboni which may indicate that it is not good firewood for smelting. There is however, need for further investigations.

The second most common charcoal at Great Zimbabwe was the taxon that closely resembles *Acacia polyacantha*. This type comprised more than 20% of the total charcoal assemblage from Great Zimbabwe. The wood was used in five different localities namely the Hill Complex, Terrace area, Ridge Ruins, Great Enclosure, 2030 BD 57 (site of the furnace), and the Barrier hut. It was most prominent in the Barrier Hut sample (50 charcoal fragments). *Acacia polyacantha?* was one of the species that was utilized at both Great Zimbabwe and Chigaramboni. It could have been used as firewood or in construction of houses. In fact the Barrier hut existed during the period of the Great Zimbabwe and it was one of the *dhaka* structures found outside the stone enclosures demarcated by the outer perimeter wall. The wood was found to have been utilized in both the elite and the commoners' areas. *Acacia polyacantha?* was also widely exploited at Chigaramboni. It was the most widely burnt wood being identified by 685 charcoal fragments (approximately 41.4% of the total charcoal assemblage from Chigaramboni). This wood was burnt and used in four of the excavated sites at Chigaramboni metallurgical site was burnt in combination with at least three other species. This may suggest that it was not considered a wood only used by elites and was available to anyone.

Acacia polyacantha is a tall tree that occurs in bushveld, often on heavy soils. Heavy soils combined with good moisture content entailed a good harvest. It is said to be good firewood with high calorific value (Timberlake *et al.* 1999). The wood burns well (Coates Palgrave 2002). The timber is strong and termite resistant. *Acacia polyacantha* trees were not found in the modern vegetation survey conducted by the author but Timberlake *et al.* (1999) and Coates Palgrave (2002) note that it is widespread in Zimbabwe today. Thus its absence today from Great Zimbabwe and Chigaramboni may be an indication that it no longer grows in the immediate area due to over-exploitation.

Julbernardia globiflora comprised 10% of the total charcoal assemblage from Great Zimbabwe. It appeared to have been mainly exploited on the Ridge Ruin and the Hill Complex. The wood was not found in the charcoal assemblage from Chigaramboni and this may be an indication that it may have been burnt completely to ashes or it was not good for smelting. *Julbernardia globiflora*, a hard, coarse, multipurpose wood (Coates Palgrave 2002), however, is growing today at Great Zimbabwe and Chigaramboni. It is an ecologically important species which is co-dominant with *Brachystegia spiciformis*.

Brachystegia spiciformis and *Brachystegia boehmii* were also found to be burnt on the Hill Complex, Terrace area and the Ridge Ruin but in quantities less than those of *Julbernardia* *globiflora*. *Brachystegia spiciformis* comprised 2% of the assemblage at Great Zimbabwe whereas at Chigaramboni it was 16.6% (274 charcoal fragments). Thus the wood was widely burnt as it was found in four excavated trenches at Chigaramboni metallurgical site. It was burnt in combination with at least one other taxon. *Brachystegia spiciformis* is a characteristic of *miombo* woodlands growing in association with *Julbernardia globiflora*.

Brachystegia boehmii was burnt mainly on the Hill Complex and the Terrace area, forming a combined frequency of approximately 3% of the total charcoal assemblage from Great Zimbabwe. At Chigaramboni, *Brachystegia boehmii* was the second most common charcoal with 441 fragments (approximately 26.7% of the total Chigaramboni charcoal assemblage), and found in four of the excavated trenches. Two of the excavated trenches at Chigaramboni yielded *Brachystegia boehmii* only.

Androstachys johnsonii was burnt on the Hill Complex and contributing approximately 7% of the total charcoal assemblage from Great Zimbabwe. Polygonal shaped charcoal fragments of this species were analysed. These had clearly been curved for structures, ornamentation or rituals. It is not clear what the objects were and what purpose they served. *Androstachys jonhsonii* was also utilised as lintels in the stone walls at Great Zimbabwe (Huffman and Vogel 1991). As the wood is extremely hard and termite proof it is much sought after. It occurs at low altitudes on rocky hillsides and is not growing near Great Zimbabwe now. The presence of *Androstachys johnsonii*, like *Colophospermum mopane* in the archaeological record may be an indication of movement in wood as tributes. *Androstachys johnsonii* has been recorded to be growing along or Mtilikwe River about 10 km from Great Zimbabwe site.

Anthracology has revealed that *Dichrostachys cinerea* was common at the studied sites. At Great Zimbabwe it was burnt on the Hill Complex with a proportion of approximately 2% whilst at Chigaramboni a total of 130 (close to 8% of the total charcoal assemblage) charcoal fragments were identified. The charcoal fragments were found in the same context as iron slag and haematite at Chigaramboni metallurgical site. It was also found in five of the excavated trenches at Chigaramboni metallurgical sites. The fact that *Dichrostachys cinerea* was found in five different contexts suggests that it possesses good qualities needed in ancient iron smelting. It also shows that it was widely selected at Chigaramboni site. The tree resprouts rapidly after cutting and is an excellent firewood that burns slowly (van Wyk and van Wyk 1997) and so its occurrence at Chigaramboni is expected. Since *Dichrostachys cinerea* is a common bush land and wooded grassland species of warmer and frost-free areas it tells us very little about the palaeoenvironment but confirms its historical utilization in metallurgical processing.

14.2 Species present in low quantities

The following taxa: *Burkea africana, Spirostachys africana, Brachylaena discolor, Acacia robusta, Acacia karoo, Acacia burkei, Acacia xanthophloea, Acacia sieberiana, Acacia mellifera, Acacia tortilis, Ficus capensis, Ficus sycomorus, Faurea saligna, Strychnos spinosa, Parinari curatellifolia, Uapaca kirkiana, Pterocarpus angolensis, Pterocarpus rotundifolius* and *Mimusops zeyheri* were either present in small quantities at Great Zimbabwe and Chigaramboni or absent from one of the sites. The small numbers may be due to taphonomic processes, burning qualities and period. These species were collected for burning (or for some other uses and were accidentally burned) and so were present in the region. Archaeologically the rare species represent culturally selected taxa and their presence is considered more important than their quantity. The presence or absences of taxa are equally important as different types of wood do not burn equally.

Burkea africana was only recorded at the Chigaramboni metallurgical site in amounts less than 1%. Today *Burkea africana* grows within Great Zimbabwe and Chigaramboni archaeological sites. Its presence in the Chigaramboni archaeological record is significant in that it was found in the historic-woodlands and that the inhabitants of Chigaramboni could have benefited from other products that were associated with it. It is also possible that *Burkea africana* was one of the woods used in metallurgical processing. According to ethnographic studies of the Njanja ironworkers in Chivhu district in Zimbabwe conducted by Franklin (1945) and Mackenzie (1975), the trees of *Burkea africana* were cut down and charcoal for iron smelting was produced from them. Therefore *Burkea africana* could have been a key taxon in metallurgical processing at Chigaramboni and the low quantities in the archaeological record might be due to the burning conditions that allowed it to completely burn into ashes. *Burkea africana* gives hard charcoal which burns exceptionally slowly (Friede *et al.* 1977). Küsel (1974) noted that the *Syzygium gerrardii, Rapanea melanophloeos* and *Burkea africana* were used to obtain charcoal in South Africa. Mackenzie (1975) observed two other tree taxa of *Myange?* and *Monotes glaber (Mushava)* that were cut down and processed into charcoal for iron smelting. Franklin (1945) noted that there were rituals involved in obtaining trees and during the production of charcoal conducted by the Njanja ironworkers. In South Africa Friede *et al*. (1977) indicated that *Acacia nigrescens*, *Acacia giraffae* and *Acacia caffra* have been used in smelting process since time immemorial. They also noted that *Terminalia sericea*, *Combretum imberbe* and *Combretum apiculatum* have ideal properties required in smelting because they burn slowly and retain heat for a long time. In addition the ash of *Combretum imberbe* contains high lime content and therefore forms a good flux. On the other hand Haaland *et al.* (2004) conducted ethnographic fieldwork in Dawio Data Dea in Ethiopia on iron smelting. They noted that charcoal was made by a specialist called *Manja*, but they did not record the species or taxa used in making charcoal in iron smelting. Similarly Schmidt *et al.* (1997) and Schmidt (2000) have done much in the studies of iron smelting that are associated with symbolisms and rituals in Tanzania. However, the tree taxa used as charcoal in iron processing were not recorded. That leaves us with no information on tree species used as sources of charcoal in other regions outside Zimbabwe. Although there are case studies on the diversity of *miombo* products in southern Africa, a metallurgical perspective of resource use is extremely limited. It is therefore recommended that further investigations in this area of the role of *miombo* in metallurgy be conducted.

Approximately 2 % of charcoal fragments analysed from Great Zimbabwe were identified as *Pterocarpus angolensis*. The bulk of the charcoal fragments were found at Nemanwa Ruins. Apparently this species does not make good firewood but it was used as lintels on the Hill Complex in the Western Enclosure at Great Zimbabwe (Schofield 1932, *unpublished*). The wood was not burnt at Chigaramboni, which again probably speaks to its poor burning qualities. The wood was mainly used in construction of stone walls as lintels at Great Zimbabwe. Less than 1 % of the total charcoal assemblage from Great Zimbabwe represents *Pterocarpus angolensis*. Both species *Pterocarpus angolensis* and *Pterocarpus rotundifolius* are growing at Great Zimbabwe and Chigaramboni and within their vicinities. Thus they were part of the taxa that grew in the environment during the period when the two sites were occupied in the past.

Spirostachys africana is one of the rarest woods in the analysed charcoal assemblage of Great Zimbabwe represented by six charcoal fragments, but equally important as it sheds light on cultural selection. Today *Spirostachys africana* neither grows at Great Zimbabwe nor within its vicinity. It seems equally possible that the species could have been present in the region at that time. The wood is almost indestructible and strong. *Tamboti* lintels were recorded at Great Zimbabwe (Coates Palgrave 1981; Summers 1955, 1963). Although there seems to be dearth of literature on historical evidence for wood transport in southern Africa, an ethnographic study on wood usage conducted by Vermeulen *et al.* (1996) in Gokwe shows that people are prepared to travel long distances for special trees to be used in construction. There is, however, abundant literature on trade in *miombo* woodland products such as charcoal. There is substantial information on marketing of woodland products. However, much of it is inadequate or lacks sufficient depth to allow more rigorous analyses. *Miombo* woodlands are a vital source of wood fuel for rural and urban populations. Nhira and Fortman (1995) and Grandy (1995a) noted local trade in firewood between wood-rich areas and the neighbouring deforested communal areas. Different tree species are harvested from *miombo* and associated woodlands for their timber in Southern Africa. For example *Afzelia quanzensis, Diospyros mespiliformis, Pterocapus angolensis* and *Spirostachys africana* (also refer to Table 2). Research on carvers in Zimbabwe by Brigham (1994) showed that most travelled long distances up to 11km to collect wood suitable for carving.

Households in urban areas depend on wood transported from considerable distances for their energy needs (Dewees 1993; Hines and Edeman 1993; Brigham 1994). According to Brigham *et al*. (1996), particular species are favourable for charcoal production due to the dense and hard charcoal they produce. In Tanzania charcoal production sites are located more than 30km from the main road and in some areas they are sited about 5-15km from main roads (Boberg 1993) and Zambia (Hibajene and Ellegard 1994). In Malawi charcoal is produced at varying distances from the market centres. The distances range from 25km to 80km (Kambewa *et al*. 2007). It may therefore be possible that during the ancient Great Zimbabwe wood might have come from such long distances.

Brachylaena discolor is one of the species that shows evidence of possible rare exploitation as it is confined to the Barrier hut. When the whole charcoal assemblage is considered the charcoal fragments that were identified to *Brachylaena discolor* were just less than 1%. *Brachylaena discolor* context is interesting as it was excavated from a hut floor. Its function was either associated with the activities that took place in the hut or used in the construction of the hut itself. The subspecies *discolor* was not identified or recorded in the vegetation survey that was conducted in March 2011, but the other species, *Brachylaena rotundata* was recorded. *Brachylaena discolor* was not present in archaeological record at Chigaramboni and nor was it recorded in the vicinity. Identification of some of these charcoal fragments to the species level presented some challenges in some instances because some charcoal fragments were poorly preserved.

Five species of *Acacia, A. robusta, A. karoo, A. burkei, A. xanthophloea,* and *A. sieberiana* contributed close to 3% of the total charcoal assemblage that was analysed from Great Zimbabwe. *Acacia tortilis* alone contributed close to 2% of the total charcoal assemblage at Great Zimbabwe. While at Chigaramboni site the combined frequencies of *Acacia mellifera* and *Acacia tortilis* contributed close to 2% of the total charcoal assemblage from that site.

Although the different species of the genus Acacia occur in low proportions, their presence is important. Most of these *Acacia* species identified have a limited environmental range hence they provide good proxies for past environment and climate. During the modern vegetation study we were able to identify *Acacia sieberiana* but the rest were not found in close proximity to the sites, indicating that either the archaeological samples were harvested far from the sites or just that the trees no longer grow in the vicinity.

The combined frequencies of *Ficus capensis* and *Ficus sycomorus* were less than 1% of the total assemblage at Great Zimbabwe. There was none from the charcoal assemblage from Chigaramboni. Two charcoal fragments were recovered from the Terrace area. One fragment was found on the terrace path and the other was found in the terrace midden. *Ficus capensis* grows at Great Zimbabwe today. .*Ficus capensis* occurs in wooded grasslands, usually along the streams and moist riversides. Neither species would be considered firewood but may have had medicinal or ritual uses.

Faurea saligna was identified by only one charcoal fragment at Great Zimbabwe, but it has stronger presence at Chigaramboni where 40 (approximately 2.5% of the total charcoal assemblage) charcoal fragments were identified as *Faurea saligna*. The presence of *Faurea saligna* in the archaeological record at Chigaramboni indicated that it was one of the taxa used as a source of fuel energy for metallurgical processing. It is a hard wood, works well and makes good firewood.

Schotia brachypetala was burnt at Chigaramboni site only. The charcoal representation was less than 1%. The presence of the taxon shows its availability in the vicinity of the site. It was however, not one of the species that was popularly burnt at the site. The reason for this could have been purely cultural. Its presence in the archaeological record indicates its presence in the ancient environment and therefore it is of significance when reconstructing palaeoenvironment of this area and the region as a whole.

Parinari curatellifolia charcoal was present at Great Zimbabwe only. The proportion of charcoal fragments burnt at Great Zimbabwe contributed 2.5% of the total charcoal fragments where it was confined to the Hill Complex and the Great Enclosure only. Most of the charcoal recovered was found on wall foundations on the Hill Complex. Thus this is important in giving information on the types of trees that are contemporary with or predate the stone walls.

Strychnos spinosa was identified by two charcoal fragments at Great Zimbabwe. It was not burnt at Chigaramboni metallurgical site. This suggests that it might not have been a suitable wood for metallurgy. The various species in this genus are used medicinally for many ailments (Coates Palgrave 2002).

An insignificant percentage of charcoal fragments identified as *Uapaca kirkiana* were found. This was 0.5%. The charcoal fragments were found on the Hill Complex. None was found at Chigaramboni site. The species is still growing at Great Zimbabwe and Chigaramboni. The cultural significance of this taxon is difficult to decipher. Culturally it shows the tree species that the inhabitants of Great Zimbabwe had exploited for fuel wood or for other purposes (see Table 2).

At Great Zimbabwe site the burning of *Mimusops zeyheri* appeared to have been practiced on the Hill Complex only. *Mimusops zeyheri* was not burnt at Chigaramboni although the species is found in the areas around the site. A number of trees of *Mimusops zeyheri* are currently growing within the site of Great Zimbabwe. They are the most popular trees that are found in the Great Enclosure near the conical tower. These trees have been found to be causing structural problems in the Great Enclosure but the challenge is that they cannot be removed as they have become part of the monument.

15 Palaeoecological implications of the charcoal assemblages from Great Zimbabwe and Chigaramboni

It is evident that the taxa found in this study at one point were part of the historical woodlands which the inhabitants of the two settlements of Great Zimbabwe and Chigaramboni exploited. This study has shown that the past woodlands were typical *miombo* woodlands which are the same today. However, there is very little published on palaeoecological data that is suitable to support this conclusion from the area around Great Zimbabwe. The study by Thorp (1995) focused on the animal economy of Great Zimbabwe, whilst Jonsson (1998) focused on the early plant economy in Zimbabwe, Walker (1995) focused on seeds from Matopos and Tomilson (1973) focused on pollen studies in Nyanga area in Zimbabwe. None of these studies focused on anthracology.

Generally speaking the bulk of the identified species are mesophytic. These include such taxa as *Acacia robusta*, *Acacia sieberiana*, *Acacia xanthophloea*, *Acacia polyacantha*, *Acacia burkei, Faurea saligna, Schotia brachypetala, Kigelia africana* and *Parinari curatellifolia*. These taxa grow in areas of high moisture content but some have a limited tolerance range and will not tolerate extreme climatic conditions whereas as others can tolerate extremes. *Acacia sieberiana* and *Parinari curatellifolia* fall into the former category and it is presumed that the inhabitants of Great Zimbabwe experienced a mesic environment. This concurs with Jonsson's (1998) findings. According to Jonsson (1998), the data from Mwenezi and Great Zimbabwe suggest a wetter climate during the Medieval Warm Epoch. Today Great Zimbabwe experiences a microclimate which is characterized by high rainfall which is different from the surrounding areas and this appears to have been the trend during the ancient times.

16 Conclusion

The charcoals analyzed in this thesis are a product of purposeful human action. They present a subsample of the local vegetation and related human activities contemporary with the period of sites use. A substantial effort has been invested in the development of a modern vegetation reference collection database. This will go a long way in assisting future researchers in the region and is an extremely valuable and essential primary contribution to the development of wood charcoal studies in the region. It has been demonstrated that anthracology is a useful tool that can be used in understanding past human behaviour in the landscape.

It was hypothesised that wood fuel for the domestic cooking and warming was different from wood used for industrial and construction purposes. At Chigaramboni metallurgical site the following taxa were exploited: *Acacia mellifera, Acacia polyacantha, Acacia tortilis, Brachystegia boehmii, Dichrostachys cinerea, Faurea saligna, Faurea macnaughtonii, Kigelia africana, Burkea africana, and Brachystegia spiciformis*. It has been concluded that these taxa were used as fuel wood and flux in metallurgical processing at Chigaramboni. It has been concluded that a wide range of taxa was burnt at Great Zimbabwe where thirty different tree species were burnt. It is quite likely that the multipurpose nature of the settlement resulted in different types of tree species being utilized.

It has been concluded that fuel wood exploitation at Chigaramboni closely resembles that from Great Zimbabwe. It is quite likely that the firewood used in metallurgy were collected whilst they were wet. This was evident in some charcoal specimens where the bark was still attached to the wood. In addition to that the wood showed lots of ruptures indicating that there was pressure in the vessels or along the rays that was due to high moisture content of the wood. The same observations were made during the study of the modern reference charcoals. As the burning temperature increased the pressure also increased and resulted in the rupturing of the ground tissue and the vessels. Ruptures in the analyzed wood, however, could also have resulted from high resin content in the wood. Alternatively, if the charcoals were made and then burnt for the second time then that might have caused the ruptures in the archaeological charcoal.

It is concluded that there was long distance movement of wood particularly *Spirostachys africana* and *Colophospermum mopane* because of their excellent construction qualities. It is quite possible that the inhabitants of Great Zimbabwe or their trading partners opted to travel long distances in order to collect those particular logs. The analysis of charcoal from the sites has revealed the genera, in some cases species, that were used for fuel wood or timber. From the evidence it would appear that during the period of occupation of Great Zimbabwe *Colophospermum mopane* was not a preferred fuel source in metallurgical processes at Chigaramboni. It would have been easier to obtain *Colophospermum mopane* as it is growing today near the site as compared to the distance between its source and Great Zimbabwe.

The second hypothesis of this thesis was that modern wood vegetation did not correlate with palaeo-wood vegetation. This is, however, not true as the species composition in the archaeological record indicates a *miombo* kind of vegetation which is the present type of vegetation at Great Zimbabwe and Chigaramboni. This seems to suggest that climate change did not occur. It is therefore concluded that the woodlands of Great Zimbabwe and Chigaramboni did not change from the time of occupation by their original inhabitants to date. *Miombo* is characterized by wet >1000mm and dry <1000mm climates in sub-Saharan Africa (White 1983). *Miombo* generally grows in nutrient poor and heavily leached soils. Mean annual rainfall in *miombo* regions ranges from 650- 1400mm. *Miombo* woodland is resilient to minor environmental changes, it is therefore difficult determine any changes unless there are major changes in the environment. Some species such as *Brachystegia spiciformis* and *Julbernardia globiflora* are affected by occasional lower temperatures that result in heavy frost damage. In the absence of charcoal data from a sealed context it is difficult to prove whether or not climate change took place. Interestingly most of the taxa exploited indicate a riverine habitat and it can be concluded that some of the areas around Great Zimbabwe had high moisture content or groundwater sources. It can also be concluded that the inhabitants of Great Zimbabwe had access to wet patches such as swamps or permanent water bodies. Although some workers in this field have pointed out the limitations of charcoal evidence because charcoals are artifacts which have been subjected to a cultural filter (Western 1971), the anthracological studies have demonstrated that it is also possible to make inferences about climate. With the evidence at present one can suggest that the mature vegetation was being exploited for fuel and construction.

Based on the mesophytic species identified in this thesis such as *Acacia robusta, Acacia sieberiana, Acacia xanthophloea, Acacia polyacantha, Acacia burkei, Faurea saligna, Schotia brachypetala, Kigelia africana* and *Parinari curatellifolia,* it is concluded that the inhabitants of ancient Great Zimbabwe and Chigaramboni experienced a mesic environment.

Finally this thesis provides the foundations for future research by recognising the need to understand the ecology in more detail and at a larger geographical scale, both with respect to iron production and palaeoecology. It is hoped that permission will be granted in the future to carry out a proper archaeological excavation in Great Zimbabwe to collect charcoal from dated stratigraphic levels. Then a detailed analysis will be possible.

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APPENDIX 1: Charcoal analysis form for archaeological and modern specimens.

Example:

Z 100 Piliostigma thonningii

Transverse section (TS)

no distinctive growth rings
diffuse ring porous
solitary
radial multiples(2-3)
1-2? Seriate
Rays sometimes merge to become one
Sometimes two separate rays converge to become biseriate (Tv6)
Generally the space between rays is very narrow
amorphous deposits
paratracheal axial parenchyma-confluent to banded

Average vessel diameter count = 65
Mean = 85.46 µm
Minimum = 36.06 µm
Maximum = 130.55 µm
standard deviation = 19.13 µm

 # Vessels per millimetre square = 36.6

Traverse longitudinal (TLS)

Rays:
ray width is 1-2 seriate
both weakly heterocellular to homocellular and heterocellular uniseriate
biseriates are heterocellular
some biseriates are short
bands of parenchyma (Tv88-89)

Tracheids:

Vessels:

vessels with pits (Tv 106)
there are two types of pitting on the vessels

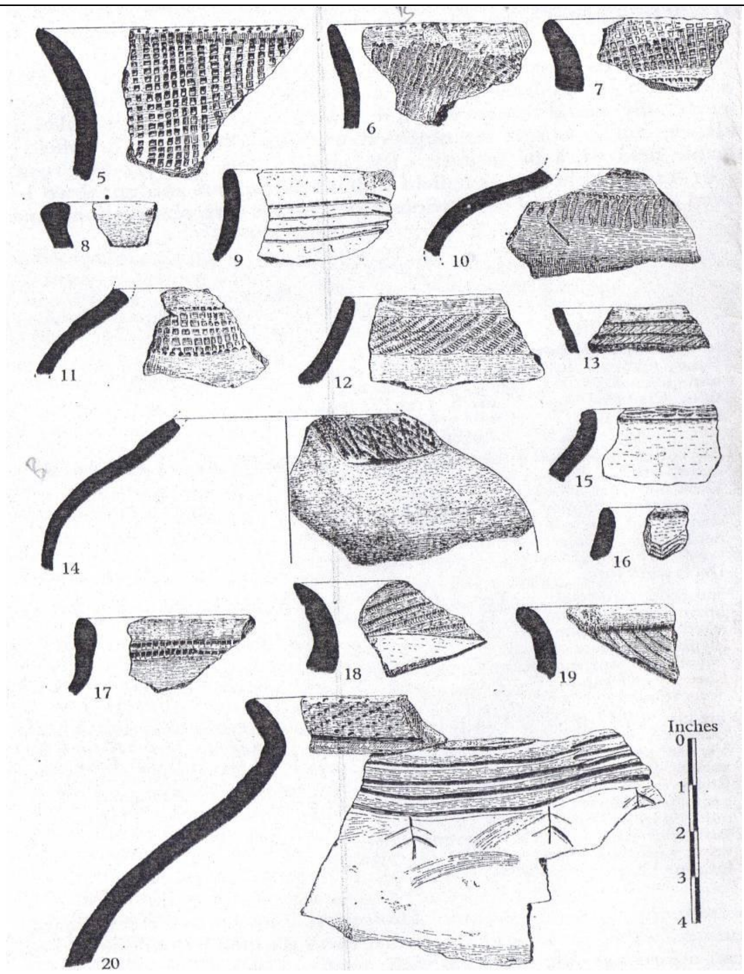
Fibres

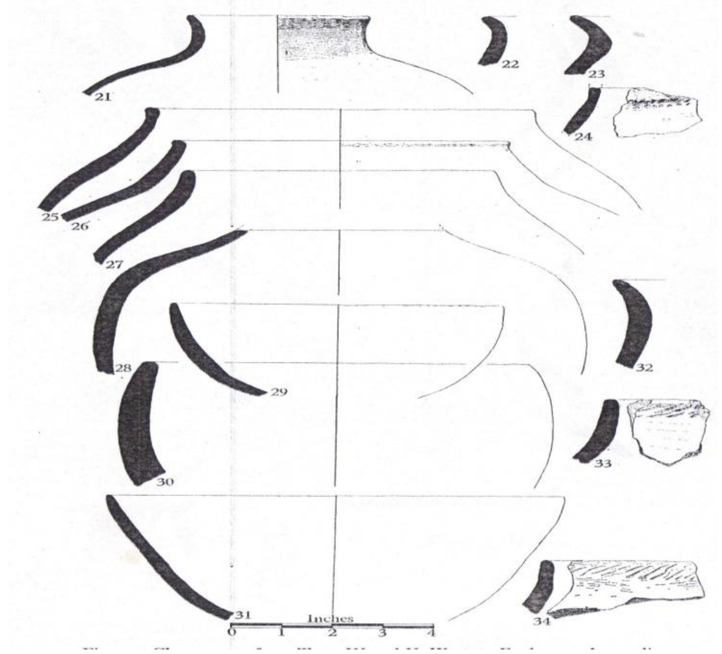
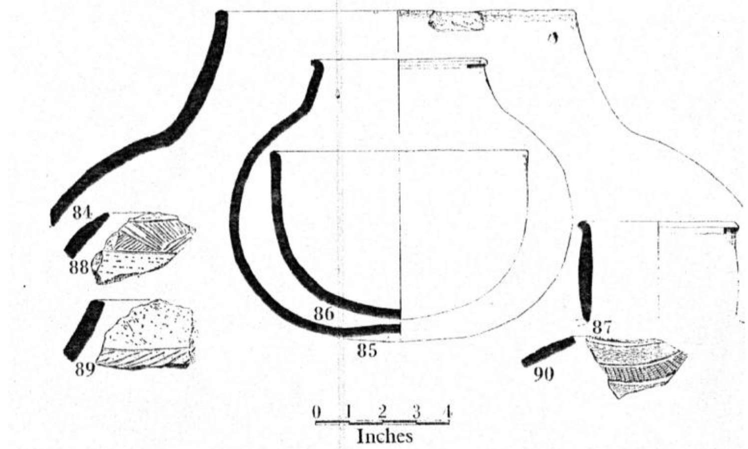
fibres with simple pits

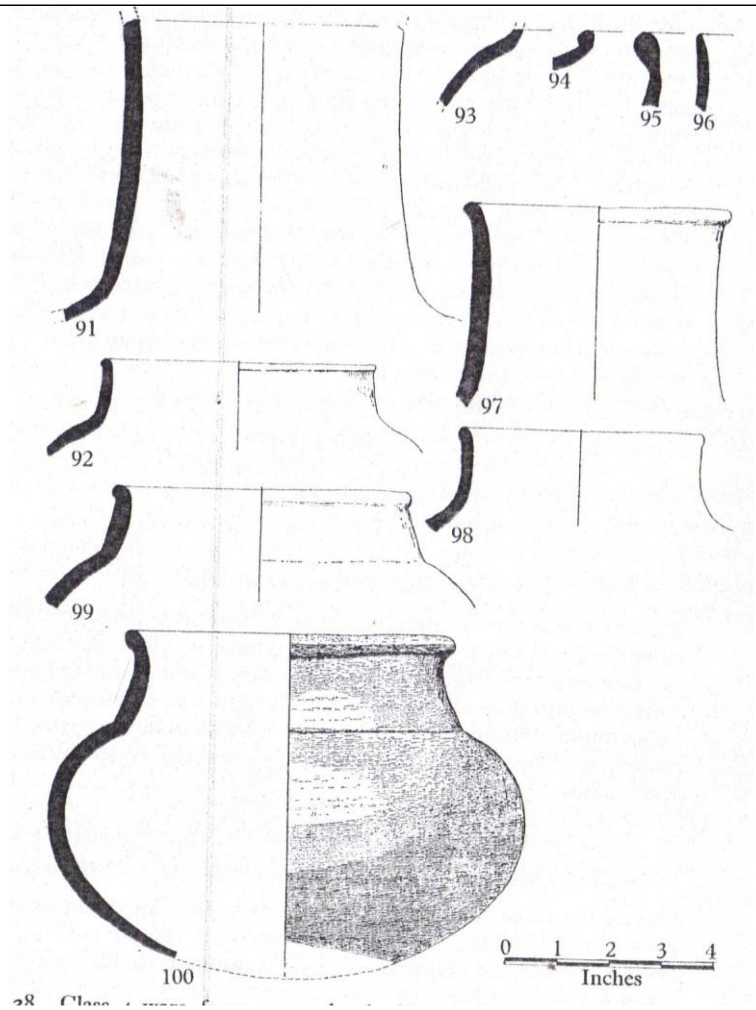
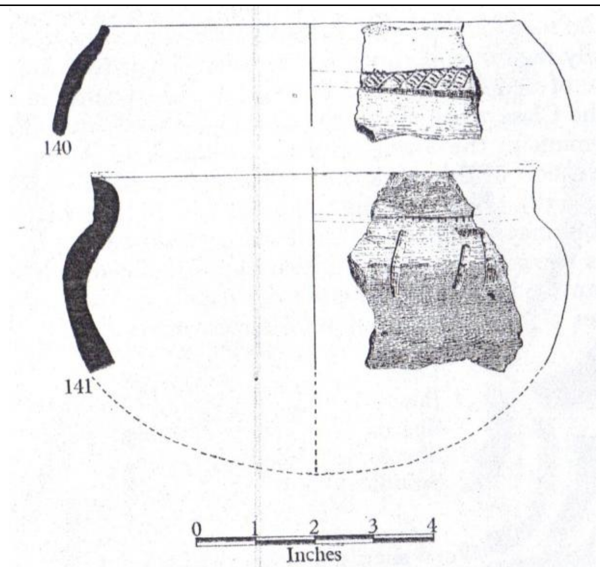
Radial longitudinal (RLS)

Mixture of square and upright cells
heterogenous

18 APPENDIX 2

Clas s	Description	Illustrations (After Robinson 1961)
1	Brown to reddish mat. Sandy texture Stamp and channel decoration, clay free from grits, Fine and evenly fired, usually free from additional matter such as grit. Graphite might have been used. The commonest pot seems to be globular with a short flared vertical neck. The rim band was sometimes thickened and often decorated with oblique lines of rectangular stamps, probably done with a comb. Immediately below the neck there were four or five channelled grooves running round the circumference of the pot, and below these there was either a narrow of impressions obtained by using the end of a small bone or stick, or series of incised motifs. Pots with larger type of neck occurred as may be seen in fig 23. In some instances decorations extends over the lip which is covered with small round impressions. There is a meander form of decoration which is common in the Leopard's Kopje and related wares. The use of bangle-type decoration maybe noted. Bowls show thickening and flattening of the rim and thickening only	

2	-firing appears erratic, the finish is often rough, majority of pots are modelled on the gourd, flattened type of rims resembling the rim of a gourd, -some of the vessels have small circular hollow which occurs in the base of the vessels, in most cases the necks are poorly developed -pots had probably tapered necks and were occasionally decorated -bowls are hemispherical or deep bowls, simple and undecorated.	
3	-firing was even and thorough -shouldered pots with a vertical neck, some of the shouldered pots have bevelled and facetted rims, some do have thickened and bevelled rims. -some gourd pots occur and are made in the finer fabrics, -in some pots motifs are composed of incised triangles that are probably arranged in a narrow band below the neck of the pot -the bowls are rare in class 3.	

4	-fine clay, thin fabric –graphite is common. -vertical necks of varying heights, engraved and incised geometrical designs, not in narrow bands -plain black-polished ware, with raised ribs forming panels on pot -the clay was poorly fired, burnish was frequently added to the outside of the vessel, often black graphite was added, thin walls of small vessels, larger pots were thick and with a red finish or buff ma -decorated vessels are scarce pots with spherical bodies and short necks with beaded rims -pots with spherical or globular bodies with comparatively tall necks, the rims are beaded or outwardly flared. Spherical pots with very short necks and heavily rolled rims -spherical pots without necks and rolled rims	
5	-decorated with cross hatching	

Source: Robinson (1961)